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The Effect Of Breastfeeding On Child Development At 5 Years: A Cohort Study

PJ QUINN,[1] M O'CALLAGHAN,[2] GM WILLIAMS,[3] JM NAJMAN,[4] MJ ANDERSEN[5] and W BOR[6]

1 Mater Children's Hospital
2 Child Development and Rehabilitation Services, Mater Children's Hospital,
3 Tropical Health and Nutrition Program, University of Queensland
4 Department of Anthropology and Sociology,University of Queensland
5 Department of Obstetrics and Gynaecology, University of Queensland
6 Child and Youth Mental Health, Royal Children's Hospital Health District, Brisbane, Queensland, Australia

Abstract

Objective: It is uncertain to what degree the relationship between breastfeeding and later cognitive development is a true biological effect, or is confounded by psychosocial factors. The study aim was to further investigate this relationship and the effect of duration of breast feeding on cognitive development.

Methods: A total of 3880 children were followed from birth. Breastfeeding duration was measured by questionaire at 6 months of age and a Peabody Picture Vocabulary Test Revised (PPVT-R) was administered at 5 years. PPVT-R scores were adjusted for the effects of a large array of biological and psychosocial confounders. The relationship between breastfeeding and the mean PPVT-R scores were examined using analysis of variance and multiple linear regression.

Results: A strong positive relationship was demonstrated between breastfeeding and the PPVT-R scores with increasing scores with increased duration of breastfeeding. After adjusting for a wide range of biological and social factors, the adjusted mean for those breastfed for 6 months or more was 8.2 points higher for females and 5.8 points for males when compared to those never breastfed.

Conclusion: These findings suggest a significant benefit to child development is conferred by breastfeeding and is related independently to longer periods of breastfeeding.

Keywords: breastfeeding; child development; intelligence; Peabody; cohort studies

A substantial body of evidence suggests a benefit on cognitive development in infants as a result of breastfeeding. [1–7] Several population studies have been conducted in term infants, the majority of which show a positive effect on cognitive development in breastfed infants. [2–5] This positive association is by no means universal or necessarily indicative of a causal association. Several studies have shown that a large number of social and parental educational factors that could reasonably be expected to influence child development independently effect the incidence of breastfeeding. [2–4] Studies by Silva *et al.* [8] Jacobson *et al.*,[9] and Wigg *et al.*[10] suggest that once con-founders such as social advantage, maternal education and intelligence, and the quality of a child's developmental experiences were taken into account, the differences between bottle and breastfed groups were no longer statistically significant. A number of criticisms including lack of statistical power,[8] populations initially selected for other exposures [9,10] and the timing and quality of measurement of intervening variables [9] can be made of these studies. Pollock [4] selected a cohort of relatively advantaged mothers, and after controlling for factors associated with the likelihood of breastfeeding, demonstrated that infants breastfed for at least 3 months had small though statistically significant improvements in mean picture vocabulary scores at 5 years and ability scores at 10 years.

If the association between breastfeeding and infant cognitive development is causal, two possible explanations have been suggested. First, a unique nutritional component of breast milk, possibly a lipid, could be essential for optimal brain development. The most often discussed is the Omega-3 fatty acids, [7,11,12] but it is possible that other lipids present in breast milk but not in the vegetable oils used in formulas could be responsible. Second, it is possible that the benefits reported in other studies could be the result of stronger psychological attachment between mother and baby facilitating cognitive development and not solely related to the ingestion of breast milk.

To further investigate the relationship between duration of breastfeeding and its effect on cognitive development, we used data from the Mater Hospital-University of Queensland Study of Pregnancy (MUSP) project [13] to examine the hypothesis that duration of breast feeding would have direct beneficial effects on child development at 5 years and that this effect would be independent of social and family influences.

