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Original Article

Inadequate feeding practices and impaired growth among children from subsistence farming households in Sidama, Southern Ethiopia

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Abstract

Whether current child feeding practices and behaviours among rural households in Sidama, Southern Ethiopia conform to the World Health Organization (WHO) guiding principles for complementary feeding is uncertain. We assessed socio-demographic status, anthropometry, breastfeeding, complementary feeding practices and behaviours, and motor development milestones in a convenience sample of 97 breastfed children aged 6–23 months from three rural Sidama communities. Energy and nutrient intakes from complementary foods were also calculated from 1-day in-home weighed records. Prevalence of stunting ranged from 25% for infants aged 6–8 months to 52% for children aged 12–23 months, whereas for wasting, the corresponding prevalence was 10% and 14%, respectively. Very few children were exclusively breastfed up to 6 months of age ($n = 2$), or received solids/semi-solids for the recommended minimum number of times containing the recommended number of food groups. Responsive feeding was not practised and no cellular animal products were consumed. Median intakes of energy, and intakes and densities of micronutrients from complementary foods (but not protein) were below WHO recommendations, assuming average breast milk intakes; greatest shortfalls were for retinol, vitamin C and calcium densities. Mothers of stunted children were shorter and lighter, and from households of lower socio-economic status than non-stunted children ($P < 0.05$). Acquisition of some motor development milestones was delayed in stunted infants compared with their non-stunted counter-parts. In conclusion, interventions that address the WHO guiding principles for complementary feeding practices and behaviours, as well as prenatal influences on growth, are urgently required in this setting.

Keywords: Ethiopia, stunting, complementary feeding, nutrient intakes, diet quality, motor milestones.

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Introduction

In recent years, the promotion of breastfeeding has received much attention in many low-income countries. However, there has been no comparable effort to promote complementary feeding and this critical aspect of child feeding has often been neglected, in part because of the absence of reliable data on current complementary feeding practices. As a result, the World Health Organization (WHO) [Pan American Health Organization (PAHO)/WHO 2003] developed guiding principles for complementary feeding practices and behaviours because of their overwhelming impact on subsequent growth, health and cognitive development during early childhood.

Ethiopia is one of the poorest countries in Sub-Saharan Africa, and child malnutrition is a serious public health problem, especially in the Southern Nations, Nationalities and Peoples (SNNP) region of Southern Ethiopia, where the rates for stunting (52%) and underweight (35%) among children <5 years are among the highest in the world [Central Statistical Agency (CSA) 2006]. In the Sidama zone of Southern Ethiopia, as in many other rural areas of Sub-Saharan Africa (Hautvast *et al*. 1999; Hotz & Gibson 2001), unrefined maize is the major staple used for young-child feeding. Such maize-based complementary diets are often inadequate in energy and growth-limiting micronutrients, notably calcium, iron and zinc, in part because of their high content of phytic acid (myoinositol hexaphosphate), a potent inhibitor of mineral absorption (WHO 1998). Several other exacerbating factors, besides the poor nutritional quality of their complementary diets, may predispose young children in Sidama to micronutrient deficiencies and poor growth. These include suboptimal maternal micronutrient status (Abebe *et al*. 2008; Gibson *et al*. 2008), as well as inappropriate caring practices, behaviours and poor food safety and hygiene – all concerns addressed in the WHO guiding principles for complementary feeding of the breastfed child (PAHO/WHO 2003). At present, however, there are limited data on whether current child feeding practices and behaviours among mothers from subsistence farming households in the Sidama Zone adhere to these WHO guiding principles. In addition, there are no quantitative data on the nutritional adequacy of complementary diets in this region. Such data are essential for designing appropriate interventions to enhance the quality of complementary feeding during the vulnerable period of transition from breastfeeding to the family diet. In this study, we have: (1) characterized breastfeeding and complementary feeding practices and behaviours; and (2) assessed the energy and micronutrient intakes and dietary quality of the complementary diets of young children in the Sidama Zone of the SNNP region of Southern Ethiopia. Finally, because of the widespread prevalence of stunting in this setting, we have compared the anthropometric status, dietary intakes and motor development of the stunted and non-stunted Sidama children, as well as the socio-economic and anthropometric status of their mothers. This study was part of a more extensive pilot investigation of the nutritional status of pregnant women from subsistence farming households in these same rural communities (Abebe *et al*. 2008; Gibson *et al*. 2008).

Subjects and methods

Study site and subjects

This cross-sectional study was conducted in June 2006 in three adjacent small rural communities (Alamura, Kurda and Finchawoa) located near the town of Awassa in the Sidama Zone of the SNNP region of Ethiopia. The communities are served by the Bushulo Health Centre that provides free vaccinations, vitamin A supplements and other primary health care to the children.

The Sidama Zone is centred on the Rift Valley in Southern Ethiopia and covers an area of approximately 6800 km^2 with a population of about three million. The inhabitants are predominantly subsistence farmers producing fermented enset (*Enset ventricosum)* and maize (*Zea mays L.*) as food staples, coffee as a cash crop, and chat (*Catha edulis)* and sugar cane for supplementary cash; vegetables such as potatoes, cabbage, haricot beans, pumpkin and kale are grown by some households. Traditional rearing of animals, mainly cattle and goats, is practised to generate income, although the number of livestock per household is declining as grazing land becomes scarce with the increasing population. Livestock are rarely slaughtered to provide meat for the household (Brandt *et al*. 1997).

The participants were a convenience sample of 100 apparently healthy infants and young children aged 6–23 months, randomly selected from a list of children within this age range prepared by the local health worker for each of the three communities. All parents who were invited to participate agreed, unless their child was ill ($n = 1$). Our data and sample size allowed us to characterize the mean energy intake of each age group with a 95% confidence interval of approximately ±30 kcal. Birth dates of the children were assessed from immunization cards or, when necessary, from a local calendar of events. Exclusion criteria were children of multiple pregnancies and children with evidence of chronic disease (e.g. active tuberculosis, symptomatic HIV). Ethical approval of the study protocol was obtained from the Human Ethics Committees of Hawassa University, Awassa, Ethiopia, and the University of Otago, New Zealand, and the Colorado Multiple Institutional Review Board, Denver, CO, USA. Verbal informed consent was obtained from all the mothers or guardians of each child after the purpose and methods of the study had been fully explained to them and witnessed by a local health worker or community leader. All questionnaires were translated into Amharic for the study.

