Breastfeeding is Associated with Improved Child Cognitive Development: A Population-Based Cohort Study

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Objective To assess the association between breastfeeding and child cognitive development in term and preterm children.

Study design We analyzed data on white singleton children from the United Kingdom Millennium Cohort Study. Children were grouped according to breastfeeding duration. Results were stratified by gestational age at birth: 37 to 42 weeks (term, n = 11 101), and 28 to 36 weeks (preterm, n = 778). British Ability Scales tests were administered at age 5 years (naming vocabulary, pattern construction, and picture similarities subscales).

Results The mean scores for all subscales increased with breastfeeding duration. After adjusting for confounders, there was a significant difference in mean score between children who were breastfed and children who were never breastfed: in term children, a two-point increase in score for picture similarities (when breastfed ≥4 months) and naming vocabulary (when breastfed ≥6 months); in preterm children, a 4-point increase for naming vocabulary (when breastfed ≥4 months) and picture similarities (when breastfed ≥2 months) and a 6-point increase for pattern construction (when breastfed ≥2 months). These differences suggest that breastfed children will be 1 to 6 months ahead of children who were never breastfed.

Conclusions In white, singleton children in the United Kingdom, breastfeeding is associated with improved cognitive development, particularly in children born preterm. *(J Pediatr 2012;160:25-32)*.

Many studies have assessed the association between breastfeeding and child cognitive development. On average, breastfed children have an IQ that is approximately 5 points higher than children who were never breastfed.[1,2] Most studies are observational, however, and after adjustment for confounders, particularly maternal education and maternal IQ, this effect is weaker.

Two large and rigorous studies of breastfeeding and cognitive development, with very different study designs, gave conflicting results. In a US national cohort study of 5475 children of normal birth weight, ever being breastfed was associated with almost a 5-point higher child IQ, but this decreased after adjustment for confounders (mean difference, 0.5; 95% CI, −0.2-1.2).[3] In a cluster randomized trial of an intervention aimed at the promotion of breastfeeding in 13 889 children in Belarus, there was a 6-point difference in the cluster-adjusted mean IQ between the intervention and control arms,[4] suggesting that the intervention was associated with a higher IQ.

Few studies of cognitive development have assessed whether there is a dose-response relationship for both any breastfeeding and exclusive breastfeeding. Here we present data for the association between the duration of any breastfeeding and exclusive breastfeeding on cognitive development at age 5 years in a UK cohort of 11 879 children. We have adjusted for many factors from pregnancy and throughout the life course of the child, which were potentially associated with cognitive development. Our study is unique in that we stratified the population according to prematurity at birth. Prematurity is strongly associated with infant feeding[5-7] and cognitive development,[8] and earlier studies have observed a larger effect of breastfeeding on cognitive development in children born preterm than in children born at term.[1,2]

Methods

Millennium Cohort Study

The Millennium Cohort Study (MCS) is a nationally representative UK longitudinal study of 18 818 infants born in the United Kingdom.[9] A random two-stage sample of all infants born in England and Wales between September 2000 and August 2001 and in Scotland and Northern Ireland between November 2000 and January 2002 who were alive and living in the United Kingdom at age 9 months was

BAS	British Ability Scales
MCS	Millennium Cohort Study
NVQ	National Vocational Qualification

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drawn from Child Benefit registers. Child Benefit claims in the United Kingdom cover virtually all children, except those ineligible because of recent or temporary immigrant status. The MCS does not cover births in which the infant died within the first 9 to 10 months after birth, but these constituted <1% of all births.[10] Stratified sampling by electoral ward (defined geographical area) was used, with over-sampling of ethnic minority and disadvantaged areas. Children were recruited at approximately age 9 months (sweep 1), and detailed information was collected on a range of socioeconomic and health factors with parental interview. Parents were interviewed again when the children were 3, 5, and 7 years of age (sweeps 2-4).