METHODS

Subjects

A total of 8556 women attending their first antenatal visit at the Mater Mothers Hospital between 1981 and 1984 were enrolled in the Mater Hospital-University of Queensland Study of Pregnancy (MUSP) project.[13] After stillbirths, neonatal or infant deaths, multiple births, adoptions, and those delivered at other centres were excluded, 7357 singleton children remained in the study after birth. Data were collected at enrolment, shortly after birth, at 6 months and at 5 years after delivery by questionnaire and included social features of the family and psychological characteristics of the mother. Biological measures of the pregnancy, birth, and delivery were recorded by obstetric staff associated with the project at or shortly after birth. At 5 years, a similar questionnaire was completed by 5627 mothers who could be contacted. Because of a lack of funding in the later part of the study and practical issues such as distance, only 4049 children were able to attend for a clinical assessment at the 5 years follow up including administration of the Peabody Picture Vocabulary Test Revised (PPVT-R). [14]

Predictor variables

Mothers were asked in the 6-month questionnaire whether they had breastfed their infants. Mothers were also asked to categorize the period for which they had breastfed as never breastfed, fed less than 3 weeks, 3 weeks to less than 7 weeks, 7 weeks to less than 4 months, 4 months to less than 6 months, or still breastfeeding at 6 months. No distinction was made between partial or complete breastfeeding.

Outcome measures

At 5 years, the PPVT-R was administered. The PPVT-R is a standardized test of receptive language, which has been extensively validated against other standardized tests of intelligence in children and is indicative of verbal intelligence. [14–16] Children with major neurological abnormalities such as cerebral palsy and those for whom the data was incomplete were excluded leaving 3880 subjects (1842 females and 2038 males) for final analysis.

Other variables measured

Because of potential confounding, a large number of psycho-logical and biological parameters were examined. These included the sex of the infant, birth weight, Apgar at 5 min and small for gestational age status (defined as less than the 10th percentile for birthweight given gender and gestation within the cohort). The number of ear infections over the previous 12 months, a history of previous ear surgery and overall health of the child were collected at 5 years, using questions from the Rand Health Survey. [17] In addition, at the 5-year follow up, the number of children in the household and the time the subject child spent in daycare or preschool were measured. Psycho-social and maternal factors included marital status at the first pregnancy visit and the 5-year follow up, whether or not the parents were born in an English-speaking country and how long they had lived in Australia, the level of maternal education at the first visit, and maternal age and families experiencing consistent poverty at each follow up. Four questions at the 6-month follow up regarding the degree to which the mother played with the child, talked to the child, taught the child, and encouraged the child’s interests were used as a measure of infant stimulation (Cronbach alpha 0.68). The level of maternal cigarette smoking in early pregnancy, late pregnancy and at the 5-year follow up was recorded. Symptoms of maternal depression and anxiety were measured in early pregnancy, at birth, at 6 months, and at the 5-year follow up using the Delusions Symptoms States Inventory (DSSI).[18,19]

Statistical analysis

Differences in the mean PPVT-R score for each breastfeeding category were examined using analysis of variance. To examine for potential confounding, the relationship between each child, maternal and social variables described in the methods above and the PPVT-R score were examined. Those factors that were significantly ($P < 0.05$) associated with the PPVT-R score were added simultaneously to a multiple linear regression model together with breastfeeding with the PPVT-R score as the dependant variable. The six breastfeeding groups were treated as five ‘dummy’ categories, with the ‘Never breastfed group’ being the reference category. Analyses were preformed separately for male and female children.

Table 1 Comparison of Children completing Peabody Picture Vocabulary Test Revised assessment and children not assessed at 5 years

First pregnancy visit	Not assessed *n* = 4653 %	Assessed *n* = 3880 %	*P* value
Maternal Education			
Primary	4.8	4.3	
Started secondary	15.3	12.9	
Completed Grade 10	53.2	55.0	
Completed Grade 12	10.1	9.1	
College	13.8	16.3	
University	2.8	2.3	0.001
Maternal age (years)			
< 20	33.2	35.9	
20–24	30.9	11.2	
25–29	22.1	31.7	
30–34	10.0	15.5	
> 34	3.8	5.6	0.000
Marital status			
Married	67.3	81.7	
Single	14.0	7.8	
Living together	15.0	8.5	
Other	3.7	2.0	0.000
Maternal mental health			
Depression	7.0	4.5	0.000
Anxiety	15.1	10.6	0.000
Birth *n* = 3871 *n* = 3880			
Birthweight (g)*	3320 (585)	3400 (524)	0.000
Gestation in weeks*	39.3 (2.0)	39.4 (1.7)	0.04
Percentage SGA	12.5%	9.2%	0.000
Male gender	51.3%	52.5%	0.3
Six month follow up	*n* = 2878 %	*n* = 3880 %	
Still breastfeeding	25.6	31.8	
Breastfed 4 – 6 months	9.4	10.5	
7 weeks – < 4 months	13.6	14.4	
3 – < 7 weeks	14.6	12.1	
< 3 weeks	12.8	11.1	
Not breastfed at all	24.0	20.2	0.000

* Mean (standard deviation).