Table 1. Household, maternal and infant characteristics

Household characteristics ($n = 97$)	
Male head of household (HOH) (%)	97
HOH has some formal education	47
Land size >5000 m^2 (%)	54
Corrugated iron roof (not thatch) (%)	18
Household sanitary facilities (%)	55
Four or more children in family (%)	56
Own cows (%)	62
Mother owns umbrella (%)	22
Maternal characteristics ($n = 96$)*	
Height (cm)	156.2 ± 5.7
Proportion of mothers with height <145 cm	3/96 (3%)
Weight (kg)	48.4 ± 5.3
Body mass index (BMI) (kg/m^2)	19.9 ± 1.8
Proportion of mothers with BMI < 18.5 kg/m^2	23/96 (24%)
Infant/child characteristics ($n = 97$)	
Mean age (months)	13.3 ± 5.1
Proportion of male children	52/97 (54%)
Mean height-for-age Z-score	–1.91 ± 1.55
Proportion fully or partially immunized	65/97 (67%)

*One mother was absent when maternal anthropometric measurements were taken.

Methods

Socio-demographic status, breastfeeding and complementary feeding practices, and behaviours

Trained Ethiopian research assistants fluent in both local languages – Sidamigno and Amharic – and with a good understanding of English, administered two pre-tested questionnaires to the mother and/or caregiver of the child in their own homes during the day of the weighed record (Table 1). These research assistants were graduate students from the Department of Family Sciences and Rural Development, College of Agriculture, Hawassa University, who had participated in our earlier research studies in these three rural communities (Abebe *et al*. 2008; Gibson *et al*. 2008). They received training for 1 day in a classroom setting prior to the commencement of this study.

The first questionnaire focussed on socio-demographic and immunization status of the children, and breastfeeding practices, whereas the second was designed to assess whether mothers and/or caregivers were adhering to the WHO guiding principles for complementary feeding of the breastfed child (PAHO/WHO 2003). Questions for the latter were drawn from Arimond & Ruel (2003) and translated into Amharic prior to use. The research assistants also recorded information on sanitation facilities, personal hygiene practices and food safety issues from observations in the households during the recording of the 1-day weighed food records.

Additional information on child feeding and caring practices and behaviours was elicited through focus group discussions conducted by YA with groups of mothers. The number of mothers participating in each of the three communities was 9, 19 and 20 in Alamura, Finchawoha and Kurda, respectively. Topics discussed included: time of initiation of breastfeeding and use of pre-lacteal feeds; duration of exclusive breastfeeding and age of introduction of complementary foods; the amount and type of complementary foods fed to children when they were healthy and when they were sick; safe preparation and storage of complementary foods; reasons why mothers did not give their children goat's milk or avocado.

Infant motor developmental milestones

Nine motor skills (raising their head when on their front, turning and rolling over, sitting supported by arm, sitting without support, hands-and-knees crawling, standing with support, standing unsupported, walking supported and walking unsupported) were chosen and data recorded from observations in the households during the collection of the 1-day food records. The research assistants were trained by an Ethiopian psychologist in a classroom for one day using standard descriptions, criteria and testing procedures, to judge whether the index child had achieved a milestone (as measured by pass/fail) (Frankenburg & Dodds 1969). Because of the small number of children in each age group, these data were only used to compare the acquisition of certain motor development milestones of the stunted and non-stunted children.

Anthropometry

Measurements of head circumference, weight, recumbent length, mid-upper arm circumference (MUAC), and triceps skinfold thickness were taken in duplicate on each child using calibrated equipment and standardized techniques (WHO 2004), with children wearing a light cotton shirt of known weight supplied by the investigators. A third measurement was taken if the difference between the first two measurements was outside the allowable difference for that measure (Frisancho 1990). Both supine length and maternal height were measured to the nearest millimetre using a portable adult/infant length/stature measuring board (Perspective Enterprises, Portage, MI, USA), weight via an electronic scale (Seca 770, Seca Corporation, Hanover, MD, USA), triceps skinfold via a skinfold caliper (Lange, Beta Technology Inc., Cambridge, MD, USA) and arm and head circumferences with a fibreglass insertion tape (Ross Laboratories, Columbus, OH, USA). One anthropometrist (RSG) performed all the measurements to eliminate inter-examiner error. Height and weight of the mothers were also measured using standardized techniques with the subjects wearing light clothing and no shoes. Maternal body mass index (BMI; wt (kg)/ht (m)^2) was also calculated. For the children, *Z*-scores for length-for-age (LAZ), weight-for-age (WAZ), weight-for-length (WLZ), BMI-for-age, head circumference-for-age, MUAC-for-age and triceps skinfold thickness-for-age were calculated from the WHO 2006 multicentre growth reference data using the computer program WHO ANTHRO 2007 (Blössner *et al*. 2007). None of the children had unacceptably extreme anthropometric values (WHO 1995). Stunting, underweight, and wasting were defined by *Z*-scores for LAZ, WAZ and WLZ < -2 standard deviations (SD), respectively, below the median values of the reference data.

Dietary assessment

The research assistants responsible for the dietary assessment were experienced, having previously collected 1-day weighed food records on pregnant women from the same three rural Sidama communities in our earlier research study (Abebe *et al*. 2008). They received additional training for 3 days in a classroom setting for this study, and were supervised by RSG during the collection of the dietary data in the homes. The research assistants weighed all foods and beverages consumed by the children over 1 day in the home using digital scales (2 kg maximum weight: Model CS 2000, Ohaus Corporation, Pine Brook, NJ, USA) accurate to $\pm$ 1 g. The assessment period lasted from the time the children awoke until they were put to bed for the night. Weekend days and weekdays were proportionately represented in the final survey to account for any day-of-the-week effects on food and/or nutrient intake. Detailed weighed recipe data were also collected for all the composite dishes consumed by the children during the entire day of the survey, and used to calculate the weight of the actual ingredients consumed, as described by Gibson & Ferguson (1999). Average recipe data were compiled for use when actual recipe data were not available.

