Original Research

Feeding Behaviors and Other Motor Development in Healthy Children (2–24 Months)

Betty Ruth Carruth, PhD, RD, Jean D. Skinner, PhD, RD

Nutrition Department, College of Human Ecology, University of Tennessee, Knoxville, Tennessee

Key words: infant feeding behaviors, motor development, self-feeding

Objectives: To monitor infant's gross, fine and oral motor development patterns related to feeding.

Design: An incomplete block design was used with 57 to 60 (sample = 98) mothers interviewed when their children were 2, 3, 4, 6, 8, 10, 12, 16 and 24 months (within ± 5 days of birth date). Each mother had 5 to 6 interviews.

Setting: Selected developmental feeding behaviors were monitored using in-home interviews conducted by trained interviewers (n = 2). At each interview, mothers reported the child's age when behaviors first occurred, and anthropometric measurements were performed.

Subjects: Subjects were healthy white children who lived mostly in homes with educated two-parent families of upper socioeconomic status.

Results: Mean behavioral ages were within normal ranges reported in the literature, whereas individuals exhibited a wide diversity in reported ages. Examples of gross motor skills (age in months, ± SD) included sitting without help (5.50 ± 2.08) and crawling (8.00 ± 1.55). Mean ages for self-feeding fine motor skills showed children reaching for a spoon when hungry (5.47 ± 1.44), using fingers to rake food toward self (8.87 ± 2.58) and using fingers to self-feed soft foods (13.52 ± 2.83). Oral behaviors included children opening their mouth when food approached (4.46 ± 1.37), eating food with tiny lumps (8.70 ± 2.03) and chewing and swallowing firmer foods without choking (12.17 ± 2.28).

Conclusions: Mean ages for feeding behaviors occurred within expected age ranges associated with normal development. However, mothers reported that individual children exhibited a wide age range for achieving these behaviors. Our results should be considered in counseling mothers about infant feeding practices.

INTRODUCTION

In the first two years of life, evolving patterns for gross motor, fine motor and oral motor development function as predecessors to subsequent development of self-feeding skills that in turn affect nutritional intake and growth of infants [1–8]. Thelen *et al.* [9] posit that the range of infants' ages when a developmental milestone is achieved represents the "consequences of the natural dynamics of the system and the active exploration between those dynamics and the task," such as reaching for a spoon. It is also recognized that developmental patterns of infants are influenced by culture [10, 11], health status [9, 12] and physical wellness in the first two years of life [13, 14].

The study objective was to track gross motor, fine motor and oral motor developmental patterns of 98 white, healthy children aged 2 to 24 months. The use of drinking and eating utensils was assessed for the same time period. This report represents the initial phase (2 to 24 months) of an ongoing comprehensive longitudinal study of healthy children (2 to 96 months). Data collected include growth indices, food intake, family environment, social development and socioeconomic factors that may influence food practices of children. By monitoring gross, fine and oral motor development, a data base was established that indicated the study children over time exhibited a range of behavioral patterns associated with normal feeding practices.

METHODS

Sample

White mother/child pairs (n = 98) were purposely recruited to represent families of middle and upper socioeconomic status

Address reprint requests to: Betty Ruth Carruth, PhD, RD, Nutrition Department, University of Tennessee, Knoxville, TN 37996-1900. E-mail: bcarruth@utk.edu

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who had access to needed health care services and food availability [16] and whose children were healthy, (i.e., full term gestation, Apgar scores ≥ 7, birth weights of ≥ 5.5 pounds and absence of neonatal and birth anomalies). The strategy of recruiting a sample from middle/upper socioeconomic status and healthy infants addressed factors known to influence development and food intake such as healthy status *versus* infants with birth and/or neonatal anomalies, differences in growth patterns associated with ethnicity, the negative influence of lower socioeconomic status on food availability and access to health care and the effect of limited parental education.

Study participants were recruited via birth announcements, posters displayed in health care facilities, personal referrals and through churches. A telephone contact was made initially to explain the study. For those expressing interest, occupational and educational information about the primary wage earner or both parents was obtained. Based on information given at that time, socioeconomic status was calculated by the Hollingshead Four Factor Index [17], and mothers were immediately informed about study eligibility. Enrollees in the study received letters providing further information about the study, giving informed consent, their responsibilities and benefits of participating in the study. The research protocol was approved by the institutional review board for use of human subjects. Mothers received $20 to $30 per interview depending on interview length.

