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Relationship between breast-feeding and adiposity in infants and pre-school children

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Abstract

Objectives: We aimed to establish associations of duration of breast-feeding with mean BMI and waist circumference, as well as the likelihood of being overweight/ obese, during early childhood. Design: Cross-sectional, population-based study. Height, weight and waist circumference were measured and BMI calculated. Interviewer-administered questionnaire determined whether the child was ever breast-fed and the duration of breast-feeding. Setting: Sydney, Australia. Subjects: Infants and pre-school children (n 2092) aged 1-6 years were examined in the Sydney Paediatric Eye Disease Study during 2007-2009. Results: Of the children aged 1-6 years, 1270 had been breast-fed compared with 822 who were never breast-fed. After multivariable adjustment, 1-6-year-old children who were ever breast-fed compared with those who were not had significantly lower BMI, 16.7 (SE 0.1) kg/m2 v. 17.1 (SE 0.2) kg/m2 (P=0.01). Decreasing BMI was associated with increasing duration of breast-feeding (Ptrend=0.002). After multivariable adjustment, each month increase in breastfeeding was associated with an average BMI decrease of 0.04 kg/m2 (P=0.002) and 0.03 kg/m2 (P=0.03) among children aged 1-2 years and 3-4 years, respectively. In 1-2-year-old children, each month increase in breast-feeding duration was associated with a 0.06cm decrease in waist circumference (P=0.04). Significant associations were not observed among 5-6-year-old children. Children who were ever breast-fed v. those never breast-fed were less likely to be overweight/obese (multivariable-adjusted OR=0.54; 95% CI 0.36, 0.83). Conclusions: We demonstrated a modest influence of breast-feeding on children's BMI during early childhood, particularly among those aged less than 5 years.

Keywords

pre, infants, adiposity, children, feeding, school, breast, between, relationship

Disciplines

Arts and Humanities | Life Sciences | Medicine and Health Sciences | Social and Behavioral Sciences

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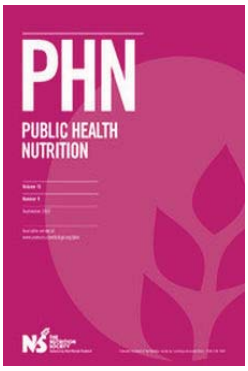

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Relationship between breast-feeding and adiposity in infants and pre-school children

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Abstract

Objectives: We aimed to establish associations of duration of breast-feeding with mean BMI and waist circumference, as well as the likelihood of being overweight/obese, during early childhood.

Design: Cross-sectional, population-based study. Height, weight and waist circumference were measured and BMI calculated. Interviewer-administered questionnaire determined whether the child was ever breast-fed and the duration of breast-feeding.

Setting: Sydney, Australia.

Subjects: Infants and pre-school children (n 2092) aged 1–6 years were examined in the Sydney Paediatric Eye Disease Study during 2007–2009.

Results: Of the children aged 1–6 years, 1270 had been breast-fed compared with 822 who were never breast-fed. After multivariable adjustment, 1–6-year-old children who were ever breast-fed compared with those who were not had significantly lower BMI, 16·7 (SE 0·1) kg/m^2 *v.* 17·1 (SE 0·2) kg/m^2 ($P = 0{\cdot}01$). Decreasing BMI was associated with increasing duration of breast-feeding ($P_{trend} = 0{\cdot}002$). After multivariable adjustment, each month increase in breast-feeding was associated with an average BMI decrease of 0·04 kg/m^2 ($P = 0{\cdot}002$) and 0·03 kg/m^2 ($P = 0{\cdot}03$) among children aged 1–2 years and 3–4 years, respectively. In 1–2-year-old children, each month increase in breast-feeding duration was associated with a 0·06 cm decrease in waist circumference ($P = 0{\cdot}04$). Significant associations were not observed among 5–6-year-old children. Children who were ever breast-fed *v.* those never breast-fed were less likely to be overweight/obese (multivariable-adjusted OR = 0·54; 95% CI 0·36, 0·83).

Conclusions: We demonstrated a modest influence of breast-feeding on children's BMI during early childhood, particularly among those aged less than 5 years.