Collection and analysis of complementary foods

During the collection of the weighed food records, samples of complementary foods prepared 'as eaten' were purchased from the households. These were oven-dried (95–105°C) in a laboratory in Hawassa University, weighed and then transported as a fine powder in sealed polyethylene bags to the trace element laboratory at the University of Otago, Dunedin, New Zealand, where they were stored at 4–8°C until analysed. Each complementary food was analysed for calcium, zinc and iron by flame atomic absorption spectrophotometry (AA-800, Perkin-Elmer Corp., Norwalk, CT, USA) using standard procedures to minimize all sources of adventitious contamination during each stage of the preparation and analyses (Abebe *et al*. 2007). Inositol hexa-(IP6) and penta-(IP5) phosphates were also analysed using a modification of the high performance liquid chromatography (HPLC) procedure of Lehrfeld (1989), as described earlier (Abebe *et al*. 2007). Accuracy and precision of the trace element analysis was checked by analysis of National Institute of Standards and Technology (NIST) certified reference materials [1572: citrus leaves; Standard Reference Materials (SRM) 1568a: rice flour] and the IP6 and IP5 analyses by inter-laboratory comparison of a sample of wheat bran, analysed by the same HPLC method.

Compilation of a Sidama nutrient composition database

Where possible, nutrient values for calcium, iron, zinc and phytate were based on our analysed data, whereas those for energy, protein, the B vitamins and vitamin C were compiled from Ethiopian food composition tables (Ågren & Gibson 1968; ENI 1981; EHNRU 1998). Values for crude fibre and retinol in the Ethiopian food composition tables were replaced by those for total dietary fibre, beta-carotene, and retinol [expressed as retinol equivalents (REs)] compiled from USDA (2003). The content of vitamin A for all plant-based products was based on β-carotene only; data were not available for the other provitamin A carotenoids (i.e. α-carotene and β-cryptoxanthins). The vitamin A activity of foods was expressed as REs for comparison with the WHO recommendations (Dewey & Brown 2003).

Assessment of nutrient adequacy of complementary foods

Median (first and third quartile) intakes of energy and the selected nutrients (per day and per 100 kcal), phytate : zinc molar ratios and sources of energy from eight major food groups were calculated from the coded 1-day weighed food records for three age groups: 6–8 months, 9–11 months and 12–23 months. The median daily intakes of energy and nutrients from complementary foods were compared with the corresponding estimated needs based on the Food and Agriculture Organization (FAO)/WHO/United Nations University (UNU) (1985) and the WHO/FAO (2004) recommended nutrient intakes (Dewey & Brown 2003), assuming an average breast milk intake and composition, except for vitamin A when the value for the breast milk concentration of women in low-income countries was used. The adequacy of the energy intakes was evaluated in two ways, firstly by comparison of the absolute energy intakes as a percentage of estimated energy needs from complementary foods, and secondly by calculating the energy requirements of the children based on age (in months) and per kilogram body weight (FAO/WHO/UNU 2004) to account for their small size. The energy contribution from breast milk (Dewey & Brown 2003) was then subtracted from these adjusted energy requirements to yield estimated energy needs for the three age groups, again assuming average breast milk volume. Median dietary diversity scores and the proportion classified with low (0–2), medium (3–4) and high (5–7) scores (Arimond & Ruel 2004) were calculated for each age group.

Statistical analyses

All continuous variables were checked for normality using the Kolmogorov–Smirnov test. Breastfeeding and child nutrition indicators (i.e. dietary diversity, minimum number of time fed solids/semi-solids; minimum number of food groups; good infant and young child feeding practices) were derived from the two questionnaires, as reported by Arimond & Ruel (2003). Dietary intake data (per day and per 100 kcal) for the three age groups were expressed as medians (inter-quartile range) for consistency because of nonnormal distributions for some nutrients. Children were classified into two groups according to their LAZ-score: stunted (LAZ < –2) and non-stunted (LAZ ≥ –2). Mean differences in the anthropometry of the stunted and non-stunted children and their mothers were examined using the *t*-test, equal variances not assumed. Socio-economic status indicators distinguishing the two groups were examined using Fisher's exact test (1-tailed). Differences in energy intake and motor milestones were assessed using the Mann–Whitney U test and Fisher's exact test respectively. Statistical analyses were carried out using SPSS version 12 (SPSS Inc., Chicago, IL, USA). A P value of <0.05 was taken to indicate statistical significance.

Results

Socio-demographic and health status

The overall response rate for the survey was 100%. However, three children were excluded from the final sample: one was excluded because the mother had died during delivery and, as a result, her child had never been breastfed, and two were excluded because of uncertainty about their age. Hence, the final number of children included in the study was 97 (52 males, 45 females) with a mean age (SD) of 13.3 ± 5.1 months. Most of the children lived in male-headed, subsistence farming households. Houses had a rough eucalyptus frame plastered with mud, with a mud floor; the majority had thatched roofs and no windows, although 18% had corrugated iron roofs. Almost half (45%) of the households had no sanitation facility. The main water supply was from a public standpipe (98%) in each village. Of the households, 71% owned some livestock; most (62%) had a few cows, 20% kept goats and 37% had a few chickens. Almost half of the fathers but only 25% of the mothers had received some formal education. Two-thirds of the children were fully or partially immunized based on mothers' verbal reports, confirmed where possible in the households by information from vaccination cards (Table 1). Children who had received vaccinations against tuberculosis (BCG), diphtheria, whooping cough, tetanus, polio and measles, were considered fully immunized. Of the children, 90% of the infants and all of the toddlers studied reportedly received vitamin A supplements, but only one child aged 12–23 months was from a household that reported using iodized salt.

Breastfeeding and complementary feeding practices and behaviours

Based on the questionnaire data, 68% (66/97) of the children were reportedly breastfed within 1 hour after birth and the remainder within 1 day (Table 2), although focus group discussions suggested that most of the mothers discarded colostrum. Only 7% of the children were given prelacteal feeds consisting of plain water, or extracts of fenugreek (*Triginella foenum graecum L*). Almost all of the mothers reported that their children had received fluids as well as breast milk before 6 months of age, although two (10%; 2/20) in the 6–8 months age group were still exclusively breastfed. Plain water was fed most frequently (71%; 69/97), followed by fresh animal milk (20%) (mainly goat's milk); nine (9%) children consumed fenugreek extract. The trained research assistants, collecting the 1-day food records in the homes, noted that no mother boiled water for child feeding, washed their hands before cooking or feeding their infants, or stored food in places unexposed to contamination from insects or animals, although most claimed to do so when questioned in the focus groups. Fifty per cent of the mothers stated they had commenced complementary feeding because they perceived that their supply of breast milk was insufficient.