Infant Feeding. Breastfeeding initiation was assessed by the sweep 1 question, "Did you ever try to breastfeed your baby?" Breastfeeding duration and exclusivity were estimated by using the sweep 1 questions about the age of the infant when last given breast milk and when first given formula, other types of milk, and solid foods. Breastfeeding duration after sweep 1 was assessed by using the sweep 2 question, "How old was the child when s/he last had breast milk?" The duration of "any breastfeeding" (ie, exclusive or partial breastfeeding) and "exclusive breastfeeding" were grouped in 2-month bands: never breastfed; <2.0 months; 2.0 to 3.9 months; ≥4.0 months (exclusive breastfeeding for 4-6 months was recommended at the time of the study). In the term group, numbers were large enough for us to separate children who were breastfed ≥4 months as: 4.0 to 5.9 months, 6.0 to 11.9 months, and ≥12.0 months. No information was available about the types of formula fed to children who never were breastfed or in whom breastfeeding was supplemented.

Cognitive Development. Cognitive development was assessed at sweep 3 by using the British Ability Scales (BAS) Second Edition, which is a battery of individually administered tests of cognitive abilities and educational achievements suitable for use from ages 2 years 6 months to 17 years 11 months.[11,12] The tests have been validated by comparing the results of the tests with the original version of BAS, the Weschler intelligence scale, and Wechsler Objective Reading Dimensions.[11] Three BAS subscales were used in the MCS (naming vocabulary, picture similarities, and pattern construction); these assess core aspects of verbal abilities, pictorial reasoning, and spatial abilities. The subscales are robust and individually interpretable, helping us to understand the child's abilities in the 3 most significant information-processing skills.[12] Trained interviewers measured the subscales directly from the MCS children by using Computer-Assisted Personal Interviewing. The tests were not performed when the child had a learning disability or severe behavioral problem or when the child did not have the required level of English or Welsh vocabulary (the tests were administered in these languages only).

Exclusions and Loss to Follow-up. The analysis focused on the effects of breastfeeding in white, singleton children with a gestational age at birth of at least 28 completed weeks, for whom the main respondent was the child's natural mother. Children from non-white ethnic groups were excluded because of concerns about the validity of the BAS assessments in these groups.[11,12] In the MCS, the BAS assessments were only available in English or Welsh, so we also excluded children who did not speak English at home. Children who were born extremely preterm (gestation <28 weeks) were excluded because they are more likely to have had complex feeding patterns and developmental problems that may not have been accurately captured in the MCS data.

Of the 18 818 children recruited at sweep 1, we excluded 522 multiples, 37 children for whom data were not available on their natural mother, 244 children with gestational age <28 weeks or missing, 79 children with implausible data on birth weight, gestational age, or both, and 3117 children who were not white. This yielded an eligible study population of 14 819 children recruited at sweep 1, of whom 11 951 (81%) participated in sweep 3. A further 72 children were excluded because they did not speak English at home at sweep 3. Thus, the study population was based on 11 879 children (11 101 who were born at term and 778 born preterm). The number of children with data on BAS subscales at sweep 3 was 11 705 for naming vocabulary, 11 720 for picture similarities, and 11 658 for pattern construction (ie, 79% of the eligible population who were recruited in sweep 1).

Statistical Methods

All analysis was conducted separately in children who were born at term (gestation ≥37 completed weeks) and children who were born preterm (gestation 28-36 weeks). The mean BAS score for each subscale was estimated in each breastfeeding group. Linear regression was used to estimate the difference in mean BAS scores across breastfeeding groups after adjustment for baby's sex, birth weight, and gestational age at birth (in weeks), and the following potential confounders and mediators.

First, adjustment was made for these pregnancy-related and sociodemographic confounders: whether the pregnancy was planned; whether the baby was the first born for the mother; maternal alcohol use (never, low, moderate, high[13]) and smoking in pregnancy (non-smoker, gave up when pregnant, and <10, 10-19, 20-29, or ≥30 cigarettes per day); whether the baby had special/intensive care at birth; maternal age (<20, 20-24, 25-29, 29-34, or ≥35 years); marital status of mother (married, co-habiting, lone parent); and maternal education (grouped as "no qualification/other" or one of 5 National Vocational Qualification [NVQ] groups: NVQ 1 and 2, equivalent to qualifications at the end of compulsory schooling at age 16 years; NVQ 3, equivalent to "A level" qualifications at the end of secondary school at age 18 years; NVQ 4, bachelor's degree or equivalent; NVQ 5, postgraduate degree/diploma); social class (highest of mother/partner coded with the United Kingdom National Statistics Socioeconomic Class with 4 groups: managerial/professional, intermediate, routine/manual, never worked/long-term unemployed); and whether languages other than English were spoken in the household. Variables in this group were included in the models when they were significantly ($P < .05$)

associated with the outcome after adjustment for other socio-demographic and pregnancy-related variables in the model; this model is referred to as partially adjusted.