Interview Sampling Design

To reduce the number of interviews per participant but also to have the statistical power to extrapolate findings to the group of 98 participants, an incomplete block design was developed for the study. This design allowed a sampling base of 57 to 60 subjects out of the 98 participants for each interview when the children were 2, 3, 4, 6, 8, 10, 12, 16, 20 and 24 months of age. The investigators were especially interested in motor development occurring in the first few months of life; thus, more interviews were conducted in the 2-to-12-month time period. In addition to the lower cost of collecting data, the study design provided sample sizes adequate for multivariate analyses. All mothers had five to six interviews in the 2 to 24 month period, with each mother's interview sequence computer randomized using the incomplete block design. Interviews for each mother were scheduled $\pm$ 5 days of their child's birth date.

Anthropometric and Dietary Data Collection

Two trained interviewers conducted in-home interviews for the same families throughout the 2-to-24-month period, using research protocols previously described [16]. At the initial interview, mothers reported demographic information, infant birth weight and associated neonatal health. Birth data reported by mothers were subsequently verified with medical records at health care facilities where the children were born. The two trained interviewers, using a standard protocol, measured children at each interview. Anthropometric measurements included using a fixed head and perpendicular sliding foot board for length (nearest 0.125 in), a plastic non-stretchable tape for head circumference (nearest mm) and calibrated scales (Detecto Doctor's Infant Scale, Detecto Scale Company, Webb City, MO) for weight (nearest 0.25 oz). Measurements were made in triplicate and averaged for a single value. Inter-observer bias was reduced by having the same interviewer measure the same children during the 2 to 24 months. Periodically, the research staff assessed measurement stability over time (by interviewer/child pair) and checked calibrations of the equipment sets used by each of the trained interviewers.

Mothers reported the infant's food intake, including breast milk and the child's other food intake for the previous 24 hours. Interviewers used food models, baby food containers and similar utensils to increase the accuracy of mothers' recalls. The dietary results have been published and will not be included in this report [16].

Assessing Motor Developmental Markers

Developmental behaviors used in this study were generated using literature sources that provided descriptors of the behavior and the predictive age range within which the behavior was likely to occur in healthy children [1, 7, 8, 17–22]. For the first 6 to 8 months, motor development behaviors were divided into developmental markers related to head and trunk stability, finger and hand movements, and tongue and mouth movements that a child could possibly exhibit. As the children matured (6 to 24 months), the list of motor development skills reflected increased complexity associated with maturation, and they also included several behaviors that a few children might achieve at an early age. For example, in the first six-month interviews, mothers were asked the age (months) when their baby sucked several fingers (average 2 months) compared to picking up and holding a spoon (average 6 to 8 months). Descriptors for these behaviors are listed in Tables 1–3. At each interview, pictures of infants performing these behaviors were available for about two-thirds of the descriptive statements used in this study, particularly for easily observable gross and fine motor development markers (e.g., sitting with help, grasping toy with fingers). For the more discrete tongue/mouth movements, pictures were not available; however, interviewers were trained to explain to mothers what specific oral movements were involved. The same interviewer for the same mother/child pair used probing and explanations to improve data collection.

Based on literature sources, it was anticipated that group mean ages for the gross, fine and oral developmental behaviors would occur within the normal age range, but that individual children could show greater diversity in the age at which behaviors first occurred. In monitoring an individual child's progress, each mother was asked at each interview if the child could perform certain age appropriate behaviors and, if so, at

what age the child began. As stated earlier, behaviors were staged to include expected age-normative behaviors and some outlying behaviors that few children could be expected to do. As the monitoring progressed, interviewers continued to ask about earlier behaviors as newer age-appropriate ones were added to the interview schedules. Thus, all mothers were asked about all behaviors until a positive response by child's age was given. Then, those questions were deleted from that mother's subsequent interviews. This provided a standardized protocol and allowed for developmental diversity among children.

To help mothers record data and track developmental behaviors during the 2 to 12 months, special prototype calendars were provided to the participants. Beginning at the eighth-month interviews, mothers also reported their child's ability to drink from a cup (with and without a lid), sip from a straw (large and small) and whether the child or the mother held the drinking utensil. Similar data about spoons (type and use) were reported by mothers.

Health Assessments

At each interview mothers were asked about their children's visits to a physician, frequency and types of illnesses, hospitalizations and medications given to the child since the mother was last interviewed. This information was used to monitor these occurrences in relation to reported food intake and developmental patterns over the 2-to-24-month period.

