

Developmental Milestones and Self-Feeding Behaviors in Infants and Toddlers

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ABSTRACT

Objectives To identify ages at which gross motor developmental milestones and fine motor skills required for self-feeding were reported by primary caregivers and to relate these self-feeding skills to energy and nutrient intakes.

Design Cross-sectional survey of households with infants/toddlers, ages 4 to 24 months.

Subjects/Setting Telephone survey using a national random sample of infants and toddlers (n=3,022).

Methods Primary caregivers reported their children's food intake (one 24-hour recall), the ages when caregivers reported self-feeding skills were shown, and the number of teeth.

Statistical Analyses Performed Children's reported ages for gross motor developmental milestones, self-feeding skills, and the number of erupted teeth were summarized. Using *t* tests, differences in energy and nutrient intake were determined by age groupings and by the absence or presence of each self-feeding skill.

Results Self-feeding skills achieved in the first 2 years and details about age ranges at which developmental readiness to self-feed were evidenced are described. The ages at which children were reported to show gross motor developmental milestones and eruption of teeth occurred within expected age ranges. A majority of the children who were reported to show developmental readiness to self-feed at an earlier age (7 to 14 months) had higher intakes of energy and most nutrients than those who did not. By 15 to 18 months, most of the children were reported to show comparable self-feeding skills regardless of whether they self-fed earlier or later.

Applications/Conclusions Assuming a variety of nutritious foods are offered to infants and toddlers, caregivers may encourage self-feeding without concern for jeopardizing energy and nutrient adequacy. In the first year, the addition of foods that require chewing should reflect the number of erupted teeth.

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Literature on the emergence and sequencing of fine and gross motor development includes the classic works of Gesell and colleagues (1-3), observational/therapy studies (4,5), pediatric publications (6,7), research studies (8-16), and clinical assessments (17-19). The developmental sequence is influenced by health, including the absence of birth or neonatal anomalies (16), as well as by cultural factors (20). Among healthy children who are less than 2 years of age, food intake and gains in weight and length for age are commonly used as indices of normal development and wellness (21,22). No recent large cross-sectional studies have reported gross and fine motor development of children and related them to the developmental readiness to self-feed or to nutrient intakes. Moreover, it is not known whether nutrient intakes differ among healthy infants and toddlers who are developmentally advanced in self-feeding from intakes of their age peers who are less advanced.

The study objectives were (a) to identify the ages at which gross motor developmental milestones and fine motor skills required for self-feeding were reported by the primary caregivers, and (b) to relate these self-feeding skills to energy and nutrient intakes at those ages.

METHODS

Primary caregivers who had infants and toddlers ages 4 to 24 months were recruited for the Feeding Infants and Toddler Study (FITS). This cross-sectional study of 3,022 infants and toddlers is described in detail in this supplement (23).

Data Collection

The primary caregivers who verified their responsibility for foods selected and offered to their children completed telephone interviews. Data included one 24-hour recall of foods consumed by the infants and toddlers, ethnicity of the child, number of teeth, and selected gross motor and fine motor skills that the child showed at the time of the telephone interview.

Analyses

The study child's food consumption (including breast milk, formula, and supplements) was coded for nutrient analysis using the Nutrition Data System Research Manual (24). Statistical analyses were performed in 2003 by Mathematica Policy Research, Princeton, NJ, using the SAS System for Unix (Version 8.2, 2001, SAS Institute Inc, Cary, NC). Because of the difficulty in estimating the quantity of breast milk for those infants 4 to 6 months of age who consume breast milk and other nonmilk food and beverages, nutrient intakes for the ages 4 to 6 months were not included in these analyses (25). Although this same issue of estimating the quantity of breast milk also applies to older breastfed infants, two factors justify including older breastfeeding infants in the analysis: (a) the quantity of breast milk consumed for these older infants

Table 1. Developmental milestones for dentition and gross motor skills in infants and toddlers^a