Second, adjustment was made for these potential mediators related to parenting and early years learning: mother's and father's parenting beliefs and time spent doing childcare activities as reported at sweep 1; Condon maternal attachment questionnaire[14] at sweep 1; frequency of mother and father doing activities with the child at sweep 3 (eg, reading, drawing); mother's perceived parenting competence at sweep 3; maternal depression measured by using the Malaise Inventory score[15] at sweep 1 and Kessler questionnaire[16] at sweep 3; child care at sweep 1 (none, nursery, child minder, informal); child's age in months when started formal child care (nursery, child minder, pre-school); and number of months since child had started school and whether full-time or part-time. Variables in this group were added to the partially adjusted models when they were significantly ($P < .05$) associated with the outcome after adjustment for the other parenting and early years variables; these models are referred to as fully adjusted.

A variable was considered statistically significant when any of its co-efficients yielded a Wald test P value <.05. The variables that remained in the partially and fully adjusted final models are given in the footnotes to Tables I and II. Finally, the co-efficients from the fully adjusted regression models were expressed as the equivalent progress one would expect in a month in an average 5-year-old child; this was done by using the age-equivalents derived for the MCS population.[17,18] For example, in a 1-month period, we would expect the BAS scores of a typical 5-year-old child to increase by 0.83 for naming vocabulary, 0.62 for picture similarities, and 1.81 for pattern construction. We also tested whether breastfeeding had a different association with cognitive development in boys compared with girls,[19] but the interaction was not statistically significant and was not included in the models.

All analyses allowed for the clustered, stratified sample by using the "survey commands" in Stata software version 10 (Stata Corporation, College Station, Texas). Thus, all CIs and P values account for clustering, and all proportions, means, and regression coefficients are weighted by using sweep 3 weights. These weights allow for non-response at all sweeps. Non-response at sweep 3 was the largest source of missing data. Of the children included in the analysis, <5% had missing data on most of the potential confounders and mediators. The only exception was for children in lone-parent households who had data missing from fathers; these children were included as a separate category of the parenting variables for fathers.

Results

Table III shows the descriptive characteristics in the term (n = 11 101) and preterm (n = 778) groups. Eight percent

Table I. Regression coefficients showing difference in mean BAS scores for breastfed compared with never breastfed children (born at term)

