British Journal of Nutrition (2013), **109**, 564–571
doi:10.1017/S0007114512001237

Infant nutrition in relation to eating behaviour and fruit and vegetable intake at age 5 years

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(Submitted 12 September 2011 – Final revision received 16 February 2012 – Accepted 3 March 2012 – First published online 4 May 2012)

Abstract

Infant nutrition may influence eating behaviour and food preferences in later life. The present study explores whether exclusive breast-feeding duration and age at introduction of solid foods are associated with children's eating behaviour and fruit and vegetable intake at age 5 years. Data were derived from the Amsterdam Born Children and their Development study, a prospective birth cohort in the Netherlands, and included 3624 children. During infancy, data on infant nutrition were collected. Child eating behaviour (satiety responsiveness, enjoyment of food, slowness in eating and food responsiveness) was assessed with the Children's Eating Behaviour Questionnaire; and fruit and vegetable intake was calculated from a validated child FFQ. Both questionnaires were filled in by the mothers after their child turned 5 years. Exclusive breast-feeding duration was not associated with later eating behaviour, although longer exclusive breast-feeding was significantly associated with a higher vegetable intake at age 5 years. Compared with the introduction of solid foods at age 6 months, introduction before the age of 4 months was associated with less satiety responsiveness at age 5 years (β −0·09; 95% CI −0·16, −0·02). Introducing solid foods after 6 months was associated with less enjoyment of food (β −0·07; 95% CI −0·12, −0·01) and food responsiveness (β −0·04; 95% CI −0·07, −0·01). Introducing solid foods before the age of 4 months was associated with a higher fruit intake compared with introduction at 6 months. These findings suggest that prolonged breast-feeding and introduction of solid foods between 4 and 6 months may lead to healthier eating behaviour and food preferences at age 5 years.

Key words: Infant nutrition: Eating behaviour: Food preferences: Children

Unhealthy eating habits in later life, and related unfavourable body composition and metabolic diseases, may be determined by early nutritional factors. Numerous studies have suggested that breast-feeding has beneficial effects on growth[1,2], body composition[3–5] and related metabolic functions[6–8], although in some studies this positive effect was absent[9]. The mechanism responsible for the beneficial effect of breast-feeding is not yet fully understood.

There are indications that breastfed infants may learn to regulate their energy intake or recognise satiety signals more effectively[10]. Breastfed infants can control the amount of milk they consume, whereas bottle-fed infants may be encouraged by their mothers to finish a bottle even if they are satiated. This overnutrition may lead to reduced satiety responses, as demonstrated in a study in which bottle-fed infants were more likely to empty milk in a cup or bottle in late infancy than breastfed infants[11]. Animal studies also show convincing results with respect to this satiety hypothesis, as early postnatal overfeeding leads to an increased appetite and food consumption, which persists into adulthood[12,13] and to increased weight gain and body fat, which can lead to overweight and metabolic alterations similar to those in the human metabolic syndrome[12,14].

In concordance with the satiety hypothesis, mothers who breastfeed their infants for at least 6 months show less controlling feeding styles[15]. It is known that maternal feeding

Abbreviations: ABCD, Amsterdam Born Children and their Development; CEBQ, Children's Eating Behaviour Questionnaire.

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styles influence children's eating behaviour[16] and therefore breast-feeding may also indirectly contribute to children's natural satiety recognition and thus to the development of overweight.

Besides children's eating behaviour, infant nutrition may also influence later diet preferences. If mothers regularly eat healthy food during breast-feeding, this leads to more acceptance of these foods in infants[17], possibly because some flavours are present in breast milk. Breastfed infants, who are repeatedly exposed, may therefore respond better to these familiar flavours at a later age[18,19]. Recently, Burnier *et al.*[20] found that children who were exclusively breastfed for 3 or more months consume more vegetables at age 4 years than other infants. In contrast, Cooke *et al.*[21] found that fruit consumption was associated with duration of breast-feeding, whereas they did not find any such evidence for vegetable intake. Thus, the relationship between breast-feeding and food preferences remains unclear.