Keywords
Breast-feeding
BMI
Overweight/obesity
Sydney Paediatric Eye Disease Study

Unhealthy weight gain and paediatric obesity have been demonstrated to track into later childhood and adulthood[1,2]. Due to the many long-term adverse effects of paediatric obesity, the prevention of child obesity has been recognized as a public health priority[3].

Breast-feeding within the first months of life may prevent excess weight gain in childhood[4]. However, a recent review of the epidemiological literature in this area concluded that although the influence of breast-feeding on body mass in later life appears plausible, it has been difficult to prove empirically[5]. That review identified several observational studies that have shown evidence of a small protective effect of breast-feeding with respect to overweight in childhood. Further, three meta-analyses reported significant protective effects of breast-feeding against overweight in later life[4,6,7], although another meta-analysis[8] showed no effect of breast-feeding on mean BMI after adjusting for potential confounders[5].

Moreover, epidemiological evidence from Australia on the association between breast-feeding and body composition among infants is limited. Burke *et al.* conducted one of the few large, longitudinal, population-based studies in this area and showed that infants from Western Australia breast-fed for >12 months were leaner at 1 year but not at 8 years[9]. Given that the prevalence of childhood overweight/obesity remains high in Australia[10], a better understanding of the roles of modifiable factors such as exposure to breast-feeding in childhood is

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required if any future reductions in the prevalence of overweight/obesity are to be achieved.

Therefore, we used a large data set of infants and children of pre-school age (1–6 years) to establish the relationship between duration of breast-feeding and mean BMI and waist circumference, as well as the likelihood of being overweight/obese, during early childhood.

Methods

The Sydney Paediatric Eye Disease Study (SPEDS) was conducted during 2007–2009. Eligible children between the ages 6 and 72 months (*n* 3333) were identified and recruited via door-to-door census in four randomly selected postcodes in metropolitan Sydney, Australia. A total of 2461 children were examined (73·8 % response rate). The current report focuses on children aged 1–6 years. Written informed consent was obtained from parents and all examination protocols were approved by the University of Sydney's Human Research Ethics Committee and adhered to the tenets of the Declaration of Helsinki.

Two questionnaires (113 items and sixty-three items) were completed by the parents (generally by the mother, otherwise by the father of the child). These included questions on self-reported ethnicity (European Caucasian (referred to as Caucasian in the present paper), East Asian (China, Malaysia, Singapore, Indonesia, Philippines, Japan, Korea, Myanmar, Thailand, Laos, Cambodia, and Vietnam), South Asian (India, Sri Lanka and Pakistan), Middle Eastern or Others/Mixed (includes all other ethnicities)) and parental education (ranged from never having attended school to having completed a higher degree such as a Masters or PhD). Mothers were also asked: 'At any time during the pregnancy with your child did you smoke?' (yes/no/don't know). If they answered 'yes' to this question they were considered to have smoked during the pregnancy.

Data from the government-issued personal health record for children provided to the parents of all Australia-born children, containing details on birth parameters (birth weight, weeks of gestation) recorded at the time of birth and at subsequent baby health check visits, were gathered where possible.

Questions on breast-feeding included the following: (i) 'Has your child ever been breast-fed?' (yes/no/don't know); and (ii) 'Including times of weaning, what is the total time that your child was breast-fed?' (number of weeks or months/less than a week/don't know). We categorized breast-feeding duration into the following: never breast-fed, <1 month, 1–<3 months, 3–<6 months and ≥6 months.

Anthropometric parameters were measured at the site of a study clinic (which was set up in rented premises) by the same study personnel. Length was measured in children less than 24 months of age and height in children 24 months and older. Height was measured using a free-standing telescopic height rod (SECA model 220; Hamburg, Germany). Waist circumference (cm) was measured using a steel measuring tape with measurements made halfway between the lower border of the ribs and the iliac crest in a horizontal plane. Weight was measured using a SECA 4802 digital floor scale (Scaletronix, White Plains, NY, USA). BMI was calculated as weight divided by the square of height (kg/m^2). Children were classified on the basis of age- and sex-specific BMI into three groups: <85th percentile (non-overweight/obese), ≥85th and <95th percentile (overweight) and ≥95th percentile (obese)[11]. Due to the small number of overweight and obese children, we combined the two to form a group termed 'overweight/obese'.