		Any breastfeeding (partial or exclusive)			Exclusive breastfeeding
Duration of breastfeeding	Mean (n)	Crude Coefficient (95% CI)	Partially adjusted coefficient* (95% CI)	Fully adjusted coefficient† (95% CI)	Fully adjusted coefficient† (95% CI)
BAS naming vocabulary scale		n = 10 944	n = 10 929	n = 10 416	n = 10 416
Never	106.5 (3825)	Reference	Reference	Reference	Reference
<2.0 months	110.2 (2901)	3.7 (2.8-4.6)	0.7 (−0.1-1.5)	0.7 (−0.1-1.5)	1.1 (0.4-1.9)
2.0-3.9 months	111.8 (1047)	5.4 (4.1-6.6)	1.2 (0-2.4)	1.2 (0-2.4)	1.0 (0-2.0)
4.0-5.9 months‡	113.0 (889)	6.5 (5.1-7.9)	1.2 (0-2.5)	1.0 (−0.3-2.3)	
6.0-11.9 months	114.1 (1392)	7.7 (6.5-8.8)	2.2 (1.2-3.2)	2.0 (1.0-3.0)	1.6 (0.6-2.5)
≥12.0 months	114.2 (890)	7.7 (6.6-8.9)	2.4 (1.3-3.5)	2.4 (1.3-3.6)	
BAS picture similarities scale		n = 10 957	n = 10 949	n = 10 526	n = 10 641
Never	79.9 (3836)	Reference	Reference	Reference	Reference
<2.0 months	82.4 (2901)	2.5 (1.8-3.2)	1.4 (0.7-2.1)	1.4 (0.7-2.1)	1.4 (0.7-2.0)
2.0-3.9 months	82.6 (1047)	2.7 (1.7-3.7)	1.0 (0.1-1.9)	0.9 (0-1.9)	1.4 (0.6-2.2)
4.0-5.9 months‡	83.8 (889)	4.0 (3.0-5.0)	1.8 (0.9-2.8)	1.7 (0.8-2.7)	
6.0-11.9 months	84.1 (1393)	4.2 (3.2-5.2)	2.0 (1.0-3.0)	1.9 (0.9-2.9)	2.0 (1.1-3.0)
≥12.0 months	83.9 (891)	4.0 (3.0-5.0)	1.7 (0.7-2.7)	1.9 (0.9-2.8)	
BAS pattern construction scale		n = 10 902	n = 10 887	n = 10 678	n = 10 678
Never	85.4 (3812)	Reference	Reference	Reference	Reference
<2.0 months	88.5 (2885)	3.1 (2.0-4.2)	0.9 (−0.2-2.0)	1.0 (−0.1-2.1)	1.1 (0.1-2.1)
2.0-3.9 months	90.4 (1042)	5.0 (3.6-6.4)	1.7 (0.4-3.0)	1.7 (0.3-3.0)	2.1 (0.9-3.4)
4.0-5.9 months‡	92.2 (886)	6.8 (5.2-8.4)	2.5 (1.0-4.0)	2.4 (0.8-3.9)	
6.0-11.9 months	92.1 (1389)	6.7 (5.2-8.2)	2.0 (0.6-3.4)	2.0 (0.5-3.4)	1.4 (0-2.8)
≥12.0 months	91.3 (888)	5.9 (4.3-7.6)	1.1 (−0.5-2.7)	1.0 (−0.6-2.6)	

*All models were adjusted for gestation, birth weight, baby's sex, mother's age (BAS naming vocabulary and BAS picture similarities only), household socioeconomic status, mother's education, whether the baby was firstborn (BAS naming vocabulary and BAS picture similarities only), alcohol in pregnancy (BAS naming vocabulary and BAS pattern construction only), smoking in pregnancy (BAS pattern construction only), admission to neonatal intensive care unit (BAS naming vocabulary and BAS pattern construction only), and language spoken at home (BAS naming vocabulary only).
†All models were adjusted as in * with additional adjustment for BAS naming vocabulary: maternal belief at sweep 1 in the importance of stimulation and regular eating and sleeping patterns; maternal reading with child and getting child to obey instructions at sweep 3; maternal depression at sweep 3; maternal parenting competence at sweep 3; and child care at sweep 1; and whether full/part time at school. BAS picture similarities: getting child to obey instructions at sweep 3; maternal depression at sweep 3; child care at sweep 1; and months since started school. BAS pattern construction: maternal belief at sweep 1 in the importance of talking to a baby and regular eating and sleeping patterns; maternal telling stories to child, painting/drawing with the child and spends plenty of time with child at sweep 3; maternal depression at sweep 3; months since started school; and whether full/part time at school.
‡For exclusive breastfeeding results, this category is ≥4 months.

Table II. Regression coefficients showing difference in mean BAS scores for breastfed compared with never breastfed children (born preterm)