RESULTS

A comparison of those children assessed with the PPVT-R with those not assessed is shown in Table 1. In general, the mothers of those not assessed were younger, less likely to be married, were more likely to be suffering with depressive or anxiety symptoms at the first visit, and were more likely to have breast-fed for shorter periods than mothers of those assessed. The infants not assessed were, on average, 1.1 weeks of earlier gestation and of slightly lighter birthweight than those assessed. Whilst there were differences in the level of maternal education which reached statistical significance, the magnitude of these differences was small.

The relationship between the duration of breastfeeding category and mean PPVT-R at 5 years is presented in Table 2. Those still breastfeeding at 6 months had a mean PPVT-R score at 5 years of 103.6 (standard deviation (SD) 13.1) compared with 94.2 (SD 14.1) for those not breastfed at all. There was a significant trend towards increasing PPVT-R scores with increased duration of breastfeeding ($P = 0.000$). The relationship was examined for males and females separately. Whilst female scores were slightly higher on average than males, the relationship between an increased PPVT-R score with increased duration of breastfeeding was consistent. Males and females still breastfed at 6 months had higher mean PPVT-R scores at 5 years, respectively, of 7.5 ($P = 0.000$) and 10.9 ($P = 0.000$) points compared with those for each sex not breastfed at all.

Table 2 Relationship between duration of breast feeding and the mean Peabody Picture Vocabulary Test Revised score at 5 years

Duration of breastfeeding	Total study group		
	n	Mean	SD
Still breastfeeding at 6 months	1235	103.6	13.1
4 – 6 months	406	101.3	12.8
7 weeks – < 4 months	557	99.4	13.5
3 weeks – < 7 weeks	471	98.4	13.9
< 3 weeks	429	97.1	13.1
Not at all	782	94.2	14.1

F 52.92 (df 5, 3874) $P = 0.000$. SD, standard deviation.

Using multiple linear regression, the PPVT-R scores were then adjusted for factors found to be significant independent predictors of the PPVT-R. Those variables included in the adjusted model were birthweight, poverty, maternal education, maternal age, time in daycare or preschool, number of children in the household at 5 years, English speaking background for mother and father, and infant stimulation at 6 months together with the five categories of breastfeeding and with children never breastfed as the reference category. Differences in mean PPVT-R scores and their 95% confidence intervals (CI) are shown in Tables 3 and 4 for males and females, respectively, for each level of breastfeeding compared to children never breastfed at all, both for the adjusted and unadjusted analysis.

Table 3 Comparison of unadjusted and adjusted differences in mean Peabody Picture Vocabulary Test Revised score in males according to duration of breastfeeding (reference category; infants that were never breastfed)

Duration of breastfeeding `	Unadjusted difference in means (95% CI)	Adjusted difference in means (95% CI)
Never breastfed	*	*
< 3 weeks	1.5 (–0.6, 3.7)	1.0 (–1.1, 3.2)
3 weeks – < 7 weeks	2.0 (–0.1, 4.0)	1.6 (–0.4, 3.7)
7 weeks – < 4 months	4.0 (2.0, 6.0)	3.2 (1.2, 5.2)
4 – 6 months	6.3 (4.1, 8.5)	4.8 (2.6, 7.0)
Still breast feeding at 6 months	7.5 (5.9, 9.1)	5.8 (4.1, 7.5)
R squared	0.05	0.13
F (df)	20.4 (5, 2105)	13.2 (23, 1979)
P value	0.000	0.000

* Reference category

Other factors in model all remain significant predictors of Peabody Picture Vocabulary Test Revised: birthweight, poverty, maternal education, maternal age, time in daycare/preschool, number of children in household at 5 years, English speaking background for mother, English speaking background for father and degree of infant stimulation.