Analyses

Using SAS [23], descriptive statistics were generated for anthropometry, the reported children's ages at which motor developmental behaviors first occurred and infant birth weight. To determine if developmental patterns were related to birth weight and gender, male and female infants were grouped by their birth weight to form low, middle and high weight groups. General Linear Mixed Models (GLMM) were used for these analyses.

Table 1. Gross Motor Development of Children ($\bar{x} \pm$ SD, Range in Months)[a]

Behavior	Mean Age ($\pm$ SD) Months	Age Range Months
On tummy holds up head	1.45 ± 0.83	0.09–4.5
Keeps head controlled when tipped	2.27 ± 0.80	0.63–6.0
On tummy, supports weight on forearms	2.47 ± 1.19	0.38–5.5
On tummy, pushes up on arms with straight elbows	4.01 ± 1.71	1.0–9.0
Sitting in caregiver's lap without help	5.54 ± 2.08	0.25–9.0
Crawls on hands and knees	8.00 ± 1.55	5.5–14.5
Upper body turns from sitting to crawling position	8.18 ± 1.66	5.5–15.0
Walks without help	11.93 ± 1.35	9.0–17.0
Climbs furniture	13.21 ± 2.70	8.5–20.0
Runs without falling	15.19 ± 2.37	11.0–22.0

[a] Sample n = 98.

Table 2. Fine Motor Development of Children Related to Feeding Behaviors ($\bar{x} \pm$ SD, Range in Months)[a]

Behavior	Mean Age ($\pm$ SD) Months	Age Range Months
Brings toy to mouth	3.29 ± 0.99	0.13–6.5
Reaches for spoon when hungry	5.47 ± 1.44	2.5–9.5
Transfer toys or food from one hand to the other	6.68 ± 1.63	4.0–14.0
Feeds self cookie or cracker	7.70 ± 1.63	4.0–14.0
Eats finger foods without gagging	8.44 ± 1.53	6.0–12.0
Uses fingers to rake food toward self	8.67 ± 2.58	5.0–20.0
Puts finger in mouth to move food and keep it in	9.30 ± 2.80	4.0–18.0
Pokes food with index finger	10.24 ± 2.62	4.0–18.0
Uses fingers to self-feed soft, chopped food	13.52 ± 2.83	9.5–20.0
Brings side of spoon to mouth	14.37 ± 2.71	9.0–20.0
Picks up, dips foods, and brings to mouth	16.42 ± 2.75	10.0–23.0
Scoops puddings and brings to mouth	17.05 ± 2.75	11.0–24.0

[a] Sample n = 98.

Table 3. Children's Oral Motor Development Related to Feeding Behaviors ($\bar{x} \pm$ SD, Range in Months)[a]

Behavior	Mean Age ($\pm$ SD) Months	Age Range Months
Opens mouth when spoon approaches/touches lips	4.46 ± 1.37	0.50–9.0
Tongue moves gently back and forth as food enters mouth	4.85 ± 1.58	2.0–10.0
Tongue used to move food to back of mouth to swallow	4.95 ± 1.27	2.0–7.5
Keeps food in mouth and is not re-fed	5.72 ± 1.58	0.50–10.5
Uses tongue and mouth to explore shapes and textures of toys	6.29 ± 1.44	3.5–9.5
Brings top lip down on spoon to remove food	7.73 ± 2.23	4.0–16.0
Eats food with tiny lumps without gagging	8.70 ± 2.03	4.8–15.5
Chews softer foods, keeps most in mouth	9.42 ± 1.79	6.0–14.0
Chews firmer foods, keeps most in mouth	10.53 ± 2.10	4.0–16.0
Chews and swallows firmer foods without choking	12.17 ± 2.28	7.5–20.0
Chews foods that produce juice	15.28 ± 3.25	9.5–23.0

[a] Sample n = 98.

RESULTS AND DISCUSSION

Gross Motor Development

As shown in Table 1, developmental markers for head and trunk control show a progression from holding up head while on tummy at mean age of 1.45 ± 0.83 months (range of 0.09 months to 4.5 months) to sitting in care giver's lap without help at 5.54 ± 2.08 months (range 0.25 to 9.0 months). Whereas the behavioral age ranges indicated a wide diversity among children, group means for these gross motor behaviors were similar to those published in a study of 25 infants (2 to 24 months) [21]. Using results from The Denver Developmental Screening Test, Frankenburg *et al.* [24] published data based on 2096 children. The sample subgroups were drawn to represent diversity in maternal education and ethnicity, place of residence and child's gender. Fifty percent of infants mastered sitting without help by 5.5 months and 90% by 7.8 months [24]. In our study, children sat without help at 5.5 months and 83% by 7.6 months. Crawling typically occurs between 8 and 10 months [25, 26], and our study group of children achieved this behavior at a mean age of 8.0 ± 1.55 months.