		Any breastfeeding (partial or exclusive)			Exclusive breastfeeding
Duration of breastfeeding	Mean (n)	Crude coefficient (95% CI)	Partially adjusted coefficient* (95% CI)	Fully adjusted coefficient† (95% CI)	Fully adjusted coefficient† (95% CI)
BAS naming vocabulary scale		n = 761	n = 760	n = 745	n = 745
Never	106.2 (292)	Reference	Reference	Reference	Reference
<2.0 months	108.2 (245)	2.0 (−1.0-4.9)	0.8 (−1.9-3.5)	0.6 (−2.2-3.3)	1.6 (−1.0-4.3)
2.0-3.9 months	111.4 (69)	5.2 (1.8-8.7)	2.2 (−1.1-5.6)	1.9 (−1.4-5.3)	1.4 (−1.8-4.5)
≥4.0 months	115.5 (155)	9.3 (6.3 to12.2)	5.0 (2.2-7.7)	4.6 (1.7-7.5)	4.2 (0.8-7.6)
BAS picture similarities scale		n = 763	n = 762	n = 758	n = 758
Never	78.8 (295)	Reference	Reference	Reference	Reference
<2.0 months	80.8 (245)	2.0 (−0.4-4.4)	1.8 (−0.5-4.1)	2.0 (−0.3-4.4)	2.8 (0.6-4.9)
2.0-3.9 months	84.5 (68)	5.7 (2.6-8.7)	4.2 (0.9-7.6)	4.7 (1.5-7.9)	2.1 (−1.8-5.9)
≥4.0 months	84.2 (155)	5.4 (3.0-7.9)	3.5 (0.7-6.4)	4.0 (1.2-6.8)	4.9 (2.3-7.6)
BAS pattern construction scale		n = 756	n = 755	n = 727	n = 727
Never	80.6 (289)	Reference	Reference	Reference	Reference
<2.0 months	85.1 (245)	4.4 (0.1-8.7)	3.7 (−0.4-7.8)	3.1 (−1.0-7.2)	3.0 (−1.0-7.0)
2.0-3.9 months	89.2 (67)	8.6 (3.9-13.2)	7.1 (2.4-11.8)	6.1 (1.2-10.9)	7.3 (2.4-12.2)
≥4.0 months	89.3 (155)	8.7 (3.4-14.0)	6.2 (0.8-11.5)	6.0 (1.0-11.1)	7.2 (1.7-12.6)

*All models were adjusted for gestation, birth weight, baby's sex, mother's age (BAS naming vocabulary and BAS picture similarities only), mother's education, household socioeconomic status (BAS picture similarities only), whether the baby was firstborn (BAS naming vocabulary only), whether pregnancy was planned (BAS naming vocabulary and picture similarities only), alcohol in pregnancy (BAS pattern construction only), smoking in pregnancy (BAS pattern construction only).
†All models were adjusted as in * with additional adjustment for
BAS naming vocabulary: maternal belief at sweep 1 in talking-a baby and the importance of stimulation; maternal depression at sweep 3.
BAS picture similarities: maternal reading with child at sweep 3 and child care at sweep 1; BAS pattern construction: maternal painting/drawing with child at sweep 3; and getting child-obey instructions at sweep 3.

of mothers reported moderate or high alcohol consumption in pregnancy, and 23% of mothers smoked in pregnancy. Fourteen percent of mothers were lone parents, and 7% of mothers had postgraduate degrees. Many of these characteristics were similar in the preterm group. As expected, the most striking differences in the groups were for mean birth weight and having special care at birth. Mothers in the preterm group were more likely to have smoked in pregnancy and less likely to have postgraduate degrees. The preterm group was also less likely to have been breastfed ever (63% versus 68%), breastfed for at least 4 months (22% versus 31%) and exclusively breastfed for at least 4 months (11% versus 16%) compared with the term group. The variables related to parenting and early years learning that remained in any of the 6 (two gestational groups; 3 BAS subscales) fully adjusted models are shown in Table III. There were no striking differences in these variables between the term and preterm groups.

Many of these characteristics were associated with breastfeeding duration (Table III). There were striking associations between longer duration of breastfeeding and the pregnancy being planned, not smoking in pregnancy, older maternal age, not being a lone parent, higher levels of education, and higher social class. Mothers who breastfed for at least 4 months were more likely to read to their child daily (61%) compared with mothers who never breastfed (45%).

Association between Breastfeeding and BAS Scores in the Term Group

In the children born at term, the mean naming vocabulary score increased with breastfeeding duration from 106.5 in children who were never breastfed to 114.2 in children who were breastfed for at least 12 months (difference = 7.7, Table I). The difference in means between each of the breastfeeding groups and the never breastfed group became substantially smaller when partially adjusted for confounders, most notably maternal education (data available on request) and social class, and decreased further when fully adjusted. However, there remained a two-point difference between children who were breastfed for at least 6 months and children who were never breastfed. Breastfeeding for at least 4 months was associated with a two-point increase in score for picture similarities (Table I). Any length of breastfeeding was associated with at least a one-point increase in score for pattern construction, but there was no clear trend with increasing breastfeeding duration. The proportion of children exclusively breastfed for at least 4 months increased with the duration of any (ie, partial or exclusive) breastfeeding from 38% in children breastfed for 4.0 to 5.9 months, to 53% in children breastfed for 6.0 to 11.9 months and 65% in children breastfed for at least 12 months. The association between exclusive breastfeeding and BAS scores was broadly similar to that for any breastfeeding; for brevity, only the fully adjusted results are shown (Table I).