Dentition and developmental milestones	Age (mo)					
	4-6 (n=847)	7-8 (n=483)	9-11 (n=678)	12-14 (n=371)	15-18 (n=303)	19-24 (n=310)
Dentition (mean number of teeth) The infant/toddler (%)	0.4	1.9	4.4	7.4	11.0	15.2
Lifts and supports head	98	98	NA ^b	NA	NA	NA
Rolls over on purpose	78	96	NA	NA	NA	NA
Rolls from front to back	65	94	NA	NA	NA	NA
Rolls from back to front	62	94	NA	NA	NA	NA
Rolls from front to back and back to front	50	92	NA	NA	NA	NA
Sits alone without support	33	91	97	NA	NA	NA
Can crawl when left lying on stomach	10	57	88	88	NA	NA
Pulls to a standing position without help	NA	47	85	99	100	100
Walks at least two steps holding onto something	NA ^b	44	83	97	94	94
Walks at least two steps without holding onto something	NA	3	35	83	92	94
Walks across the room without holding onto anyone or anything	NA	2	20	76	92	94

^aUnweighted sample sizes for each age.
^bNA=not applicable; question not asked.

was assumed to be 600 mL for breastfed infants older than 6 months to account for the replacement of energy from solid foods for energy from breast milk as solids are introduced, and (b) the proportion of breastfeeding is substantially lower among infants 7 to 11 months of age than among younger infants, suggesting that the assumptions related to estimating the quantity of breast milk is less important for older infants.

For ages 7 to 8, 9 to 11, 12 to 14, 15 to 18, and 19 to 24 months, percentages were calculated for the number of infants and toddlers who showed the following feeding practices: child grasps food with hand, child removes food from spoon with lips, child feeds self with spoon without spilling much, child drinks from a sippy cup without help, child drinks from a regular cup without help, and child eats foods that require chewing. *t* tests were performed using the five age groupings to determine whether significant differences in energy and nutrient intakes existed between those who were reported to show a self-feeding skill and those that did not at the same age.

Percentages were calculated for the mean numbers of teeth erupted and 11 gross motor developmental milestones as reported by caregivers. These milestones represent a hierarchy of increasing head and torso control that typically occurs during a child's first 2 years.

RESULTS

Dentition

The mean numbers of erupted teeth reported for the FITS infants and toddlers are shown in Table 1. The mean of 1.9 teeth at 7 to 8 months corresponds with the normal eruption of mandibular central incisors (ie, first primary teeth), and the reported 4.4 teeth at 9 to 11 months is consistent with normal eruption of the maxillary central incisors. The mean of 7.4 teeth at 12 to 14 months corresponds with normal emergence of lateral incisors, and 11.0 teeth at 15 to 18 months and 15.2 teeth at 19 to 24 months are consistent with reported ages that canine and first molars may erupt during the second year.

Gross Motor Developmental Milestones

An infant's ability to stabilize the head and balance the trunk is a prerequisite to sitting without support and to using hand and arm movements in the self-feeding process. The majority of infants ages 4 to 8 months were reported to lift and support their heads without help (Table 1). At 4 to 6 months, 78% of infants were reported to show the ability to roll over and 50% to reverse the direction of the roll. By 7 to 8 months, 96% to 92%, respectively, had achieved these milestones.

About one-third of the infants were reported to sit alone without support at 4 to 6 months, and 97% were sitting alone without support by 9 to 11 months. By 7 to 8 months, 57% of the infants crawled when left lying on their stomachs and 88% achieved this developmental milestone by 9 to 11 months. The data illustrate the developmental concept that young children achieve gross motor skills at different ages (10). For example, 47% of infants at 7 to 8 months and 85% of infants at 9 to 11 months were reported to pull to a standing position without help; but at the same ages, about the same percentages of infants and toddlers were reported to walk at least two steps holding onto something.

The toddlers' progression to independence and ambulation is reflected in findings for the ages of 9 to 14 months. For ages 9 to 11 months, 35% of the infants were reported to walk at least two steps without holding onto something, and 20% to walk across a room without holding onto anything; whereas at 12 to 14 months, 83% and 76%, respectively, showed these skills. By 19 to 24 months, the majority of toddlers were reported to walk unassisted.