For females, those breastfed, regardless of the duration of breastfeeding, had higher unadjusted mean PPVT-R scores in each category to those never breastfed. Whilst adjustment for child, maternal, and psychosocial variables reduced the magnitude of theses differences in mean scores, the differences remained significant for all categories of breastfeeding. Furthermore, a clear trend towards increased mean PPVT-R scores compared to the reference category of 'never breastfed' with increased duration of breastfeeding exists for both un-adjusted and adjusted analyses. For males, those breastfed for 7 weeks or more had higher mean PPVT-R scores than those never breastfed in the unadjusted analysis. Again the magnitude of the benefit of breastfeeding on the mean PPVT-R was reduced with the inclusion of child, maternal, and psychosocial variables in the adjusted analysis, but those males breastfed for 7 weeks or more continued to have mean PPVT-R scores significantly higher than those in the reference category. A clear trend exists in the adjusted analysis for increasing mean PPVT-R scores with increasing duration of breastfeeding. While males breastfed for less than 7 weeks had higher mean PPVT-R scores than those never breastfed, these differences were not statistically significant. As the relationship between level of breastfeeding and PPVT-R score are linearly related, breastfeeding was entered as a single six category ranked variable in the regression model together with the other predictor variables. For females, the coefficient was 1.51 PPVT-R points (95% CI 1.2, 1.8) and for males 1.2 PPVT-R points (95% CI, 0.9, 1.5).

DISCUSSION

The findings of this study indicate a clear advantage to the PPVT-R scores in those children who were breastfed. This relationship was reduced though remained significant, when a large number of confounding social and parental factors were taken into account. Furthermore, there was a significant trend towards increasing adjusted mean scores with increased duration of breastfeeding in all categories in females and from a duration of greater than 7 weeks in males.

Table 4 Comparison of unadjusted and adjusted differences in mean Peabody Picture Vocabulary Test Revised score in females according to duration of breastfeeding (reference category; Infants that were never breastfed)

Duration of breastfeeding	Unadjusted difference in means (95% CI)	Adjusted difference in means (95% CI)
Never breastfed	*	*
< 3 weeks 3.8	(1.7, 6.0)	3.3 (1.2, 5.5)
3 weeks – < 7 weeks	6.3 (4.2, 8.4)	4.7 (2.6, 6.9)
7 weeks – < 4 months	5.9 (3.9, 7.8)	5.0 (3.0, 7.0)
4 – 6 months	7.4 (5.2, 9.5)	5.7 (3.5, 7.9)
Still breastfeeding at 6 months	10.9 (9.3,12.5)	8.2 (6.5, 9.9)
R squared	0.09	0.19
F (df)	37.8 (5,1916)	18.9 (23,1780)
P value	0.000	0.000

* Reference category

Other factors in model all remain significant predictors of Peabody Picture Vocabulary Test Revised: birthweight, poverty, maternal education, maternal age, time in daycare/preschool, number of children in household at 5 years, English speaking background for mother, English speaking background for father and degree of infant stimulation.

Our results are in keeping with a number of other studies which found higher mean scores using various measures of intelligence in breastfed infants compared to formulae fed infants once adjustment for confounders were taken into account. [1–7] Similarly, we have again demonstrated the substantial effect social and parental confounders have on the relationship. Considerable argument exists as to whether the entire effect that breastfeeding appears to have on cognitive development can be explained by such confounding. Jacobson *et al.* recently investigated this relationship with the McCarthy Scales of Children's Abilities and the PPVT-R at 4 years and with the Wechsler Intelligence Test for Children Revised at 11 years in a selected sample of mothers. [9] They found improved scores in breastfed children with an apparent 'dose-effect', even after adjustment for a large number of social confounders. However, once maternal IQ (measured by the PPVT-R) and the home observation for measurement of the environment (HOME) score, a measure of socio-environmental influence on development, were included, the relationship was no longer significant. This suggests that the positive relationship between breastfeeding and cognitive development was not due to the nutritional advantage of breast milk but rather to a more nurturing and enriching environment and parenting style and possibly to genetic influences such as maternal IQ. The measurement of the environmental influences (the HOME score) however, occurred at 4 years of age, the same time the PPVT-R and McCarthy Scales of Children's Abilities were measured. It is possible that the HOME score itself has been affected by better mother–child attachment, either as a result of the nursing process itself or because of better cognitive development in the breastfed infants. Fergusson and Woodward recently published a paper exploring the relationship between breastfeeding, IQ and psychosocial outcomes between the age of 15 and 18 years. [20] They were able to demonstrate a weak association between breastfeeding and adolescent perceptions of maternal nurturance. However, breastfeeding had no detectable effect on a child's long-term psychosocial well-being as measured by outcomes such as juvenile offending, substance abuse and mental health at 18 years of age. This extends an earlier finding that breastfeeding practices have no association with conduct problems in early childhood. [21] Fergusson argues that this lack of association between breastfeeding and various measures of individual adjustment make it unlikely that the relationship between breast feeding and cognitive development is due to the social factors associated with breast feeding or better psychosocial adjustment. [20] We have adjusted extensively for social factors in our study and the beneficial effects of breastfeeding on cognitive development remained.