Association between Breastfeeding and BAS Scores in the Preterm Group

The mean scores for picture similarities and pattern construction tended to be lower in the preterm group (Table II) compared with the term group (Table I). In the fully adjusted models for the preterm group, breastfeeding for at least 2 months was associated with a 4-point increase in score for picture similarities and a 6-point increase in score for pattern construction. Breastfeeding for at least 4 months

Table III. Descriptive characteristics of the study population according to gestational age groups and breastfeeding duration groups

	Gestational age		Any breastfeeding duration (months)			
	Term n = 11 101	Preterm n = 778	Never n = 4204	<2.0 n = 3200	2.0-3.9 n = 1123	≥4.0 n = 3352
Pregnancy-related*						
Baby was firstborn, %	42	46	36	50	47	41
Pregnancy not planned, %	42	46	55	42	35	30
Maternal smoking in pregnancy, %	23	30	52	41	35	20
Maternal alcohol in pregnancy,† %	8	9	8	8	8	9
Mean birth weight, kg (SD)	3.5 (0.5)	2.5 (0.6)	3.4 (0.6)	3.4 (0.6)	3.4 (0.6)	3.5 (0.5)
Female baby, %	49	45	50	47	50	49
Admission to special care, %	6	51	8	10	10	7
Sociodemographic						
Mean maternal age,* years (SD)	29 (5.8)	29 (6.2)	27 (6.0)	28 (5.6)	30 (5.6)	31 (4.9)
Lone parent,* %	14	16	25	13	9	5
Speak only English at home,§ %	99	99	99	99	99	98
Maternal postgraduate education, %	7	4	3	6	7	11
High parental occupation,¶ %	51	46	29	48	61	73
Parenting—strong maternal beliefs on importance of*:						
Talking to a baby, %	84	81	78	84	85	89
Stimulation for baby's development, %	66	62	58	67	68	73
Regular eating and sleeping patterns, %	52	51	52	55	55	49
Maternal parenting competence§						
Believes to be very good/better than average, %	52	44	42	49	56	62
Maternal activities and discipline with the child§						
Reading (daily), %	52	51	45	52	51	61
Tell stories (daily), %	12	11	12	12	11	11
Painting/drawing (daily), %	8	9	9	8	6	8
Child obeys instructions (always), %	54	51	51	55	55	55
Time spent with child (plenty/just enough), %	66	65	69	64	63	66
Maternal depression,§‡ %	31	35	34	33	31	27
Childcare*						
No childcare, %	60	66	69	58	53	56
Nursery/childminder, %	18	14	9	17	24	26
Informal childcare, %	22	21	22	25	23	17
Schooling§						
Attends full time, %	97	96	96	97	97	96
Months at school, mean (SD)	6.9 (2.6)	6.9 (2.6)	6.8 (2.6)	7.0 (2.6)	7.0 (2.5)	6.9 (2.5)

For brevity, many variables have been dichotomized in this table, but all categories have been included in models.
*Measured at Sweep 1.
†Moderate or high maternal alcohol in pregnancy.
‡Kessler score ≥4 indicating medium to high psychological distress.
§Measured at Sweep 3.
¶Mother or father is manager or professional or technical at sweeps 1 or 3.

was associated with a 4-point increase in score for naming vocabulary. A similar effect was observed across all subscales for exclusive breastfeeding (Table II). Of the preterm children who were breastfed for at least 4 months, approximately half (51%) were exclusively breastfed for at least 4 months; of the preterm children breastfed for 2.0 to 3.9 months, 58% were exclusively breastfed for at least 2 months.

How Do These Differences in BAS Scores Compare with the Progress of an Average 5-Year-Old Child?