Self-Feeding Skills and Nutrient Intakes

Table 2 describes a range of ages at which caregivers reported self-feeding skills among the study children, and shows the ages at which a majority of them were reported to show five self-feeding skills. The data represent subsamples of groups of children for each of the age

Table 2. Self-feeding skills and the percentage of infants and toddlers who were reported to show the self-feeding skill during the first 2 years^a

Self-feeding skills	Percentage achieving self-feeding skill by age (mo) ^b					
	4-6	7-8	9-11	12-14	15-18	19-24
Child grasps food with hands		96%				
Child removes food from spoon with lips	←		88%			
Child feeds self with spoon without spilling much		←				84%
Child drinks from a sippy cup without help					91%	
Child eats food that requires chewing					95%	

^aCaregivers reported by telephone interviews the presence or absence of the self-feeding skill on the day of the interview.
^bThe FITS data represent subsamples of groups of children for each of the age groups.

groups, and arrows in Table 2 indicate the range of ages at which some infants and toddlers were reported to show self-feeding skills on the day of the caregiver's telephone interview. For each of the age groups, the percentages of infants and toddlers who showed the self-feeding skills are cited in the text below. For all of the self-feeding skills, the data reported on nutrient intake represent at least 50 children per age group, and results are only described for those ages at which significant nutrient difference by self-feeding skill were found.

Child Grasps Food with Hand (Asked for Ages 4 to 11 Months). The percentages of children who were reported to grasp food with their hands were 68%, 96%, and 98% for the ages 4 to 6, 7 to 8, and 9 to 11 months. No significant nutrient differences by feeding skill were found.

Child Removes Food from Spoon with Lips without Spilling Much (Asked for Ages 4 to 24 Months). The percentages of children who were reported to remove food from a spoon with their lips without spilling much were 77%, 88%, 90%, 96%, and 97% for the ages 7 to 8, 9 to 11, 12 to 14, 15 to 18, and 19 to 24 months, respectively. For ages 7 to 8 months, infants who were reported to show this self-feeding skill had higher intakes of energy, protein, carbohydrate, vitamin B-6, vitamin C, and magnesium than those who did not remove food from a spoon with their lips.

Child Self-feeds with a Spoon without Spilling Much (Asked for Ages 7 to 24 Months). For the ages 7 to 8, 9 to 11, 12 to 14, 15 to 18, and 19 to 24 months, the percentages of children who were reported to self-feed with a spoon without spilling much were 5%, 11%, 29%, 64%, and 88%, respectively. Infants who self-fed with a spoon at 9 to 11 months had higher intakes of energy, all of the macronutrients, thiamin, niacin, vitamin B-6, folate, magnesium, and zinc than for those who did not (Table 3). For ages 12 to 14 months, nutrient intakes were similar to those for ages 9 to 11 months.

Child Drinks from a Sippy Cup without Help (Asked for Ages 4 to 24 Months). For the five age groupings 7 to 24 months, the percentages of children reported as drinking from a sippy cup without help were 42%, 70%, 91%, 96%, and 99%, respectively. For ages 7 to 8 months, reported intakes of energy, all of the macronutrients, folate, vitamins C and E, and calcium were significantly higher for infants who drank from a sippy cup than for those who did not (Table 4). For ages 9 to 11 months, only two nutrients (protein and vitamin B-6) were significantly higher for infants who drank from a sippy cup without help than for those who did not.

Child Drinks from a Regular Cup without Help (Asked for Ages 7 to 24 Months). At 9 to 11 months, 10% of the infants were reported to drink from a regular cup, 14% at 12 to 14, 34% at 15 to 18, and 57% at 19 to 24 months. There were a few nutrient differences at 9 to 11 months; children who were reported to drink from a cup had higher intakes of energy, protein, fat, vitamin B-6, and folate than children who did not. No nutrient differences by feeding skill were found for the ages 12 to 18 months; but at 19 to 24 months those drinking from a regular cup had higher intakes of energy and fat.