All of the children were breastfed 'on demand' at the time of the study, with the exception of two in the 12–23 months age group. Almost all of the infants aged 6–8 months (i.e. 94%) were fed solid or semi-solid foods for the recommended minimum number of times or more (i.e. ≥2) in addition to breast milk, although this proportion fell to about 75% for the two older age groups (Table 3). However, most of the children were not fed any additional nutritious snacks or the recommended minimum number of food groups (i.e. ≥ 3). Indeed, most of the children consumed only 0–2 food groups, which rarely included foods rich in vitamin A or iron (Table 3). Instead, grains, roots or

Table 2. Feeding practices and reasons for commencing complementary feeding0

	Age 6–8 months ($n = 20$)	Age 9–11 months ($n = 21$)	Age 12–23 months ($n = 56$)	All children
Number of infants ever breastfed (%)	20/20 (100)	21/21 (100)	56/56 (100)	97/97 (100)
Started breastfeeding within 1 h after birth (%)	14/20 (70)	12/21 (57)	40/56 (71)	66/97 (68)
Prelacteal feeding (%)				
Plain water	2/20 (10)	1/21 (5)	1/56 (2)	4/97 (<1)
Butter, water + sugar, and/or salt, fruit juice, tea/coffee/infusions or other	0/20 (0)	0/21 (0)	3/56 (5)	3/97 (<1)
Currently exclusively breastfeeding (%)	2/20 (10)	0/21 (0)	0/56 (0)	2/97 (<1)
Currently breastfeeding (%)	20/20 (100)	21/21 (100)	54/56 (96)	95/97 (98)
Fed these fluids yesterday (%):				
Plain water	10/20 (50)	12/21 (57)	47/56 (84)	69/97 (71)
Other milk	2/20 (10)	6/21 (29)	11/56 (20)	19/97 (20)
Fenugreek or amessa extract, coffee, tea or other liquids	3/20 (15)	0/21 (0)	6/56 (11)	9/97 (9)
Complementary feeding rate* (%)	18/20 (95)	19/21 (90)	56/56 (100)	94/97 (97)
Reasons for starting complementary foods (%):				
Not enough breast milk		7/21 (33)	28/56 (50)	45/97 (51)
Told to		1/21 (5)	1/56 (2)	2/97 (2)
Not enough time to breastfeed		0/21 (0)	0/56 (0)	1/97 (1)
Baby reaching for food		0/21 (0)	1/56 (2)	1/97 (1)
Other		11/21 (52)	25/56 (45)	45/97 (51)

*Per cent of children who received breast milk and solid or semi-solid foods in the last 24 h (Arimond & Ruel 2003).

Table 3. Complementary feeding practices

Practice	Age 6–8 months	Age 9–11 months	Age 12–23 months
Consumed foods from the following food groups in the last 24 h:			
Dairy products (%)	2/19 (11)	6/21 (29)	10/54 (19)
Eggs (%)	0/19 (0)	0/19 (0)	2/54 (4)
Grains, roots and tubers (%)	15/19 (79)	19/21 (90)	50/54 (93)
Vitamin A-rich fruits and vegetables (%)	0/19 (0)	1/21 (5)	2/54 (4)
Other fruits and vegetables (%)	0/19 (0)	0/21 (0)	0/54 (0)
Meat, poultry, fish, shellfish (%)	0/19 (0)	0/21 (0)	0/54 (0)
Legumes and nuts (%)	0/19 (0)	1/21 (5)	3/54 (6)
Foods cooked with fats or oil (%)	0/19 (0)	0/21 (0)	0/54 (0)
Consumed 0–2 food groups (%)	19/19 (100)	21/21 (100)	51/54 (94)
Consumed 3–4 food groups (%)	0/19 (0)	0/21 (0)	3/54 (6)
Dietary diversity:			
Mean number of food groups consumed	0.9 ± 0.4	1.3 ± 0.6	1.24 ± 0.8
Fed solid or semi-solid foods minimum number of times or more (%)*	16/17 (94)	15/20 (75)	36/50 (72)
Fed minimum number of food groups or more (%)†	0/19 (0)	0/21 (0)	3/54 (6)
Fed according to infant and young child feeding practices (%)‡	0/17 (0)	0/20 (0)	3/54 (6)
Consumed food rich in vitamin A (%)§	0/19 (0)	1/21 (5)	4/54 (4)
Consumed food rich in iron (%)¶	0/19 (0)	0/21 (0)	2/54 (4)
Fed maize porridge in last 24 h	6/19 (32)	3/21 (14)	7/54 (13)
Fed maize bread in last 24 h	10/19 (53)	16/21 (76)	49/54 (91)

Subjects consuming no complementary foods are included ($n = 4$); no data for three subjects. *Infants 6–8 months fed ≥ two times/day; children 9–23 months fed ≥ 3 times/day; †Fed three or more food groups; ‡Breastfed and fed solids/semi-solids minimum number of times (2/3 or more) and fed minimum number of food groups (≥3); §Includes meat (and organ meat), fish, poultry, eggs, pumpkin, red or yellow yam or squash, carrots, red sweet potatoes, dark green leafy vegetables, mango, papaya; ¶Includes meat (including organ meat), fish, poultry and eggs.