The fully adjusted differences from Tables I and II have been converted into age-equivalent scores that indicate the child's developmental progress; these differences show how many months ahead breastfed children are compared with children who were never breastfed. In the term group, children who were breastfed for at least 4 months tended to be approximately 3 months ahead of children who were never breastfed on picture similarities and children breastfed for at least 6 months were approximately 2 to 3 months ahead on naming vocabulary (Table IV). For pattern construction, the effects were much smaller, and there was no clear trend with increasing breastfeeding duration. Preterm children who were breastfed for at least 2 months tended to be at least 6 months ahead of children who were never breastfed on picture similarities and approximately 3 months ahead on pattern construction. When they were breastfed for at least 4 months, preterm children were approximately 5 to 6 months ahead on naming vocabulary.

Discussion

Our results suggest that breastfeeding, particularly when it is prolonged, is associated with better child cognitive development. The effect was smaller after adjustment for confounders, particularly maternal education and social class. Even after allowing for many known confounders, a two-point increase in BAS score at age 5 years was associated with prolonged

Table IV. Number of months ahead a breastfed child will be compared with a never breastfed child according to BAS subscale and gestational age group

	Children born at term		Children born preterm	
	Any breastfeeding	Exclusive breastfeeding	Any breastfeeding	Exclusive breastfeeding
Duration of breastfeeding	Months ahead	Months ahead	Months ahead	Months ahead
BAS naming vocabulary scale	n = 10 414	n = 10 414	n = 745	n = 745
Never	Reference	Reference	Reference	Reference
<2.0 months	*	1-2	*	*
2.0-3.9 months	1-2	*	*	*
4.0-5.9 months†	*			
6.0-11.9 months	2-3	2	5-6	5
≥12.0 months	3			
BAS picture similarities scale	n = 10 526	n = 10 641	n = 758	n = 758
Never	Reference	Reference	Reference	Reference
<2.0 months	2-3	2-3	*	4
2.0-3.9 months	*	2-3	7-8	*
4.0-5.9 months†	3			
6.0-11.9 months	3	3	6-7	8
≥12.0 months	3			
BAS pattern construction scale	n = 10 678	n = 10 195	n = 727	n = 727
Never	Reference	Reference	Reference	Reference
<2.0 months	*	<1	*	*
2.0-3.9 months	1	1	3	4
4.0-5.9 months†	1			
6.0-11.9 months	1	<1	3	4
≥12.0 months	<1			

Results have been obtained by converting coefficients in Tables I and II to months as follows: in a 1-month period, we would expect the BAS scores of a typical 5-year-old child to increase by 0.83 for naming vocabulary, 0.62 for picture similarities, and 1.81 for pattern construction.[15,16]
*Note that results have not been presented if the difference in mean in Table I or II was not statistically significant at the 5% level.
†For exclusive breastfeeding results and results in preterm group, this category is ≥4 months.

breastfeeding (≥4 months for picture similarities and ≥ at least 6 months for naming vocabulary) in children who were born at term. In preterm children, the effects were more striking, even for those breastfed for at least 2 months. These results, expressed as the equivalent progress one would expect in a month in an average 5-year-old child, suggest that on these tests children who were breastfed will be a few months ahead of children who were never breastfed.

The main strengths of our study are the large sample size, the separate effects of the duration of any breastfeeding and exclusive breastfeeding in the term and preterm groups, and the adjustment for a wide range of factors that tap into multiple dimensions of the child's environment. The main limitation is that the study was not randomized and thus is prone to the problem of confounding. One of the strongest potential confounders is maternal IQ,[3] although a strong association between breastfeeding and child IQ has remained after adjustment for maternal IQ in many studies.[1,20] Maternal IQ was not measured in the MCS, but our estimates reduced substantially with adjustment for other confounders, especially maternal education. There is likely to be some residual confounding because of maternal IQ and other unmeasured confounders. However, the striking effect observed in the preterm group is suggestive of at least some direct effect of breast milk.