Delayed introduction of solid foods also seems to protect against childhood overweight and obesity[22,23], although this finding has not always been replicated[24,25]. Whether this is due to altered eating behaviour in later life has, to our knowledge, not been studied in humans. However, evidence from animal studies has shown that early-weaned rats reach satiety in adulthood slower than animals that underwent later weaning[26]. There is evidence that infants who were introduced to complementary foods before 4 months of age are more likely to consume unhealthier food at the age of 1 year, even after correction for socio-demographic characteristics[27]. Whether these preferences persist in later life is unknown. However, studies in rats show that early weaning promotes an increased preference for palatable and fatty foods in later life, indicating permanent effects[28].

The present study is the first large prospective study to explore the association between infant nutrition (duration of exclusive breast-feeding and age at introduction of solid foods) and children's eating behaviour and fruit and vegetable intake at age 5 years. Data were derived from an extensive unselected cohort of mothers and their children in Amsterdam, which allows for the correction of important confounders such as socio-economic status and maternal BMI[3,4,20,22,29]. We hypothesised that a long duration of exclusive breast-feeding and late introduction of solid foods would be associated with healthy eating behaviour and a higher fruit and vegetable intake.

Methods

Study population

Data collection was part of the Amsterdam Born Children and their Development (ABCD) study. The ABCD study is a longitudinal community-based cohort study which examines the association between early-life factors and later-health and health differences. The design and rationale of the ABCD study have already been described[30]. In brief, between January 2003 and March 2004, 8266 pregnant women (living in Amsterdam) were included in the ABCD study after their first prenatal visit to an obstetric caregiver. They filled out an extensive questionnaire, which included questions about socio-demographic data, obstetric history, lifestyle, dietary habits and psychosocial factors (phase one).

Of these respondents, 7863 women gave birth to a viable singleton infant and 6575 gave permission to collect growth and infant feeding data of the child in the following years, obtained by the Youth Health Care registration, the Department of the Public Health Service Amsterdam that provides preventive care for children from birth until adulthood (multiple births excluded). Then, 3 months after delivery, these mothers received another questionnaire, the infancy questionnaire, concerning the course of their pregnancy and delivery, their physical and psychosocial health and the baby's health, feeding, growth and development. This questionnaire was returned by 5131 mothers (phase two).

Phase three of the study started in the summer of 2008. About 2 weeks after the children turned 5 years, 6161 mothers of singletons who initially gave permission for follow-up received a questionnaire and an informed consent sheet for the child's participation in the ABCD health check. This questionnaire contained items about family socio-demographics and history of medical conditions, maternal lifestyle and psychosocial conditions and child's health, development and behaviour. Furthermore, it contained the Children's Eating Behaviour Questionnaire (CEBQ). Then, 2 weeks before the health check, the mothers received a notifying letter and an additional self-administered validated FFQ for young children[31]. During the preparation of this article, data collection was still ongoing. The CEBQ was completed and digitalised for 4382 children; and likewise with the FFQ for 2501 children.

Data on eating behaviour and infant feeding were available for 3654 children. Exclusion criteria were gluten and cow's milk allergies (n 23) and congenital disorders (n 7). The present study included 3624 singleton children. Fruit and vegetable intake, based on the FFQ, was calculated for 2247 and 2253 children, respectively. The present study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the review boards of all Amsterdam hospitals and the Registration Committee of Amsterdam. Written informed consent was obtained from all subjects.

Measurements

Children's eating behaviour at age 5 years was assessed with the CEBQ, a questionnaire developed by Wardle *et al.*[32] that has been validated in Dutch[33]. The CEBQ is a parent-report measure designed to assess variation in eating style in children. The CEBQ consists of eight scales, of which we used four: (1) enjoyment of food and (2) food responsiveness, both representing interest in food and responsiveness to environmental food cues, (3) satiety responsiveness, which reflects a response to internal satiety cues, and (4) slowness in eating, which is characterised by a reduction in eating rate because of lack of enjoyment and interest in food. High scores on enjoyment of food and food responsiveness, and low scores on satiety responsiveness and slowness in eating, are associated with overweight and obesity in children[34–36]. The four scales included

eighteen items, with each item scored on a four-point scale (1 = definitely not true, 2 = not true, 3 = true, 4 = definitely true). The average scores on the four scales were calculated, with a minimum average score of 1 and a maximum score of 4. Scores were only calculated if at least 70 % of the items were completed. Internal reliabilities of the CEBQ scales were acceptable, with Cronbach's α ranging from 0·74 to 0·80. Fruit and vegetable intake in g/d was assessed with an FFQ that has been validated in Dutch for children aged 4–6 years[31].