Mean ages for gross motor behaviors of walking without help, climbing furniture and running without falling again are similar to results reported in the literature [1, 22, 24]. As reported by Frankenburg *et al.* [24], 50% of infants in the Denver II tests could stand alone well at 11.5 months and 90% at 13.9 months. In a study of 25 children (2 to 24 months), Shirley found that children climbed stairs at 13 months and stood alone at 14 months [21]. Thus, the study children had mean ages of achievement for selected gross motor development behaviors that are within published ages.

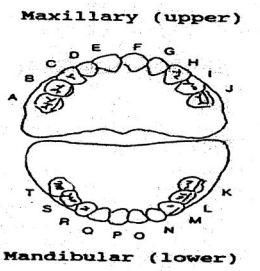
Fine Motor Development

Fine motor skills are more difficult to master than gross motor skills because they require precise coordination between complex muscle groups. In the 2-to-5-month period, the infant's manipulation and exploration of an object changes. At earlier ages, the co-occurrence of infants mouthing and looking at a novel object may be performed. As shown in Table 2, the mean age that study infants brought a toy to the mouth was 3.29 ± 0.99 months. By four months of age, Rochat [2] reported that fingering behaviors increased with infants holding an object in one hand and using the other hand to explore the object with their finger tips. Rochat and Goubet [27] found that the ability to self-sit (compared to assisted sitting) allowed children to use either or both hands in object manipulation. Around six months, most infants can grab at and hold on to an object without visually following their hand to the object. As shown by Robin *et al.* [28], infants could grab illuminated objects in an otherwise dark environment that eliminated visualization of the hand moving toward the object. In our study, children (2 to 24 months) reached for a spoon when hungry at a mean age of 5.47 ± 1.44 months and could transfer toys or food from one hand to the other at 6.68 ± 1.63 months.

As shown in Table 2, a number of behaviors involve children using one or more fingers or the pincer grasp to self-feed and/or to manipulate the food. Mastery of the pincer grasp may occur between 9 and 14 months of age [29], and the mean ages for the study children using pincer grasp movements was between 10 and 14 months of age. Other eye-hand coordination movements, such as scooping up pudding and bringing it to the mouth, represent more difficult motor tasks, coordination of eye and hand movements and stability of the trunk/arm coordination. This difficulty is reflected by mean age of occurrence for the study children, i.e., mean age of 17.05 ± 2.75 months.

Indicators of Oral Motor Development

Children's oral motor development begins with the mouth working as a total unit, but as the child matures, the movement



Age (Months)

Maxillary Tooth[b]	Mean ± S.D.[a]	Minimum	Maximum
B	15.6 ± 2.5	10.5	22.0
C	17.4 ± 2.8	9.0	22.0
D	11.0 ± 2.7	5.8	17.5
E	9.5 ± 2.3	4.0	16.5
F	9.5 ±2.3	4.0	16.0
G	11.0 ± 2.9	5.8	17.5
H	17.7 ± 2.9	9.0	23.0
I	15.8 ± 2.6	10.0	22.0
Mandibular Tooth[b]			
L	15.7 ± 2.5	9.0	22.0
M	17.7 ± 2.6	10.0	22.0
N	12.5 ± 3.1	4.8	20.0
O	7.1 ± 1.9	3.0	13.0
P	7.1 ± 1.8	3.0	13.0
Q	12.5 ± 3.1	6.0	22.0
R	17.7 ± 3.0	9.0	24.0
S	15.9 ± 2.5	10.0	22.0

Fig. 1. Tooth eruption by mean age of children 2–24 months of age. [a]Data missing for 4 of the 98 children. [b]Mean responses for maxillary teeth A and J and mandibular teeth K and T omitted because fewer than 60 children had these teeth by 24 months of age.

of jaws, the tongue and lips function as separate entities. According to Morris [7], ". . . by 6 months infants can move their tongue laterally when food is placed in the side of the mouth . . . by 8 months, the tongue moves from the center of the mouth to the sides." By the second year, the tongue is able to make a smooth midline transfer of a food bolus. As shown in Table 3, there was a progression over time in which the coordination of jaw stability (opens mouth when food approaches), lateral tongue movements (moves food to back of mouth) and lip closure (keeps most food in mouth) increased in efficiency. A literature survey indicated that no recently published studies were available to compare our data with other groups of children, aged 2 to 24 months.