Table 4. Mean (standard deviation) anthropometric measurements and *Z*-scores by age group and prevalence of stunting, wasting, and underweight ($n = 97$)

	Age 6–8 months ($n = 20$)	Age 9–11 months ($n = 21$)	Age 12–23 months ($n = 56$)
Length-for-age *Z*-score	–1.58 ± 1.48	–1.74 ± 1.16	–2.09 ± 1.69
Weight-for-age *Z*-score	–1.33 ± 1.23	0.89 ± 1.17	–1.33 ± 1.37
Weight-for-length *Z*-score	–0.06 ± 1.63	0.12 ± 1.01	–0.38 ± 1.31
Body mass index *Z*-score	–0.27 ± 1.51	0.18 ± 1.03	–0.06 ± 1.34
Head circumference *Z*-score	0.50 ± 1.08	0.43 ± 1.16	0.58 ± 1.06
Arm circumference *Z*-score	–0.16 ± 1.09	0.05 ± 0.89	–0.25 ± 1.20
Triceps skinfold *Z*-score	0.19 ± 1.19	0.12 ± 1.56	0.21 ± 1.74
Prevalence of stunting (%)*	5/20 (25)	10/21 (48)	29/56 (52)
Prevalence of wasting (%)	2/20 (10)	2/21 (10)	8/56 (14)
Prevalence of underweight (%)	4/20 (20)	3/21 (14)	15/56 (27)

*Significantly different by age group ($p = 0.033$, Monte Carlo 1-sided significance).

tubers were the most frequently consumed food group and maize was the predominant food. As a result, the mean dietary diversity scores for each age group were very low. Similarly, none or very few (6%) of the children were fed according to good infant and young child feeding practices (Table 3).

Anthropometry

Table 4 presents the growth and selected body composition variables by age group. The mean LAZ scores were negative for all three age groups. In contrast, although the mean WAZ and WLZ were negative for the infants aged 6–8 months and toddlers aged 12–23 months, they were both positive for the infants aged 9–11 months. The mean LAZ- and WHZ-scores were lower for toddlers than for the infants. Mean *Z*-scores for head circumference and triceps skinfold thickness were slightly above zero for all three age groups. In contrast, mean *Z*-scores for both MUAC and BMI were slightly negative for the 6–8 and 12–23 months age groups, but slightly above zero or nearly zero for those aged 9–11 months.

The prevalence of stunting, but not wasting or underweight, was higher for the children aged 9–11 and 12–23 months compared with their younger counterparts (Table 4). The median number of children in the families was four; families containing a stunted child were not significantly larger. The mean height, weight and BMIs of the mothers were low; 3% had a height below 145 cm and 24% had a BMI < 18.5; none had a BMI ≥ 24 (Table 1).

Adequacy of energy and nutrient intakes and micronutrient densities

Table 5 compares the median energy and nutrient intakes from complementary foods for the three age groups, calculated from the weighed records, in comparison with the estimated needs based on the energy requirements of FAO/WHO/UNU (2004) and the WHO/FAO (2004) recommended nutrient intakes. Four children did not consume any complementary foods on the weighed record day and were therefore excluded from this data set. Estimated needs for protein were taken from WHO (1998). Not surprisingly, median intakes of energy and most nutrients increased with age, particularly after 12 months. However, with the exception of protein, median intakes of energy and all the micronutrients listed in Table 5 for each age group were below the corresponding estimated needs from complementary foods.

However, when energy requirements were expressed per kilogram body weight to account for the small size of the subjects (data not shown), the median energy intakes met or were only slightly below the estimated needs for the infants aged 6–8 months and 9–11 months, respectively, but below those for the children aged 12–23 months.

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Table 5. Median (first, third quartile) energy and nutrient intakes from complementary foods by age group, in relation to estimated needs

	Age 6–8 months (*n* = 17)	Age 9–11 months (*n* = 20)	Age 12–23 months (*n* = 56)
Energy (kcal) (*n* = 97)	142 (58, 231)	169 (80, 291)	292 (193, 402)
Estimated need*	202	307	548
Estimated need†	134 (72, 226)	229 (164, 337)	404 (274, 470)
Protein (g)	3.3 (0.9, 5.5)	3.6 (1.6, 7.3)	7.3 (4.8, 9.6)
Estimated need	2	3.1	5
Calcium (mg)	8.3 (4.6, 12.7)	7.6 (3.6, 14.2)	22.4 (10.7, 112.6)
Estimated need	211	228	346
Iron (mg)	2.8 (0.8, 3.8)	2.1 (0.9, 3.9)	4.5 (3.0, 6.6)
Estimated need	18.4 (L), 9.1 (M)	18.4 (L), 9.1 (M)	11.4 (L), 5.8 (M)
Zinc (Zn; mg)	0.9 (0.3, 1.8)	0.9 (0.3, 1.9)	1.8 (1.4, 2.3)
Estimated need	7.6 (L), 3.3 (M)	7.7 (L), 3.4 (M)	7.6 (L), 3.7 (M)
Thiamin (mg)	0.04 (0.02, 0.10)	0.06 (0.02, 0.14)	0.10 (0.06, 0.19)
Estimated need	0.16	0.17	0.38
Riboflavin (mg)	0.04 (0.02, 0.07)	0.03 (0.01, 0.10)	0.09 (0.05, 0.16)
Estimated need	0.16	0.18	0.31
Niacin (mg)	0.75 (0.18, 1.25)	0.64 (0.26, 1.35)	1.37 (0.90, 2.15)
Estimated need	2.99	3.08	5.18
Vitamin C (mg)	0.0 (0.0, 0.0)	0.0 (0.0, 0.4)	0.0 (0.3, 2.4)
Estimated need	3.0	5.4	8.0
Vitamin A (RE)	0.0 (0.0, 3.8)	0.0 (0.0, 0.0)	0.0 (0.0, 30.9)
Estimated need	63	92	126
Phytate (Phy; mg)	133 (9, 266)	195 (71, 281)	319 (147, 425)
[Phy] : [Zn]	21 (3, 26)	21 (16, 22)	17 (13, 21)

Subjects consuming no complementary food on the weighed record day (*n* = 4) and subjects never breastfed were excluded (*n* = 1); Subjects of uncertain age were also excluded (*n* = 2); L, low bioavailability; M, moderate bioavailability; RE, retinol equivalent; *Estimated need from complementary foods based on US longitudinal data of Butte *et al.* (2000); †Estimated need from complementary foods based on FAO/WHO/UNU (2004) data but adjusted for age and body weight.

Median nutrient densities of the complementary foods were similar across all three age groups (Table 6). All were less than 80% of the desired level, except for protein for all three age groups, and iron and zinc for the children 12–23 months, when moderate bioavailability was assumed. Based on low bioavailability, however, the shortfalls were 63 and 42% of the desired levels for iron and zinc density, respectively. The greatest shortfalls were for the nutrient densities of retinol, vitamin C and calcium.