Information on duration of breast-feeding and introduction of formula feeding was available from the infancy questionnaire received when the child was 3 months old, and from the Youth Health Care registration. This prospectively collected information was combined with retrospective information of the 5-year questionnaire to complete the data (19·9 % for breast-feeding and 25·4 % for formula feeding). The intra-class correlation coefficient, an index of the reliability between the sources, was 0·64 for formula feeding and 0·81 for breast-feeding ($P<0·05$), indicating that breast-feeding and formula feeding can reliably be reported retrospectively after 5 years. Information on introduction of solid foods was obtained from the Youth Health Care registration and the 5-year questionnaire (95·9 %). Duration of exclusive breast-feeding was categorised into: none, <1, 1–2·9, 3–6 and ≥6 months; and was defined as the period in which children received breast-feeding and did not receive any formula feeding or solid foods. Age of the child when solid foods were introduced was categorised into: <4, 4–5, 6 and >6 months.

In the analyses, we corrected for maternal factors: age (years), pre-pregnancy BMI (kg/m^2) based on self-reported height and weight, ethnicity (Dutch, Mediterranean, African, other) defined by country of birth of the mother and her mother and educational level (years of education after primary school; ≤5, 6–10, >10 years) and for child factors: birth weight (g), gestational age (weeks) and sex. Maternal factors were obtained from the pregnancy questionnaire, and child factors were obtained from the Youth Health Care registration.

Statistical analyses

Differences in group characteristics as a function of feeding pattern at age 6 months were examined with the χ^2 test (categorical data) or ANOVA (continuous data). The following groups were compared *post hoc* with the exclusive breast-feeding group: breast-feeding combined with formula feeding (and solid foods), formula feeding and/or solid foods, and breast-feeding combined with solid foods. For each of the CEBQ scales and for fruit and vegetable intake, associations with each of the independent variables (duration of exclusive breast-feeding and introduction of solid foods) were explored using linear regression analyses. First, a crude model was analysed, with only the independent variables added to the model. In a second model, all potential confounders (maternal pre-pregnancy BMI, age, education and ethnicity and child birth weight, gestational age and sex) were added.

Significance was accepted at $P<0·05$. Food responsiveness, a CEBQ subscale, was log-transformed to better resemble a normal distribution, as it was positively skewed. All statistical analyses were performed with SPSS version 18.0 (SPSS, Inc.).

Results

The group that was initially approached for phase three of the study, but did not respond (n 2518), and the group that was used for these analyses (n 3624) were similar with respect to sex (50·6 *v.* 49·9 % girls). The participating mothers were older, had a lower pre-pregnancy BMI, a higher education and were more often of Dutch origin compared with the non-responders ($P<0·001$). Children of participating mothers had a higher birth weight ($P<0·001$) (data not shown).

Table 1 presents the group characteristics, stratified for the feeding pattern of the child at 6 months of age. A total of 467 children (13 %) were fed according to the WHO guidelines[37], which recommend exclusive breast-feeding for 6 months. Fruit and vegetable intake at age 5 years was, on average, 137 (SD 70) and 79 (SD 50) g/d, respectively. Mothers who exclusively breastfed for at least 6 months were generally older, and less often of African and more often of Mediterranean origin compared with mothers who did not breastfeed their child at age 6 months ($P<0·05$). Their children had a higher birth weight, on average. Furthermore, exclusively breastfed children had a higher vegetable intake at age 5 years than children who were not breastfed ($P=0·004$). Mothers who combined breast-feeding with solid foods when their child was 6 months old had a higher pre-pregnancy BMI than mothers who exclusively breastfed ($P<0·05$). There were no differences in mean CEBQ scores between the groups.