It is possible that unmeasured social influences are confounding the relationship we have seen, but given the size of the benefit (8.2 points in females and 5.8 points in males after adjustment) it is difficult to suggest that such influences alone would explain all this difference.

An alternative suggestion to explain the relationship between breastfeeding and cognitive development is that it is due to a unique constituent of breast milk not found in formula feeds. Whilst many such constituents may exist, favoured are the long-chain polyunsaturated fatty acids and docosahexaenoic acid (DHA) in particular. Evidence is emerging to suggest that DHA is important in the proper neural and visual development of preterm and possibly term infants. [22] Recently Willatts et al. reported cognitive advantages in problem solving skills at 10 months in infants fed long-chain polyunsaturated fatty acid enriched formula. [23] As most term infant formulae do not contain DHA, the issue is of clinical relevance. However, study of the role of DHA in term infant cognitive development is made more difficult for the fact that DHA levels in breast milk vary considerably with maternal diet, especially with the consumption of fish. It is possible that because of the comparatively high fish intake for those mother's selected in the study by Jacobson *et al.*'s study, their infants may also have had comparatively high fish intake once weened and consequently higher DHA levels in their early life mitigating the effects of breast feeding. Further work in this area is warranted.

We have included measures of parenting style which while important fail to substantially reduce the association between breastfeeding and the mean PPVT-R score. Our measures, though not as broad a measure of environmental stimulation as those used in the study of Jacobson et al., do have the advantage of being measured much earlier in the infant's life and thus are likely to be less effected by maternal-child attachment issues arising from either the nursing process itself of better infant cognitive development in the breastfed children. It is possible that had we measured maternal IQ this may have further reduced the relationship between breastfeeding and the PPVT-R, though because of the magnitude of the difference we reported it is unlikely to have abolished the relationship entirely. Maternal IQ itself may have been influenced in turn by previous breastfeeding and psychosocial environment in childhood.

There are two further issues that need to be considered as they potentially may influence the study conclusions. Loss to follow up includes an increased proportion of more socially disadvantaged families. For a factor to influence the estimates of the relationship between level of breastfeeding and PPVT-R score, it should be related to both loss to follow up and PPVT-R score. A range of factors was examined in the follow-up sample and adjustments made to the stratum specific estimates. If similar relationships hold in those lost to follow up, then though the overall impact of breastfeeding on PPVT-R score may be altered by differential loss to follow up, the stratum specific estimates of the strength of the relationship should be reasonably valid, particularly given the strength of the overall relationship between breastfeeding and PPVT-R score. How-ever, no adjustment is possible, for the potential effect of factors that were not measured, and are related to both breast-feeding and PPVT-R score. Mothers were asked at the 6 month visit to recall their duration of breastfeeding. This information is likely to be correct for those still breastfeeding (31.8%) or those who never breastfed (20.2%). As the relationship between level of breastfeeding and PPVT-R score is linear, and misclassification is likely to be unbiased, the influence of information recall error of duration of breastfeeding on validity of study findings should be limited.

In conclusion, this study shows a clinically important and significant association between the duration of breastfeeding and cognitive development as measured by the PPVT-R at 5 years of age, independent of a range of social and parental factors. Questions remain as to what extent the effect of breast milk on cognitive development is mediated by biological or psychological means. Although randomized controlled trials are not feasible, cohorts with measures of maternal IQ and progressive measures of the stimulating and nurturing aspects of the environment at home would help clarify this issue, as would direct investigation of the role of essential fatty acids and their derivatives. In addition to the other known benefits of breastfeeding, the magnitude and dose-response relationship between breastfeeding and child development reported in this study support the need to encourage breastfeeding of infants where possible.

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