The ability to chew a variety of foods with varying firmness and texture is associated with normal tooth eruptions in the first two years of life [30]. The diagram in Fig. 1 indicates the normal distribution of teeth in the maxillary (upper) and mandibular (lower) jaws, and the mean ages indicate when these teeth erupted during the 2-to-24-month period. The teeth labeled E, F, P, and O are used in biting or breaking off food pieces and were present in the study children by a mean age of 7 to 10 months. The cuspids and molars associated with grinding and lateral mandibular movements erupted in the 12-to-18-month period; this corresponded with data shown in Table 3 that described the chewing behaviors reported by mothers. In general, the mean ages for tooth eruptions of the study children were within expected age ranges.

Eating and Drinking Utensils

The study children primarily used cups/glasses with lids from 8 to 20 months (60%) with increasing use of utensils without lids by 24 months of age (Fig. 2). In order to achieve jaw stability in drinking, children bite the rim of the cup/glass, and these behaviors usually first occur between 15 and 18 months [7]. These stabilizing behaviors are complemented by the protruding spout of a sippy cup that enhances learning to drink from a cup before children reach the necessary postural stability to drink from an open cup/glass (24 to 36 months) [7].

Before 12 months, most mothers held the cup (with or without a lid) as their child drank. By 16 months 98% of mothers let the child hold the drinking utensil (with lid) most of the time, whereas 23 of the 34 mothers who used cups/glasses without lids continued to hold the utensil while the child drank. Our findings indicate that most study mothers did not allow their 24-month-old children the autonomy to drink from cups/glasses without lids; however, some individual children at 24 months were able to drink successfully from cups/glasses without lids. These age differences in using various cups/glasses could be attributed to some mothers' lack of concern about