Grains, mainly unrefined maize and wheat, provided more than 80% of the energy from complementary foods for all three age groups (data not shown). Dairy products (mainly goat's milk) provided less than 1% of energy, and no cellular animal foods were consumed. Of the grain products, corn bread was consumed most frequently by all three age groups, although 21% (20/97) of the children received corn porridge (based on the food records). A few children were fed unleavened wheat bread (*n* = 16) and leavened white bread (*n* = 9) purchased from a local store. Kocho – a fermented starchy food based on enset (*E. ventricosum*) – and Irish potato were consumed by 10 and six children, respectively. None of the children consumed any fruits, except banana (*n* = 5), any dark green leafy vegetables, except boiled kale (*Brassica carinata*) (*n* = 7) or any source of orange/yellow vegetables or fruits, even though pumpkins, papayas and mangoes were grown in some household gardens. One child was fed plumpy-nut (Nutriset, Malaunay, France) distributed by the World Food Programme.

Selected maternal and household characteristics of stunted and non-stunted children

The children were classified into two groups: stunted (*n* = 44) (LAZ ≤ –2) and non-stunted (*n* = 53) (LAZ > –2). As expected, the mean WAZ and WLZ scores for the stunted children were significantly lower than those for the non-stunted children (Table 7). The stunted children also tended to be

Table 6. Observed nutrient densities of complementary foods by age-group in relation to desired nutrient densities

	Age 6–8 months ($n = 17$)	Age 9–11 months ($n = 20$)	Age 12–23 months ($n = 56$)
Protein density (g/100 kcal)	2.30 (2.10, 2.88)	2.12 (2.10, 2.61)	2.30 (2.10, 2.67)
Desired	1.0	1.0	0.9
Calcium density (mg/100 kcal)	6.1 (2.9, 23.2)	4.1 (2.4, 11.9)	8.0 (3.7, 31.0)
Desired	105	74	63
Iron density (mg/100 kcal)	1.3 (1.1, 2.0)	1.2 (1.1, 1.5)	1.3 (1.2, 1.8)
Desired	9.1 (L), 4.5(M)	6.0 (L), 3.0 (M)	2.1 (L), 1.0 (M)
Zinc density (mg/100 kcal)	0.6 (0.4, 0.7)	0.6 (0.5, 0.6)	0.6 (0.5, 0.7)
Desired	3.8 (L), 1.6 (M)	2.5 (L), 1.1 (M)	1.4 (L), 0.6 (M)
Thiamin density (mg/100 kcal)	0.03 (0.02, 0.06)	0.04 (0.03, 0.05)	0.03 (0.04, 0.05)
Desired	0.08	0.06	0.07
Riboflavin density (mg/100 kcal)	0.02 (0.01, 0.05)	0.02 (0.01, 0.04)	0.02 (0.02, 0.05)
Desired	0.08	0.06	0.06
Niacin density (mg/100 kcal)	0.43 (0.27, 0.73)	0.35 (0.34, 0.53)	0.42 (0.34, 0.59)
Desired	1.5	1.0	0.9
Vitamin C density (mg/100 kcal)	0.0 (0.00, 0.00)	0.0 (0.00, 0.17)	0.0 (0.09, 0.80)
Desired	1.5	1.7	1.5
Vitamin A density (RE/100 kcal)	0.0 (0.0, 3.2)	0.0 (0.0, 0.0)	0.0 (0.0, 7.5)
Desired	31	30	23

L, low bioavailability; M, moderate bioavailability; RE, retinol equivalent.

thinner based on lower mean arm circumference and triceps skinfold thickness Z-scores than their non-stunted counterparts. Head circumference Z-scores were also significantly lower for the stunted children. Mothers of the stunted children were also significantly shorter and lighter than those of the non-stunted children, although their values for BMI and parity were comparable (Table 7).

Differences in household socio-economic status between the two groups were marked. Fewer households of the stunted children had roofs of corrugated iron, possessed a separate building for the animals or for a kitchen, owned cows, an umbrella or a mosquito net (Table 7). However, there were no differences in source of drinking water, or number of people living in the household, or in their hygiene, sanitation, garbage disposal or food safety practices (data not shown). Median daily intakes of energy from complementary foods for the stunted infants aged 6–8 months (but not for the two older groups) were significantly lower than those of their non-stunted counterparts, but the difference was not apparent when intakes were expressed per kilogram body weight (Table 7). Micronutrient densities of the complementary diets of the stunted and non-stunted children were comparable. Some differences in the achievement of selected motor development milestones existed between the stunted and non-stunted infants. For example, in the infants aged 6–11 months, fewer stunted infants could raise their head and chest when on their stomach, turn and roll over, sit without support or crawl using hands and knees (Table 7).

Discussion

The high prevalence of stunting and low prevalence of wasting among these children aged 6–23 months from subsistence farming households in three rural Sidama communities in the SNNP region of Ethiopia are not unexpected. A similar pattern in the SNNP region has been reported in the 2005 Ethiopia Demographic and Health Survey (CSA 2006), even though breastfeeding for nearly 2 years is almost universal, as reported here. However, we identified several complementary feeding practices and behaviours among the Sidama caregivers studied here that were not in accordance with the WHO guiding principles for breastfed children (PAHO/WHO, 2003). They included practices associated with a high risk of morbidity, and complementary diets inadequate in quantity and quality, which together probably contributed to the linear growth failure observed in these children.

Table 7. Anthropometric indices, energy intakes and motor development milestones for stunted and non-stunted children, together with maternal anthropometric and socio-economic status variables