Exclusive breast-feeding

In the crude analyses, children who were exclusively breastfed for 3–6 months scored higher on food responsiveness than children who received exclusive breast-feeding for at least 6 months (Table 2). In comparison with children who were exclusively breastfed for 6 months or longer, a significantly lower vegetable intake was found for children who were never exclusively breastfed, or exclusively breastfed for 1–2·9 months. No associations were found with fruit intake.

After adjustment for maternal and child factors, only children who were never exclusively breastfed had a lower vegetable intake than children who were exclusively breastfed for 6 months or longer. Also, children who were exclusively breastfed for 3–6 months still scored higher on food responsiveness than children who received exclusive breast-feeding for at least 6 months.

Solid foods

In the crude analyses, children who received solid foods before the age of 4 months had lower scores on satiety responsiveness than children who received solid foods at age 6 months (Table 3). Children who were introduced to solid foods after the age of 6 months had lower scores on enjoyment of food and food responsiveness than children who were introduced

Table 1. Child and maternal characteristics by child's nutritional status at age 6 months
(Mean values and standard deviations)

	Exclusive breast-feeding (*n* 467)		Breast-feeding and solid foods (*n* 130)		Breast-feeding and formula feeding (and solid foods) (*n* 676)		Formula feeding/ solid foods (*n* 2351)		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	*P*
Maternal factors									
Pre-pregnancy BMI (kg/m^2)	22·8	3·5	23·8*	5·2	22·6	3·4	22·9	3·8	0·009
% Overweight	18·0		19·2		12·9		15·5		
% Obesity	4·1		6·9		4·3		5·1		
Age (years)	32·2	4·7	31·9	4·3	32·3	4·5	31·7	4·6	0·006
Education (%)									0·020
0–5 years	14·0		6·2		13·8		14·7		
6–10 years	32·8		34·6		33·2		36·9		
> 10 years	53·1		59·2		53·0		48·4		
Ethnicity (%)									0·003†
Dutch	64·6		66·2		59·5		65·5		
African	2·6		3·8		4·3		5·7		
Mediterranean	9·2		10·0		10·4		7·0		
Other	23·6		20·0		25·9		21·8		
Child factors									
Sex (%)									0·826
Girl	49·3		53·8		49·9		49·8		
Boy	50·7		46·2		50·1		50·2		
Birth weight (g)	3549·0	502·0	3631·0	497·0	3499·0	498·0	3449·0*	559·0	< 0·001
Gestational age (weeks)	40·0	1·5	40·1	1·4	40·0	1·6	39·8	1·7	0·002
Enjoyment of food	2·53	0·47	2·47	0·47	2·53	0·51	2·53	0·50	0·645
Satiety responsiveness	2·36	0·48	2·38	0·58	2·35	0·52	2·37	0·49	0·711
Slowness in eating	2·41	0·58	2·51	0·59	2·46	0·57	2·47	0·57	0·194
Food responsiveness	1·83	0·47	1·86	0·53	1·89	0·50	1·90	0·52	0·092
Fruit intake (g/d)‡	141·2	73·6	149·6	70·8	143·1	67·3	133·8	69·8	0·019
Vegetable intake (g/d)‡	85·6	49·7	87·8	54·2	81·3	51·8	76·1*	49·3	0·004

* Mean values are significantly different from the exclusive breast-feeding group.
† Ethnic composition in the formula feeding/solid foods group is significantly different from the exclusive breast-feeding group.
‡ Based on a subsample, *n* 2247 for fruit intake and *n* 2253 for vegetable intake.

to solid foods at age 6 months. After adjusting for confounders, the differences in eating behaviour remained significant.

Children who received solid foods before 4 months of age had a higher fruit intake than children who received solid foods at age 6 months; this difference became significant after adjustment for confounders. No associations were found with vegetable intake.