Statistical analyses were performed using the SAS statistical software package version 8·2 (SAS Institute Inc., Cary, NC, USA). Regression models were used to examine possible linear relationships between breast-feeding and BMI and waist circumference. BMI and waist circumference were analysed as continuous (per kg/m^2 or cm increase) and categorical variables (overweight/obese). Breast-feeding duration was also examined as a continuous variable (per month increase) and a categorical variable (never breast-fed, <1 month, 1–<3 months, etc.). Logistic regression analysis was also used to calculate adjusted odds ratios and 95 % confidence intervals. Logistic regression models were constructed to assess significant associations between breast-feeding and overweight/obesity among 1–6-year-old children defined using the age- and sex-specific BMI percentiles. Multivariable modelling was conducted with BMI or waist circumference as the study outcome, and breast-feeding as the independent variable. Linear and logistic regression models were adjusted first for age and sex, and then further adjusted for ethnicity, height, birth weight, parental education and maternal smoking during pregnancy. Significance was taken as $P < 0{\cdot}05$.

Results

There were 2092 children aged 1–6 years who were examined and Table 1 shows the characteristics of the study sample. Children in the oldest (5–6 years) *v.* the youngest (1–2 years) age group were more likely to have higher BMI and waist circumference, but were less likely to have been breast-fed for a longer duration (>1 month). We also compared study characteristics between mothers who provided information on breast-feeding duration (*n* 1349) compared with those who did not (*n* 743). Mothers who responded to the question on breast-feeding duration *v.* those who did not were more likely to be Caucasian (49·3 % *v.* 40·3 %, $P < 0{\cdot}0001$), tertiary qualified (53·0 % *v.* 42·2 %, $P = 0{\cdot}01$) and have children with higher birth weight (3·38 *v.* 3·27 kg, $P = 0{\cdot}001$). Significant differences were not observed between the two groups of respondents in relation to any of the other study characteristics.

Table 1 Characteristics of the study sample by age group: infants and pre-school children (1–6 years), Sydney Paediatric Eye Disease Study, 2007–2009

	Study population (*n* 2092)						
	1–2 years (*n* 797)		3–4 years (*n* 731)		5–6 years (*n* 564)		
Characteristics	Mean or *n*	SD or %	Mean or *n*	SD or %	Mean or *n*	SD or %	*P* value*
Age (years)†	2·03	0·6	4·00	0·6	5·86	0·5	<0·0001
Male	424	53·2	350	52·1	302	53·6	0·86
Ethnicity							
Caucasian	368	46·2	338	46·2	258	45·8	0·86
East Asian	150	18·8	155	21·2	123	21·9	
South Asian	105	13·2	97	13·3	76	13·5	
Middle Eastern	79	9·9	61	8·3	49	8·7	
Others/Mixed	95	11·9	80	10·9	57	10·1	
Parents with tertiary-level education	314	53·4	261	50·9	207	50·0	0·48
Mother smoking during pregnancy	60	10·4	52	10·4	38	9·3	0·84
Breast-fed							
No	72	12·5	80	15·7	70	17·2	0·11
Yes	503	87·5	429	84·3	338	82·8	
Duration of breast-feeding (months)							
Never	72	13·9	80	17·4	70	18·9	0·02
<1 month	46	8·9	32	7·0	28	7·6	
1–<3 months	50	9·6	40	8·7	33	8·9	
3–<6 months	100	19·3	52	11·3	52	14·1	
≥6 months	251	48·4	256	55·7	187	50·5	
Birth weight (kg)†	3·4	0·6	3·4	0·5	3·3	0·6	0·95
BMI (kg/m^2)†	17·3	2·0	16·2	2·0	16·4	2·5	<0·0001
Waist circumference (cm)	48·9	5·3	52·2	5·4	55·8	7·5	<0·0001
Prevalence of overweight/obesity	106	14·9	100	15·0	78	14·9	0·99

*Unadjusted *P* value from test for heterogeneity across age groups.
†These data presented as mean and SD; other data as *n* and %.