	Stunted ($n = 44$)	Non-stunted ($n = 53$)	Difference (95% confidence interval) or P
Anthropometric indices*			
Length-for-age Z-score	–3.26 ± 0.84	–0.79 ± 0.99	
Weight-for-age Z-score	–2.01 ± 1.18	–0.52 ± 0.98	1.49 (1.05, 1.93)
Weight-for-length Z-score	–0.30 ± 1.59	–0.13 ± 1.07	0.18 (–0.38, 0.74)
BMI-for-age Z-score	–0.02 ± 1.53	–0.08 ± 1.11	–0.06 (–0.62, 0.49)
Head circumference Z-score	0.04 ± 1.03	0.93 ± 0.95	0.89 (0.48, 1.29)
Arm circumference Z-score	–0.64 ± 1.12	0.23 ± 0.95	0.86 (0.44, 1.29)
Triceps skinfold Z-score	0.03 ± 1.80	0.32 ± 1.39	0.30 (–0.36, 0.96)
Maternal anthropometry and parity*			
Height (cm)	154.2 ± 5.3	157.8 ± 5.6	3.64 (1.42, 5.85)
Weight (cm)	46.9 ± 5.3	49.7 ± 5.0	2.74 (0.63, 4.85)
Body mass index (kg/m^2)	19.7 ± 1.9	19.9 ± 1.7	0.21 (–0.53, 0.95)
Parity	4.0 ± 2.2	4.1 ± 2.6	0.14 (–0.82, 1.10)
Socio-economic status variables†			
Corrugated-iron roofed hut	3	14	0.010
Grass-roofed hut	41	39	
Own barn, kitchen, etc.	3	15	0.006
Only own living hut	41	38	
Own cows	23	37	0.059
No cows	21	16	
Own umbrella	6	15	0.066
No umbrella	38	38	
Energy intake‡			
(6–8 months) (kcal)	15 (0, 106) ($n = 5$)	142 (57, 256) ($n = 15$)	0.049
(kcal/kg)	2.3 (0.0, 16.6) ($n = 5$)	17.5 (7.6, 28.5) ($n = 15$)	0.073
(9–11 months) (kcal)	159 (69, 247) ($n = 10$)	168 (53, 300) ($n = 11$)	0.833
(kcal/kg)	21.7 (9.5, 32.4) ($n = 10$)	19.9 (5.6, 39.8) ($n = 11$)	0.944
(12–23 months) (kcal)	291 (211, 441) ($n = 29$)	294 (188, 387) ($n = 27$)	0.799
(kcal/kg)	34.0 (24.4, 50.1) ($n = 29$)	28.8 (21.8, 40.7) ($n = 27$)	0.228
Motor milestones for infants 6–11 months†	($n = 15$)	($n = 26$)	
Can raise head when on front chest on stomach	11 (73%)	25 (96%)	0.051
Can turn and rollover	9 (60%)	25 (96%)	0.006
Sits without support	11 (73%)	26 (100%)	0.051
Crawls using hands and knees	5 (33%)	18 (69%)	0.028

*Mean ± standard deviation and mean difference (95th confidence interval) from the t-test, equal variances not assumed; †Data are observed number of subjects in each category; significance from Fisher's exact test (1-tailed); ‡Median (first, third quartile): significance from Mann–Whitney U test.

We did not collect any measure of morbidity for these Sidama children. However, the risk of morbidity was likely to be high for all the children in this cross-sectional study. Only two-thirds of the children were fully or partially immunized, and very few had been fed colostrum, despite its antiviral and antibacterial benefits. Few were exclusively breastfed up to 6 months of age, even though most focus group mothers responded that complementary feeding should not start until aged 6 months. Moreover, most of the children were observed to receive unboiled water, often accompanied by semi-solid or solid foods of poor dietary quality that were not prepared or stored safely. Episodes of both acute and chronic infections are known to have adverse effects on linear growth during childhood (Stephensen 1999), as well as on the intake of complementary foods (Brown *et al.* 1990; Brown 1997). Such reductions in complementary food intake after illness are likely to be especially detrimental for these Sidama children because focus group discussions suggested mothers were unaware of the importance of both responsive feeding and increasing the amount of fluids and/or foods fed after illness. An additional factor compromising their food intake may be the monotony of a complementary diet with such low dietary diversity, as suggested by other investigators (Underwood 1985).

In view of these detrimental practices, the low energy intakes of our Sidama children when compared with their WHO estimated needs from complementary foods are not unexpected, and consistent with earlier reports of children from subsistence farming households in Sub-Saharan Africa (Hautvast *et al*. 1999; Hotz & Gibson 2001). In most other Sub-Saharan African countries, however, young children are fed cereal-based porridges (Brown *et al*. 1988; Hatløy *et al*. 1998; Hautvast *et al*. 1999; Hotz & Gibson 2001; Mamiro *et al*. 2005). Among the Sidama children, only 17% consumed maize porridge (Table 3). Instead, pieces of unmashed maize bread were the main complementary food consumed, even by infants as young as 6 to 8 months. This inappropriate practice probably contributed to the low energy intakes. Nevertheless, when energy requirements were adjusted for the low body weight of the Sidama children, then the energy intakes from the complementary diets of the youngest age group (i.e. 6–8 months) appeared to meet their estimated needs. However, such energy intakes would not be adequate to provide for catch-up growth and allow the infants to regain their expected growth trajectory. Indeed, such increased needs for catch-up growth have been estimated as up to 14.5% more than the energy requirements for well-nourished infants (FAO/WHO/UNU 2004).

It is of interest that among the Sidama infants aged 6–8 months, those classified as stunted (i.e. LAZ < –2SD) had lower median intake of energy than their non-stunted counterparts, although this difference was not significant when expressed as energy intake per kilogram body weight (Table 7). Similar findings have been reported earlier among stunted Zambian children (Hautvast *et al*. 1999). This trend arose in part because so few of the stunted Sidama infants were fed any semi-solid or solid complementary foods at this age. This practice may be attributed, at least in part, to household food shortages and not just to infection-induced anorexia. Certainly, the stunted children in our study were from very resource-poor households (Table 7), as noted elsewhere, although the hygiene practices of their caregivers were not worse than those observed for their non-stunted counterparts.

Acquisition of certain motor development milestones appeared to be delayed in the stunted infants aged 6–11 months compared with their non-stunted counterparts, as reported by others (Pollitt *et al*. 1994; Meeks Gardner *et al*. 1995; Olney *et al*. 2007). This trend is probably related to infection or illness and micronutrient deficiencies such as iron and zinc (Sazawal *et al*. 1996; Olney *et al*. 2007). Such delays in motor development can also have a negative impact on cognitive function as a result of the reciprocal interactions between mental and motor development (Bushnell & Boudreau 1993). These findings are important, given the high prevalence of stunting among the Sidama children.

Likewise, our finding that maternal height and weight were significantly lower for the stunted than the non-stunted children (Table 7) has also been reported among children from subsistence farming households in other countries of Sub-Saharan Africa (e.g. Malawi and Zambia) (Hautvast *et al*., 2000; Espo *et al*. 2002; Yeudall *et al*. 2002), and emphasizes that improving post-natal growth may not achieve the expected results if maternal factors are not concurrently addressed (Dewey 2001).