As there was a correlation between the age at which solid foods were introduced and other infant nutrition, we also corrected for duration of breast-feeding and introduction of formula feeding besides all covariates. However, this had no effect on the observed associations.

Discussion

The present study indicates that the age at which solid foods are introduced may influence later eating behaviour. We found that children who were introduced to solid foods before the age of 4 months were less able to recognise satiety signals at the age of 5 years, whereas a late introduction to solid foods (>6 months) was associated with less food enjoyment and food responsiveness. Vegetable intake, on the other hand, seemed to be more related to breast-feeding and formula feeding. Breast-feeding exclusively for a longer period of time and thus delaying formula feeding was associated with a higher vegetable intake at age 5 years.

To our knowledge, this is the first study to examine infant feeding in relation to eating behaviour, measured with the CEBQ. It has been shown that breast-feeding protects against later overweight and obesity[3–5]. Besides the hormonal influences of leptin and adiponectin in breastmilk[38–41], this protection may be partly due to the ability of breastfed infants to regulate their energy intake in contrast to formula-fed infants, as discussed by Li *et al.*[11]. However, we found no association between the duration of exclusive breast-feeding and later eating behaviour, except for a higher score on food responsiveness for children who were exclusively breastfed for 1–2·9 months. This latter finding is probably more by chance, as no linear trend in food responsiveness in relation to breast-feeding or formula feeding was seen. The effect of breast-feeding on satiety recognition and other eating behaviour may only be present during infancy. It is also possible that the feeding style, and not the type of milk, affects the self-regulation of infants, as Li *et al.*[11] found that directly breastfed infants are more able to control their intake in comparison with both formula-fed infants and infants who were fed expressed human milk by bottle. Unfortunately, in the present study, expressed milk and milk fed directly at the breast could not be examined separately. Future research should assess the differences in eating behaviour between directly breastfed infants and infants fed expressed milk by bottle.

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Table 2. Association between the duration of exclusive breast-feeding and the Children's Eating Behaviour Questionnaire scales and food intake

(β Coefficients and 95 % confidence intervals)

	Duration of exclusive breast-feeding																
	None (n 625)				<1 month (n 259)				1–2·9 months (n 1144)				3–6 months (n 1095)				≥6 months (n 501)
	Crude		Adjusted†		Crude		Adjusted†		Crude		Adjusted†		Crude		Adjusted†		
	β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI	
Enjoyment of food	0·03	−0·03, 0·09	0·02	−0·04, 0·08	−0·04	−0·11, 0·03	−0·03	−0·10, 0·05	−0·01	−0·06, 0·04	−0·01	−0·06, 0·05	0·00	−0·05, 0·05	−0·01	−0·06, 0·05	0·00
Satiety responsiveness	0·02	−0·04, 0·07	0·02	−0·04, 0·08	0·03	−0·05, 0·10	−0·01	−0·08, 0·07	0·01	−0·04, 0·07	0·01	−0·05, 0·06	0·01	−0·05, 0·06	0·02	−0·04, 0·07	0·00
Slowness in eating	0·05	−0·02, 0·12	0·05	−0·02, 0·12	0·04	−0·05, 0·12	0·01	−0·08, 0·09	0·05	−0·01, 0·11	0·05	−0·01, 0·11	0·05	−0·01, 0·11	0·06	0·00, 0·12	0·00
Food responsiveness‡	0·03	−0·01, 0·06	0·02	−0·01, 0·06	0·00	−0·04, 0·04	0·00	−0·04, 0·05	0·03*	0·005, 0·06	0·03*	0·01, 0·06	0·03	0·00, 0·06	0·03	0·00, 0·06	0·00
Fruit intake (g/d)	−9·9	−20·3, 0·4	−8·8	−19·3, 1·7	−11·5	−25·0, 2·0	−9·9	−23·6, 3·7	−4·1	−13·3, 5·1	−2·9	−12·3, 6·4	2·0	−7·2, 11·3	2·9	−6·5, 12·3	0·00
Vegetable intake (g/d)	−16·6*	−24·0, −9·2	−16·1*	−23·6, −8·6	−7·5	−17·1, 2·1	−5·6	−15·3, 4·1	−7·0*	−13·6, −0·4	−6·5	−13·2, 0·2	−5·6	−12·2, 1·0	−5·9	−12·7, 0·8	0·00

* β Values were significantly different from the ≥6 months' exclusive breast-feeding group.
† Adjusted for maternal pre-pregnancy BMI, age, education and ethnicity and for child birth weight, gestational age and sex.
‡ Log-transformed.