Child Eats Foods That Require Chewing (Asked for the Ages 7 to 24 Months). The percentages of children ages 7 to 24 months who were reported to eat foods that required chewing were 53%, 87%, 95%, 99%, and 99%, respectively, for all of the age groupings. Overall, nutrient intakes for the children at ages 7 to 8 and 9 to 11 months were similar (Table 5). Infants ages 7 to 8 months who were reported to eat foods that require chewing compared with intakes of those who did not were significantly higher for energy, all of the macronutrients, vitamin B-6, vitamin B-12, folate, and zinc. Thiamin, niacin, and magnesium intakes at 9 to 11 months were also significantly higher among toddlers who were reported to eat foods that require chewing compared with those who did not.

In summary, the nutrient intakes that differed significantly by self-feeding skills and by age show the following patterns: intakes of riboflavin, vitamin E, and calcium differed for one feeding skill; thiamin, vitamin B-12, niacin, vitamin C, and zinc differed for two skills; and magnesium differed for three of the five self-feeding skills. Intakes of energy, protein, carbohydrate, vitamin B-6, and folate differed for all five self-feeding skills, with fat being significantly different for four of five self-feeding skills. In all cases, higher nutrient intakes were associated with the presence of self-feeding skills at an earlier age.

DISCUSSION

Dentition

The mean numbers of teeth reported among the FITS infants and toddlers by age group were in accord with the normal eruption of teeth in healthy children during their first 2 years. On average, 16 teeth are acquired in the first 2 years and the second molars appear in the third year (26).

Table 3. Nutrient intakes that differ significantly among infants and toddlers who self-feed with a spoon without spilling much compared with those who did not^a

	9-11 mo		12-14 mo	
	No n=605	Yes n=56 ^b	No n=284	Yes n=82
Macronutrients^c	← <i>mean ± SD^d</i> →			
Energy (kcal/d)	951 ± 302	1,076 ± 437*	1,092 ± 304	1,275 ± 462**
Protein (g/d)	25 ± 12	32 ± 17**	42 ± 15	48 ± 22**
Carbohydrate (g/d)	133 ± 46	146 ± 66	141 ± 47	168 ± 61**
Fat (g/d)	36 ± 13	42 ± 18*	42 ± 15	48 ± 21*
Micronutrients				
Thiamin (mg/d)	0.9 ± 0.4	1.0 ± 0.6	1.0 ± 0.4	1.1 ± 0.5*
Niacin (mg/d)	11 ± 5	13 ± 7*	10 ± 5	13 ± 6**
Vitamin B-6 (mg/d)	0.8 ± 0.41	1.1 ± 0.64**	1.0 ± 0.50	1.2 ± 0.52**
Folate (μg/d)	213 ± 119	284 ± 214**	237 ± 123	293 ± 156**
Magnesium (mg/d)	125 ± 55	138 ± 63	166 ± 57	191 ± 76**
Zinc (mg/d)	6 ± 3	7 ± 4*	6 ± 2	7 ± 3*

^aChild feeds self with spoon without spilling much reported for ages 7-8, 9-11, 12-14, 15-18, and 19-24 months. The weighted percentages for each age group shown in the table were 8% and 22%.
^bUnweighted sample sizes were n=678 and 371, respectively.
^cWeighted nutrient intakes including supplements based on one 24-hour recall.
^dSD=standard deviation.
*P≤.05; **P≤.01.

Table 4. Nutrient intakes that differ significantly among infants and toddlers who drink from a sippy cup without help compared with those who did not^a

	Ages 7-8 mo	
	No n=280 ^b	Yes n=193
Macronutrients^c	← <i>mean ± SD^d</i> →	
Energy (kcal/d)	787 ± 195	876 ± 254**
Protein (g/d)	17 ± 6	20 ± 10**
Carbohydrate (g/d)	111 ± 33	123 ± 39**
Fat (g/d)	31 ± 8	35 ± 10**
Micronutrients		
Thiamin (mg/d)	0.76 ± 0.3	0.87 ± 0.5*
Niacin (mg/d)	9 ± 4	10 ± 5*
Riboflavin (mg/d)	1.1 ± 0.4	1.2 ± 0.7*
Vitamin B-12 (μg/d)	1.5 ± 0.9	1.9 ± 1.7*
Folate (μg/d)	156 ± 67	218 ± 445*
Vitamin C (mg/d)	99 ± 43	112 ± 51**
Vitamin E (mg/d)	9.9 ± 3.3	11.7 ± 11.2*
Calcium (mg/d)	562 ± 214	612 ± 264*