Table 2 Adjusted mean BMI and waist circumference with their standard errors according to breast-feeding status and duration in infants and pre-school children (1–6 years), Sydney Paediatric Eye Disease Study, 2007–2009

	Age- and sex-adjusted				Multivariable-adjusted*			
	BMI (kg/m^2)		Waist circumference (cm)		BMI (kg/m^2)		Waist circumference (cm)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Breast-fed								
No	17·1	0·2	52·1	0·4	17·1	0·2	51·8	0·4
Yes	16·6	0·1	51·8	0·2	16·7	0·1	51·5	0·2
P	0·002		0·44		0·01		0·55	
Duration of breast-feeding								
Never	17·1	0·2	52·2	0·4	17·1	0·2	51·8	0·4
<1 month	16·8	0·2	52·3	0·6	16·9	0·2	51·6	0·5
1–<3 months	16·8	0·2	51·9	0·5	16·8	0·2	51·1	0·5
3–<6 months	16·7	0·2	52·4	0·4	16·8	0·2	52·1	0·4
≥6 months	16·5	0·1	51·8	0·2	16·6	0·1	51·6	0·2
P for trend	0·18		0·30		0·002		0·70	

*Adjusted for age, sex, ethnicity, height, birth weight, parental education and maternal smoking during pregnancy.

Relationship between breast-feeding (as a categorical variable) and anthropometric measures (as continuous and categorical variables)

A significant correlation was observed between breast-feeding duration and BMI ($\rho = -0{\cdot}12$, $P < 0{\cdot}0001$). After adjusting for age, sex, ethnicity, height, birth weight, parental education and maternal smoking during pregnancy, 1–6-year-old children who were breast-fed compared with those who were not had a significantly lower mean BMI, 16·7 (SE 0·1) kg/m^2 *v.* 17·1 (SE 0·2) kg/m^2 ($P = 0{\cdot}01$; Table 2). A significant trend for decreasing BMI was observed with increasing duration of breast-feeding (multivariable-adjusted $P_{\text{trend}} = 0{\cdot}002$). Significant associations were not observed between breast-feeding and waist circumference among this group of children (Table 2).

Table 3 shows that children who were breast-fed *v.* those never breast-fed were 46% less likely to be overweight or obese (multivariable-adjusted OR = 0·54; 95% CI 0·36, 0·83). Children who were breast-fed for <1 month or ≥6 months compared with those never breast-fed had a 58% and 44% reduced odds of being overweight/obese,

Table 3 Association between breast-feeding and prevalence of overweight/obesity (BMI ≥ 85th percentile) in infants and pre-school children (1–6 years), Sydney Paediatric Eye Disease Study, 2007–2009

		Overweight/obesity			
		Age- and sex-adjusted		Multivariable-adjusted*	
	No. of cases/at risk	OR	95 % CI	OR	95 % CI
Breast-fed					
No	47/205	1·00	reference	1·00	reference
Yes	163/1166	0·53	0·37, 0·77	0·54	0·36, 0·83
P		0·001		0·005	
Duration of breast-feeding					
Never†	47/205	1·00	reference	1·00	reference
<1 month	12/95	0·48	0·24, 0·95	0·42	0·19, 0·95
1–<3 months	18/113	0·61	0·34, 1·12	0·59	0·30, 1·15
3–<6 months	29/185	0·60	0·36, 1·00	0·60	0·34, 1·07
≥6 months	91/645	0·54	0·36, 0·80	0·56	0·35, 0·88
P for trend		0·04		0·15	

*Adjusted for age, sex, ethnicity, height, birth weight, parental education and maternal smoking during pregnancy.
†The reference group is the 'never' breast-fed group for all comparisons concerning duration category.

Table 4 Regression analyses of breast-feeding and BMI and waist circumference in infants and pre-school children (1–6 years), Sydney Paediatric Eye Disease Study, 2007–2009

	Increase in BMI (kg/m^2)						Increase in waist circumference (cm)					
	Age- and sex-adjusted			Multivariable-adjusted*			Age- and sex-adjusted			Multivariable-adjusted*		
Per month increase in breast-feeding duration	β	SE	*P* value	β	SE	*P* value	β	SE	*P* value	β	SE	*P* value
1–2 years old (*n* 797)	−0·04	0·01	0·003	−0·04	0·01	0·002	−0·07	0·03	0·02	−0·06	0·03	0·04
3–4 years old (*n* 731)	−0·03	0·01	0·01	−0·03	0·01	0·03	−0·04	0·03	0·29	−0·01	0·04	0·80
5–6 years old (*n* 564)	−0·03	0·01	0·13	−0·01	0·02	0·48	−0·04	0·05	0·37	0·01	0·05	0·88
All ages (*n* 2092)	−0·04	0·01	<0·0001	−0·03	0·01	<0·0001	−0·05	0·02	0·03	−0·03	0·02	0·23

*Adjusted for age, sex, ethnicity, height, birth weight, parental education and maternal smoking during pregnancy.

respectively (Table 3). However, a significant trend for likelihood of overweight/obesity with increasing duration of breast-feeding was not observed in children of pre-school age.