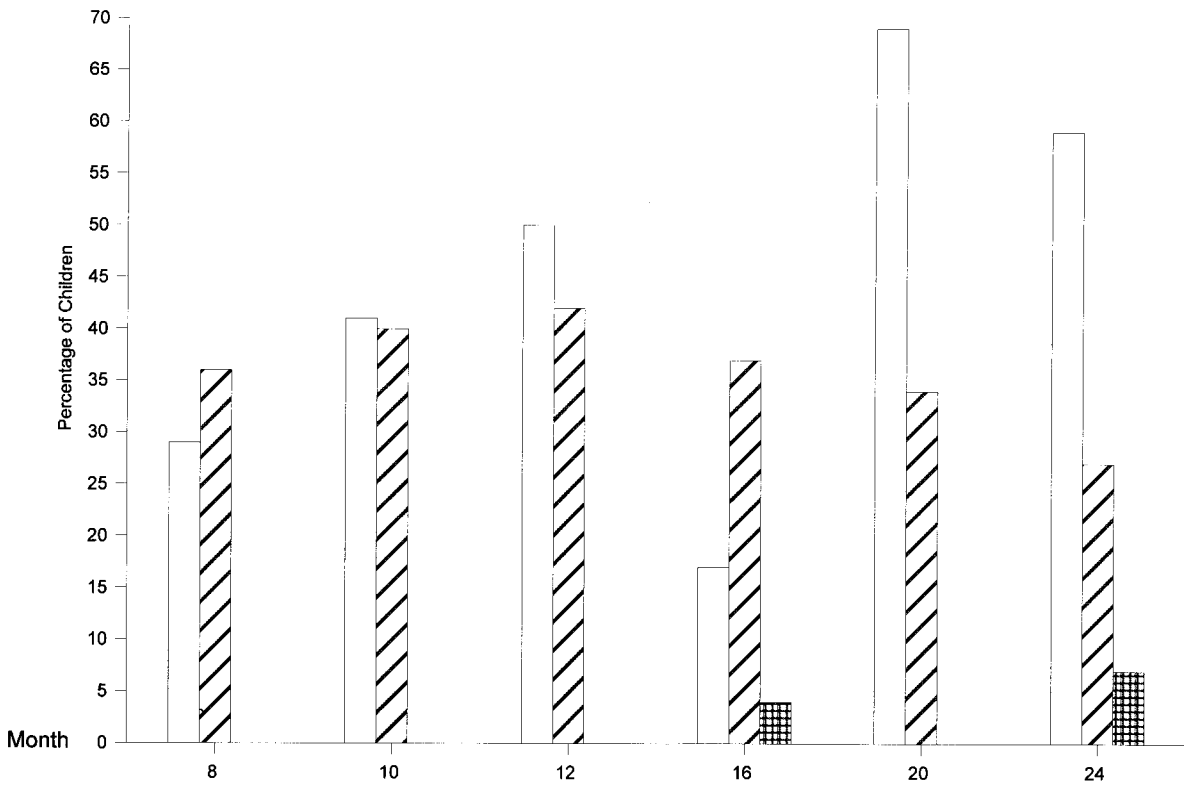


Fig. 2. Children's use of sipper cup. Study sample n = 98; incomplete block design used with computer generated random interviews (n = 59, 58, 60, 59, 57 and 57 at 8, 10, 12, 16, 20 and 24 months, respectively). No fill columns = thin spout, diagonal lines = wide spout, crosshatch = holes in lid.

spillage and messiness associated with using cups/glasses without lids, while other mothers may be concerned about choking and spillage. These age differences could also be an illustration of the Thelen *et al.* [9] theory that developmental progress is the consequence of the dynamics of the system (the infant) and active exploration of how to solve the problem (drinking without choking). This theoretical approach is posited to explain the wide range of ages at which children achieve any given developmental behavior.

Before 12 months about 15% of mothers reported children using straws. By 16 months a majority of the children used large straws (Fig. 3). In the earlier months, mothers held the straw, whereas by 16 months most children were permitted to hold their own straws. Anecdotal comments from mothers indicated that eating away from home was the major occasion during which children used straws.

As shown in Fig. 4, at 12 months 43% of children were self-feeding with spoons, and 43% of mothers had special spoons that their children used. By 24 months, 80% of the study children were self-feeding. The children's transition from using specific types of baby spoons to adult spoons began around 16 months of age with over 54% using adult spoons at 24 months. The type of spoon chosen by mothers may reflect their children's ability to grasp a spoon using thumb and fingers to pick up and hold a spoon (palm down) compared to the ability to hold a spoon like a pencil (first two fingers and thumb with palm turned up or towards face). At a mean age of 14.37 ± 2.71 months (Table 2), the children could bring the side of a spoon to their mouth, but within the same age range they also were using their fingers to self-feed (Table 2). The age of transition from special baby spoon to adult spoon may be associated with the child's receiving food from the parent's plate (using adult spoons) which would provide a differing sensory experience than a child's special spoon. As early as 10 months of age the children were making hand and body movements indicating their desire to eat from the table and especially their parents' plates [31].

As predictor variables for age when gross, fine and oral motor behaviors first occurred, birth weight and gender were non-significant. These results may reflect an almost equal distribution of genders (males n = 51; females n = 47) and similar birth weights (males 7.8 lb ± 1.2 {3,545 g}, females 7.6 ± 1.1 {3,454 g}).

CONCLUSIONS

Our study results represent a data base about feeding behaviors and other motor development of white children in the first two years of life that is currently missing in the literature.