It is noteworthy that even if the energy intakes from the complementary diets met the WHO estimated needs (Dewey & Brown 2003), the micronutrient intakes of these children from three rural Sidama communities were unlikely to achieve their estimated needs because of the very low micronutrient densities of their complementary diets (Table 6). The low micronutrient density arose from the absence in the diets of foods rich in iron or vitamin A. As a result, the diets of all three age groups had a very low mean dietary diversity, a characteristic noted earlier of Ethiopian complementary diets (Arimond & Ruel 2004; CSA 2006; Mukuria *et al*. 2006). Indeed, in the 2005 Ethiopian Demographic and Health Survey (CSA 2006), the SNNP region was one of three marked by a very low consumption of iron-rich foods by the children aged 6–59 months. As a consequence, it is not surprising that shortfalls in the growth-limiting micronutrients – zinc, iron, calcium, vitamin

A and riboflavin (Gibson & Hotz 2001) – were observed in all three age groups when compared with the WHO estimated needs. Such deficits were even greater for the stunted infants aged 6–8 months because of their very low energy intake. Hence, overcoming the perception of the Sidama mothers (revealed in the focus groups) that animal-source foods are not needed for infant and child feeding is a priority, especially as positive associations between the proportion of energy from animal-source foods and linear growth have been reported elsewhere (Allen *et al*. 1992; Marquis *et al*. 1997). Indeed, in an earlier study of Ethiopian infants in the Dodota-Sire district, children reported as receiving cow's milk tended to be less stunted (Umeta *et al*. 2003). Among our Sidama households, goats' milk was often used by adults in coffee, but according to responses in the focus group discussion, was not often offered to young children because of a fear of parasites. Almost all of the Sidama households surveyed owned some livestock, notably chickens, goats and cows, although they were used mainly as an income-generating activity rather than for home consumption. Clearly, in these three rural Sidama communities, nutrition education programmes for health-care providers and caregivers that promote enriching the complementary diets of these Sidama children with eggs, animal milk, cellular animal foods and/or small indigenous fish from nearby Lake Awassa are urgently required.

The deficits for iron and zinc in these maize-based Sidama complementary diets were almost certainly exacerbated by poor bioavailability, given the absence of any vitamin C, cellular animal protein and the high dietary phytate : zinc ratios. Nevertheless, it is noteworthy that the shortfalls in the iron intake (mg/d and per 100 kcal) were less than those reported elsewhere in Sub-Saharan Africa (Hautvast *et al*. 1999; Hotz & Gibson 2001) and South and Southeast Asia (Kimmons *et al*. 2005; Anderson *et al*. 2008). To our knowledge, there are no other quantitative data on micronutrient intakes of Ethiopian children during the complementary feeding period. However, dietary iron intakes are characteristically high among adults in Ethiopia (Gebre-Medhin *et al*. 1976; Abebe *et al*. 2007), and have been linked with contaminant iron rather than iron intrinsic to food (Hallberg & Bjorn-Rasmussen 1981). Unlike iron, the zinc deficits of our Sidama complementary diets are high, and the dietary phytate : zinc molar ratios are like those in Malawi (Hotz & Gibson 2001), and higher than those reported for Gambian breastfed infants (Paul *et al*. 1998).

Our study was restricted to a self-selected sample of children from three rural communities in the Sidama Zone of the SNNP region of Ethiopia, and hence was not designed to evaluate the adequacy of complementary diets in a representative sample of infants and toddlers aged 6–23 months from the Sidama Zone. Nevertheless, our detailed data on both maternal and child anthropometry, and breastfeeding and complementary feeding practices and behaviours follow the same pattern reported more generally for the SNNP region in the 2005 Ethiopian Demographic and Health Survey (CSA 2006). We calculated our dietary intakes from complementary foods on the assumption that breast milk volume is only adversely affected by maternal BMI in conditions of famine (Prentice *et al*. 1994). We also assumed that the breast milk of these Sidama mothers was of average composition (with the exception of vitamin A), even though breast milk concentrations of riboflavin and thiamin, like vitamin A, have the potential to be reduced by poor maternal status (WHO 1998). As a result, the shortfalls in the riboflavin and thiamin content of these Sidama complementary diets may be even greater than those reported here. Finally, our study was performed during the rainy season before the harvesting of crops, a period when household food shortages are often severe in this region. This seasonal shortage may have contributed to the low energy intakes of the Sidama children studied here.

Clearly, to ensure optimal nutritional status during the complementary feeding period in these rural Sidama communities, interventions that address both complementary feeding practices and behaviours are urgently needed. Exclusive breastfeeding until 6 months of age should be emphasized, followed by continued, frequent breastfeeding together with the replacement of maize bread by maize porridges enriched with eggs, animal milk, avocado, as well as provitamin A-containing fruits or vegetables (e.g. mango, papaya, pumpkin, kale), all foods available in at least some of the Sidama households studied here.

Such strategies would enhance the micronutrient density and nutrient bioavailability of the complementary foods used in these three rural Sidama communities, particularly for the critical growth-limiting micronutrients. Caregivers in the study setting should also receive education on the importance of responsive feeding, especially during and after illness, and the safe preparation and storage of complementary foods. However, in such resource-poor settings where growth during childhood is constrained by the intergenerational effects of maternal stunting, interventions that address prenatal influences on growth are also needed to reduce the rates of stunting during early childhood.

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Key messages

- Interventions among subsistnce farming households in Sidama, Southern Ethiopia need to promote exclusive breastfeeding up to 6 months of age, and the use of cereal-based porridges in place of maize bread for complementary feeding.
- Cereal-based porridges should be enriched with micronutrient-rich animal-source foods such as eggs or animal milk, as well as fruits and vegetables such as mango, papaya, pumpkin, kale and/or avocado containing provitamin A carotenoids, vitamin C and in some cases fat.
- Caregivers should be educated on the importance of responsive feeding, especially during and after illness, and the safe preparation and storage of complementary foods.
- Interventinos should also address prenatal influences on growth to reduce the high rate of stunting during early childhood in subsistence farming households in rural Sidama.

Conflicts of interest

None declared.

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