Our data on BAS scores are not standardized and are therefore not directly comparable with those from other studies. However, our results are consistent with the findings of a meta-analysis in which the average adjusted increase in IQ associated with ever breastfeeding was 2.7 points in children of normal birth weight and 5.2 points in children with low birth weight.[1] Several large studies published since the meta-analysis show an association between breastfeeding and cognitive development,[4,5,21-25] but others show no effect.[3,26] As is the case with many studies, our data do not distinguish between feeding directly from the breast and other modes of receiving breast milk, such as via a tube, cup, or bottle. Thus, there may be some misclassification of breastfeeding, particularly for the very preterm babies. By classifying breastfeeding duration into 2 monthly bands, we hope to have minimized such misclassification. Few studies of cognitive development have analyzed the duration of any breastfeeding and exclusive breastfeeding. In our study, both variables had a similar association with the study outcomes, although there was much overlap in these variables. Any breastfeeding for 4.0 to 5.9 months was significantly associated with picture similarities and pattern construction in the term group, although only 38% of this group was exclusively breastfed for at least 4 months.

One potential mechanism for an effect of breastfeeding on cognitive development is that breast milk contains higher concentrations of essential long-chain polyunsaturated fatty acids than formula milk. These have been shown to be essential for brain development,[27] and this is particularly important in the preterm baby. Some MCS babies may have received formula supplemented with artificial essential long-chain polyunsaturated fatty acids, but evidence is lacking on the effectiveness of these on cognitive outcomes.[28,29] Breast milk also contains

growth factors and hormones, lacking in formula, which influence brain biochemistry and functional development.[30] Alternatively, it could be the physical or social interaction associated with breastfeeding that stimulates cognitive development. Another potential mechanism is that formula feeding is associated with infantile infections and delayed developmental milestones in this population[31,32] and others,[2] and these could affect early and, in turn, later cognitive development. A combination of these mechanisms could explain the size of effect here, particularly in children born preterm.

In conclusion, we have observed an association between prolonged breastfeeding and higher cognitive development scores. In a field in which randomized studies are neither ethical nor feasible, this well-controlled, large cohort study adds considerably to the evidence base on this topic. Our results imply that not breastfeeding will delay cognitive development by a few months. Even allowing for some residual confounding, prolonged breastfeeding is likely to be associated with a quantifiable improvement in child cognitive development, particularly in children who were born preterm. These improvements were apparent at a breastfeeding duration of 4 to 6 months in term children and a duration of 2 months in preterm children, in whom the rates of exclusive breastfeeding were relatively low.

More research is needed on the association between breastfeeding and child cognitive development to elucidate the causal mechanisms and identify subgroups, such as preterm babies, who might benefit most from breastfeeding. This would require large studies collecting detailed infant feeding data, including duration of partial and exclusive breastfeeding, mode of receiving breast milk, and type of formula. ■

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50 Years Ago in *THE JOURNAL OF PEDIATRICS*

Relationships of Doctors-in-Training with Pediatric Outpatients

Glaser HH, Lynn DB, Harrison GS. J Pediatr 1962;60:142-43

The authors reported a mixed-methods study of pediatric visits that directly observed the interactions of interns, residents, and fellows with families and evaluated family perspectives via postvisit interviews. Although the interactions were moderately satisfactory for the families, the families' real needs often were not expressed—an issue that families still face today, as evidenced by the family-centered care movement. Interaction complexity, physician clarity, and positive attributes (eg, responsiveness) increased with physician training. Because visit conditions were assumed to be optimal, the influence of such factors as visit length and continuity in the doctor–family relationship were not explored, but their potential influence was discussed.

This study was a forerunner of the next 50 years of research on doctor–family interaction, facilitated by advanced technology, including audio or video recording of visits and sophisticated software to support rigorous analytic techniques. These advances have allowed for objective assessment of specific critical aspects of communication and consideration of such influences as the ongoing doctor–family relationship, as well as physician, child, and parent characteristics and communication styles.[1-3]

Since the publication of this study, resident duty hours have been drastically reduced, leading to concerns about continuity of care, residents' preparedness for the realities of medical practice, and ultimately patient outcomes and satisfaction.[4] For today's physicians managing the onslaught of pediatric chronic diseases, such as obesity and type 2 diabetes, communication skills are crucial to implementing recommended family-centered care approaches. To inform their training, more studies are needed to examine how doctor–family interactions evolve into relationships that optimize chronic disease visit satisfaction and outcomes.[5]

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