^aChild drinks from sippy cup reported for ages 4-24 months. Weighted percentage for age shown in table was 42%.
^bUnweighted sample size was n=483.
^cWeighted nutrient intakes including supplements based on one 24-hour recall.
^dSD=standard deviation.
*P≤.05; **P≤.01.

Gross Motor Developmental Milestones

Essentially all infants in the FITS were reported to lift and support their heads by 4 to 6 months, and these results are within the expected age range (7). The ability to roll over and to reverse the roll among 4- to 6-month-old infants is earlier than the means that are usually reported, but the percent achieving this milestone by 7 to 8 months of age fell within the normal age ranges (7).

Children may sit with support at 5 months (17). In a major revision and restandardization of the Denver Developmental Screening Test, Frankenburg and colleagues reported that one-half of the infants (2,096) sat alone at 5.5 months and 90% at 7.6 months (9). Similarly, for 98 white infants, Carruth and Skinner reported a mean age of 5.5 ± 2.1 months for sitting alone (8). The FITS data show similar findings for ages at which the infants sat alone without support. Infants crawl typically between 7 to 10 months of age (7,13,18). The FITS results show that 80% of the children achieved this developmental milestone by 9 to 11 months.

The average age for children to walk while holding onto something is 8 to 12 months (7). By ages 9 to 11 months, caregivers reported that 83% of the study children achieved this developmental milestone, although 35% took two steps without assistance. Pediatric guidelines cite 8 to 12 months as an average age at which children take the first independent steps (7). Most of the FITS children walked without holding onto something at 12 to 14 months. Other researchers have reported also that the children walked independently at 13 months (10). By 12 to 14 months, 75% of the FITS children were reported to walk across the room unassisted, and 94% achieved this milestone by 19 to 24 months.

Self-Feeding Skills and Nutrient Intakes

As reported elsewhere in this supplement, energy and nutrient intakes were adequate or exceeded the recommendations for each age, and the FITS children's growth curves were within normative standards for age and gender (27).

No large recent studies in the literature have used the same methodology as the FITS to assess developmental readiness to self-feed, thus our results cannot be compared with other published data. Our results suggest that infants and toddlers who were reported to show self-

Table 5. Nutrient intakes that differed significantly among infants and toddlers who ate food that requires chewing compared to those who did not^a

	7-8 mo		9-11 mo	
	No n=217	Yes n=234 ^b	No n=92	Yes n=575
Macronutrients^c	<i>mean ± SD^d</i>			
Energy (kcal/d)	785 ± 180	865 ± 252**	850 ± 271	984 ± 325**
Protein (g/d)	17 ± 6	20 ± 10**	20 ± 10	27 ± 13**
Carbohydrate (g/d)	110 ± 31	122 ± 39**	120 ± 39	138 ± 49**
Fat (g/d)	32 ± 7	34 ± 10*	33 ± 13	38 ± 14**
Micronutrients				
Thiamin (mg/d)	0.78 ± 0.4	0.84 ± 0.4	0.81 ± 0.4	0.94 ± 0.4*
Niacin (mg/d)	9 ± 4	10 ± 5	9 ± 4	11 ± 5**
Vitamin B-6 (mg/d)	0.66 ± 0.3	0.74 ± 0.4*	0.72 ± 0.3	0.89 ± 0.4**
Vitamin B-12 (μg/d)	1.5 ± 0.9	1.8 ± 1.6*	1.7 ± 1.3	2.1 ± 1.2*
Folate (μg/d)	144 ± 57	217 ± 408*	170 ± 73	228 ± 137**
Magnesium (mg/d)	101 ± 38	106 ± 43	112 ± 50	129 ± 57*
Zinc (mg/d)	5 ± 2	5 ± 2*	5 ± 2	6 ± 3**

^aChild eats food that requires chewing reported for ages 7-24 months. Weighted percentages for each age group in the table were 53% and 87%.