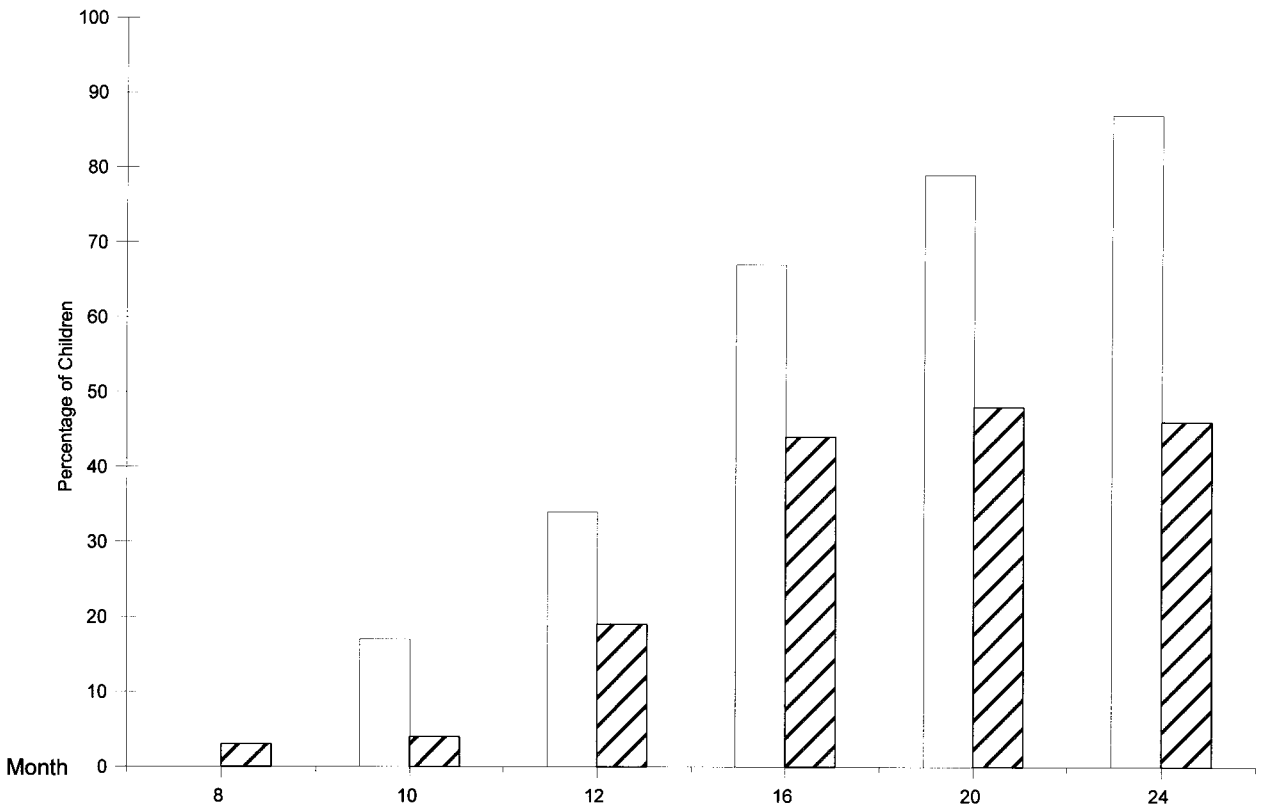


Fig. 3. Children's use of small and large straws. Study sample n = 98; incomplete block design used with computer generated random interviews (n = 59, 58, 60, 59, 57 and 57 at 8, 10, 12, 16, 20 and 24 months, respectively). No fill columns = large straw, diagonal lines = small straw.