Besides a short duration of breast-feeding, early introduction of solid foods (before the age of 4 months) may also increase the risk of later overweight[22,23]. This may be partly explained by eating behaviour, as the present study shows that these children are less capable to recognise satiety signals.

Although the age at introduction of solid foods may programme later eating behaviour, it is also possible that children with bigger appetites (compared with other children) receive complementary foods at a young age, because their mothers perceive them as being hungry. However, the fact that animal studies have shown that early weaning can influence satiety behaviour supports the programming model[26]. Children's eating behaviour may be influenced by parental eating behaviour, as children of obese parents show different eating behaviour compared with children of lean families[42]. Since we lack information on parental eating behaviour, this may have influenced the relationship between the introduction of solid foods and child eating behaviour.

Prenatal as well as infant nutrition may influence later food preferences. For example, individuals prenatally exposed to the Dutch famine showed a preference for fatty foods later in life[43]. Burnier *et al.*[20] found that children who were exclusively breastfed for 3 or more months consume more vegetables at age 4 years than other infants. In concordance with this, we found the lowest vegetable intake at age 5 years in children who were never exclusively breastfed and were thus introduced to formula feeding at birth. The duration of exclusive breast-feeding showed a linear association with fruit and vegetable intake, although not always significant. Exclusive breast-feeding for a longer period of time was associated with an increasing intake of both fruit and vegetables. These associations may be due to the fact that breast-feeding promotes healthier food preferences, as some flavours of healthy foods may be present in breast milk, and breastfed infants recognise these flavours and therefore respond better to them[18,19]. However, mothers who breastfeed for 6 months or longer may also have a healthier lifestyle and offer their child more fruits and vegetables, as they are more conscientious about their child's health. Although we corrected for socio-economic status and BMI, which are strongly related to lifestyle, some residual confounding is still possible. The reason why no significant differences were found in fruit intake may be that fruit is the most common first food for infants in the Netherlands and therefore all children have a high fruit intake. Significant differences are then more difficult to detect.

In addition to breast-feeding, the introduction of solid foods may also influence food preferences. Earlier observational and experimental studies found an unhealthy and fattier food preference when complementary foods were introduced at a young age[27,28]. In contrast with these studies, we found a higher fruit intake in children who were introduced to solid foods before the age of 4 months. This may be because these children have a big appetite and like food in general or because they have eaten more fruit at a young age (fruit is the most common first food for infants in the Netherlands) and have therefore developed a preference for fruit.

The major strengths of this study were the prospective design and the large study population. Also, we were able to control for

Table 3. Association between the age at introduction of solid foods and the Children's Eating Behaviour Questionnaire scales and food intake

(β Coefficients and 95 % confidence intervals)