^bUnweighted sample sizes were n=483 and 678, respectively.

^cWeighted nutrient intakes including supplements based on one 24-hour recall.

^dSD=standard deviation.

P* ≤ .05; *P* ≤ .01.

feeding skills earlier (ie, 7 to 14 months) had higher energy and nutrient intakes than their peers. However these differences seemed to be transitory. As expected, the majority of the FITS toddlers (those showing both earlier and later self-feeding skills) had comparable abilities by 15 to 18 months of age. However, the finding of about only 57% of the toddlers drinking from a regular cup in the second year (ages 19 to 24 months) is inconsistent with the reported age ranges (ie, 15 to 24 months) at which most children are able to show well-defined management of a regular cup (3). We suspect that our findings may reflect the continued use of a sippy cup (99% at 19 to 24 months).

In a group of children 2 to 24 months of age, Carruth and Skinner (8) found that the mean ages for self-feeding behaviors occurred within expected age ranges, however, mothers reported a broad range of ages at which individual children showed selected self-feeding skills. Our observations in the FITS confirm these findings. Thelen and colleagues (15) posited that developmental progress is a consequence of the system (ie, infant) and active exploration related to solving the problem, eg, how to self-feed with a spoon. In the FITS, one explanation for the energy and nutrient differences by self-feeding skill and by age involves whether or not the caregiver provided an opportunity for their infant to self-feed as an exploratory activity.

The statistically significant differences in nutrient intakes by reported self-feeding skills likely reflect interindividual and intraindividual developmental differences among infants and toddlers of the same age. For example, a lingering remnant of the strong tongue thrust needed to nurse inhibits the infant's ability to remove food from a spoon at 4 to 6 months of age. The absence of this tongue thrust enables the infant to consume more food, which in turn increases energy intake. Similarly, individual differences in children's age for the eruption of teeth influence the ability to chew certain foods, such as meats.

It should also be mentioned that energy intakes of the FITS group as a whole were quite high. Devaney and colleagues (27) have discussed the reported higher energy intakes compared with the Estimated Energy Requirement (EER) and the possibility that caregivers have overreported food intake. However, overreporting in general would not explain the higher nutrient intakes found for infants and toddlers with more advanced self-feeding skills than other children in their age group. We cannot, however, rule out the possibility that overreporting may have differed by the self-feeding skill category of the child (eg, more food spillage might have been unaccounted for by caregivers of the children who were self-feeding) and thus biased the results.

In conclusion, the FITS findings suggest that the attainment of gross motor developmental milestones and self-feeding skills at an earlier age was associated with higher intakes of some nutrients among children ages 7 to 14 months. However, nutrient intakes in the FITS were adequate for all age groups, regardless of the presence or absence of the feeding skills.

Limitations of Study

The findings are based on telephone interviews, and therefore no observations or verifications of the child's food intake or indicators of gross motor development or fine motor/feeding skills were conducted. Because of the cross-sectional survey design, groups were not the same children at each age. Also the reported ages at which gross motor and fine motor skills were shown may be biased if the primary caregivers were unable to accurately report their child's development. Some seeming nutrient differences may have occurred by chance because of the number of *t* tests performed and significance level used (*P* ≤ .05).

APPLICATIONS

- The ages at which children achieve gross motor milestones vary greatly among individuals, and a wide range in their emergence is compatible with normal development.
- Assuming the foods that are presented to the infant or toddler are varied and nutritious, the primary caregiver may allow the child to self-feed without concern about adequate nutrient intake.
- By the second year, healthy toddlers and infants who showed developmental readiness for self-feeding earlier have similar nutrient intakes to those showing these skills at a later age.
- The introduction of complementary foods should be consistent with eruption of teeth and the child's ability to chew.

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