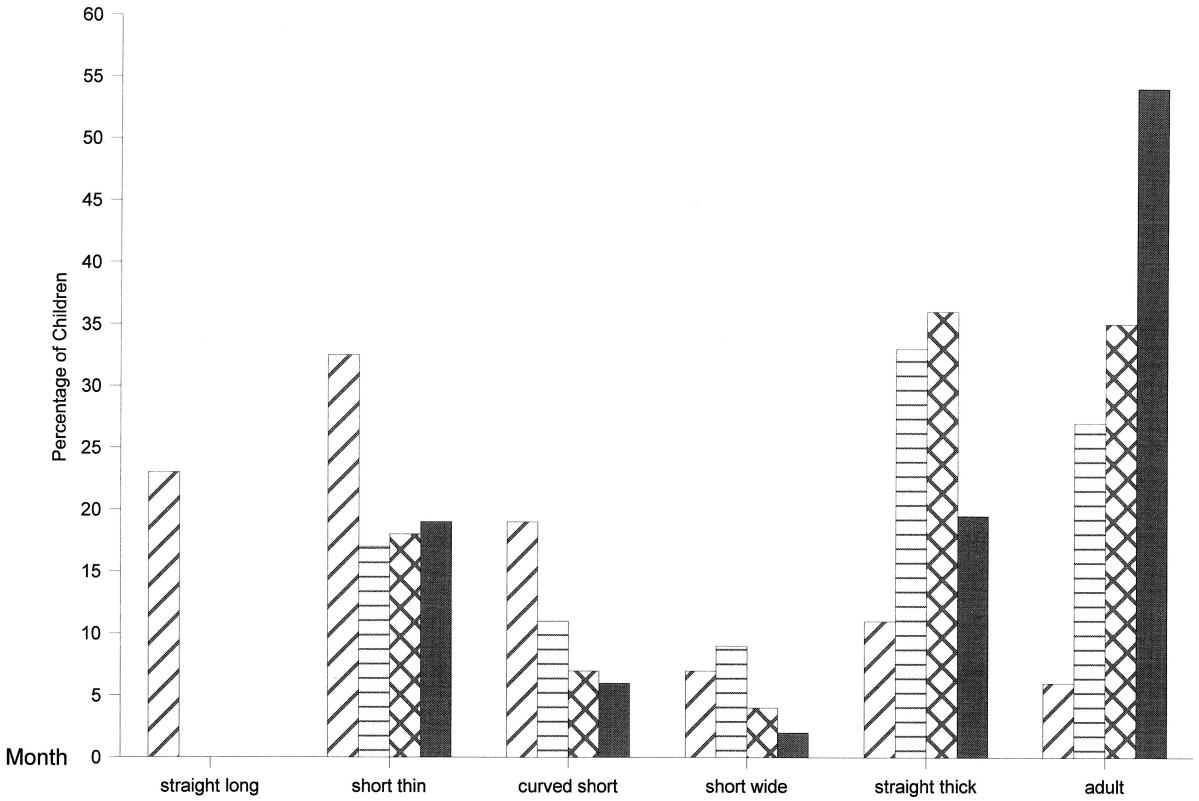


Fig. 4. Children's use of spoons by month of age. Study sample n = 98; incomplete block design used with computer generated random interviews (n = 59, 58, 60, 59, 57 and 57 at 8, 10, 12, 16, 20 and 24 months, respectively). Diagonal lines = 12 months, horizontal lines = 16 months, crosshatch = 20 months, filled columns = 24 months.

The uniqueness of this study involves concurrent monitoring of gross, fine and oral motor development in healthy white children, as well as collecting health status and dietary intake data [16] associated with normal development (2 to 24 months). By using study criteria that addressed parental education, socioeconomic status and the infant's health status, it was more likely that normal development would be reported by mothers.

Our findings also demonstrate the wide age range within which healthy children as a group and as individuals achieved the 33 behaviors identified in the study. Results also describe developmental interrelationships that support the process from the infant's being fed to self-feeding. For example, at 5 to 7 months, children could sit in the care-taker's lap without assistance, reach for a spoon when hungry and use the tongue to move soft food and liquid to the back of the mouth for swallowing. These movements require a degree of head and trunk stability which frees the arms and hands for maneuvering food toward the mouth, enhances swallowing and/or reduces the potential for choking that occurs if the infants were in a supine position. Similarly, the lower and upper front teeth (Fig. 1, teeth O, P, E, F) and related self-feeding behaviors first occurred within the 7-to-9-month period. Concurrently, the children were eating finger foods without gagging and biting off pieces of food (Table 2). These behaviors require hand/eye coordination and more precise control of arm and hand movements that also involve head and trunk stability. A developmental delay in gross, fine or oral motor development negatively impacts on learning to self-feed.

Results of this study suggest a sequential process for 33 behaviors that characterize the group, but not every child reportedly experienced a sequence. Some individual children never exhibited selected behaviors and/or they skipped certain behaviors, such as supporting weight on the forearms. These differences between individuals achieving or not achieving selected behaviors may be explained by the Thelen theory [32]. It is posited that developmental progress of infants is the consequence of the system (infant) and active exploration of how to solve the problem (raking and spearing food). Alternate explanations would be that some mothers limited their child's autonomy to explore because of accompanying messiness and spillage and/or some children were maturing at a slower rate and were unable to perform discrete behaviors comparable to their peers. Although calendars and other types of data collection records were used, mothers may not have known the exact age at which a behavior first occurred. This explanation of the diversity among children is offset by the fact that the same trained interviewer saw and measured the same child each time, and many of the behaviors could be observed.

The question arises about generalizing our findings to infants of different socioeconomic status and ethnicity. However, in comparing gross and fine motor development in our study with published data from a large representative sample (included different socioeconomic and ethnic groups) and from a smaller longitudinal study [21, 24], our study findings were similar for the mean ages at which selected behaviors first occurred (e.g., sitting without help, holding a toy or spoon). The strength of this longitudinal data (2 to 24 months) relies on multiple interviews, monitoring the infant's health status throughout the study period and having trained interviewers to observe the same mother/infant pair for the 2-to-24-month period.

In conclusion, children in our study exhibited age-appropriate developmental behaviors related to feeding practices and self-feeding with individual children exhibiting a wide age range at which behaviors first occurred. Our results could be used in counseling parents who may not be aware of or appreciate these individual behavioral differences that occur among healthy children. In addition, parents may need encouragement about allowing their children to autonomously explore activities related to the feeding process and to developing age-appropriate feeding solutions.

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