	Age at introduction of solid foods																
	<4 months (*n* 202)				4–5 months (*n* 1378)				6 months (*n* 1597)	>6 months (*n* 447)			
	Crude		Adjusted†		Crude		Adjusted†			Crude		Adjusted†	
	β	95 % CI	β	95 % CI	β	95 % CI	β	95 % CI		β	95 % CI	β	95 % CI
Enjoyment of food	0·05	−0·03, 0·12	0·04	−0·04, 0·11	−0·01	−0·05, 0·03	−0·01	−0·05, 0·03	0·00	−0·09*	−0·14, −0·03	−0·07*	−0·12, −0·01
Satiety responsiveness	−0·08*	−0·16, −0·01	−0·09*	−0·16, −0·02	−0·01	−0·04, 0·03	−0·01	−0·05, 0·02	0·00	0·03	−0·02, 0·08	0·00	−0·05, 0·06
Slowness in eating	−0·04	−0·13, 0·04	−0·05	−0·14, 0·03	−0·01	−0·05, 0·03	−0·01	−0·05, 0·03	0·00	0·01	−0·05, 0·07	0·00	−0·07, 0·06
Food responsiveness‡	0·02	−0·02, 0·06	0·01	−0·03, 0·06	0·01	−0·01, 0·03	0·01	−0·01, 0·03	0·00	−0·04*	−0·07, −0·01	−0·04*	−0·07, −0·01
Fruit intake (g/d)	13·6	−0·02, 27·2	15·9*	2·1, 29·7	4·7	−1·7, 11·1	5·2	−1·2, 11·7	0·00	−3·0	−12·5, 6·5	−3·4	−13·0, 6·2
Vegetable intake (g/d)	1·6	−8·1, 11·3	3·0	−6·8, 12·9	−3·1	−7·6, 1·5	−2·5	−7·1, 2·2	0·00	0·2	−6·6, 7·0	0·3	−6·6, 7·1

* β Values were significantly different from the group that was introduced to solid foods at age 6 months.
† Adjusted for maternal pre-pregnancy BMI, age, education and ethnicity and for child birth weight, gestational age and sex.
‡ Log-transformed.

several confounding factors. Nevertheless, a few limitations should be discussed. First, we lacked information on maternal diet. Parental fruit and vegetable intake is a predictor of children's fruit and vegetable intake[21]. The parental diet is, however, related to socio-economic status and BMI, both of which we corrected for in our analyses. Therefore, we expect little residual confounding by maternal food preferences. Second, we were unable to correct for the children's total energy intake, as we did not measure the total dietary pattern of the children. This correction would ensure that the differences in fruit and vegetable intake and eating behaviour were not explained by a bigger appetite in general in some children. Furthermore, as the study population under-represents mothers with a low socio-economic status, the results may not be applicable to the entire Dutch population. However, this has probably led to an underestimation of effects, as mothers from low socio-economic groups introduce solid foods at an earlier age and are less likely to breastfeed[44–46]. Third, most of the information was collected prospectively; however, some data on infant nutrition were completed with retrospective information. This might lead to recall bias. However, for breast-feeding and formula feeding, the intra-class correlation coefficient was quite sufficient. Lastly, food responsiveness was positively skewed in the present study, which is not in accordance with other studies. It may be caused by our multi-ethnic population or young age group, as the children in this study were younger than in most other studies that use the CEBQ. However, some smaller studies also used 5-year-old children and did not find skewness in food responsiveness[35,42]. The smaller number of these studies ($n < 500$) could explain the incongruent results.

The WHO[37] recommendations state that children should be exclusively breastfed for 6 months. The present study shows that exclusive breast-feeding for a long period of time is associated with a higher fruit and vegetable intake. The introduction of solid foods before 4 months should be discouraged, as these children seem to be less able to recognise satiety signals. However, the introduction of complementary foods after 6 months is also not recommended, as this may lead to a lower fruit intake (as indicated in the present study), and is associated with nutrient deficiencies and the development of allergies[47,48]. Although the differences in fruit and vegetable intake between the groups are small, they can have large health consequences, as average fruit (137 g/d) and vegetable (79 g/d) intakes were already below the Dutch guidelines for children aged 4–8 years, which recommend 150 g of fruit and 100–150 g of vegetables per d[49]. Therefore, an even lower intake in some children may lead to nutrient deficiencies. Other studies also indicate that the introduction of complementary feeding between the ages of 4 and 6 months is the best choice[47,48].

In conclusion, the present study shows that a long duration of breast-feeding and the introduction of solid foods between the ages of 4 and 6 months are associated with healthy eating behaviour and healthy food choices.

Acknowledgements

The ABCD study was funded by The Netherlands Organisation for Health Research and Development (ZonMw). The authors declare that they have no competing interests. L. M. M. drafted the manuscript and conducted the analyses. T. G. M. V., M. v. E. and R. J. B. J. G. designed the study and obtained funding. All authors made substantial contributions to conception, design and revising the manuscript. All authors read and approved the final manuscript.

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