Relationship between breast-feeding (as a continuous variable) and anthropometric measures (as a continuous variable)

After multivariable adjustment, each month increase in breast-feeding was associated, on average, with a BMI decrease of 0·04 kg/m^2 ($P = 0·002$) and 0·03 kg/m^2 ($P = 0·03$) among children aged 1–2 years and 3–4 years, respectively (Table 4). Among 1–2-year-olds only, each month increase in breast-feeding was associated with, on average, a 0·06 cm decrease in waist circumference (multivariable-adjusted $P = 0·04$). Significant associations between breast-feeding and anthropometry were not observed among 5–6-year-old children (Table 4).

Associations between breast-feeding and BMI stratified by sex

We also stratified the associations by sex, given that previous studies have demonstrated a sex difference in the protective effects of breast milk[12,13]. We found that 1–6-year-old girls who were ever breast-fed (*n* 68, 12·4 %), compared with those never breast-fed (*n* 21, 22·3 %), were 50 % less likely to be overweight/obese (multivariable-adjusted OR = 0·50; 95 % CI 0·26, 0·94). A non-significant association was observed between breast-feeding and being overweight/obese among boys (multivariable-adjusted OR = 0·58; 95 % CI 0·33, 1·03). Similarly, breast-fed girls had significantly lower mean BMI than girls never breast-fed, 16·4 *v.* 17·0 kg/m^2, respectively (multivariable-adjusted $P = 0·03$). Significant associations were not observed with mean BMI among boys ($P = 0·10$).

Discussion

In the present relatively large population-based study of 1–6-year-old Australian children, a modest inverse association between breast-feeding duration and BMI was observed. Linear associations between breast-feeding with BMI and waist circumference were more marked in the age groups 1–2 years and 3–4 years. Children who were ever breast-fed had a 46 % less likelihood of being overweight or obese compared with children who were never breast-fed. This association was stronger in girls than boys, i.e. girls who were *v.* those never breast-fed had a 50 % reduced odds of being overweight/obese.

Breast-feeding as an independent variable showed a modest inverse, linear association with BMI and waist circumference among these children of pre-school age, and this concurs with prior childhood studies[14–16]. More recently, the Avon Longitudinal Study of Parents and Children (n 4852) found that longer breast-feeding duration was associated with lower mean BMI ($P_{trend} < 0{\cdot}001$)[16]. The observed association between breast-feeding duration and waist circumference concurs with previous reports and suggests a possible protective effect of breast-feeding on measures of central obesity[17]. The explanation for the observed relationship with BMI and waist circumference probably lies less in inherent obesity-preventing properties of breast milk (e.g. presence of leptin in breast milk) than in the fact that breast-feeding displaces potentially more energy-dense formula feeding[18]. Additionally, there may be differences in the regulation of intake between formula-fed infants and breast-fed infants, or the higher protein/nitrogen content of infant formula compared with breast milk could cause a metabolic response of increased insulin in formula-fed infants resulting in excessive weight gain[18]. These findings could have potential public health implications, as adiposity in early childhood could influence body mass in later life given that tracking of BMI from childhood through to adulthood has been previously documented[19].

Surprisingly, a significantly reduced likelihood of being overweight/obese was observed only among children who were breast-fed for either <1 month (38 % reduced odds) or ≥6 months (46 % reduced odds). This observed protective effect of breast-feeding was larger than that reported in previous studies[9,14,18], and this could be because of the small number of cases in each monthly duration of breast-feeding stratum. We also observed a non-significant trend with increasing duration of breast-feeding. In a US study of 2685 children[18], a similar non-significant dose-dependent effect of the duration of breast-feeding on overweight status was demonstrated. Additionally, that US study also observed no threshold effect or a reduction in risk of adiposity with breast-feeding for ≥3 months or ≥6 months[18]. Our study finding could be explained by the duration of breast-feeding being based on mother's recall. Recall bias could potentially mask a true dose-dependent association between breast-feeding and overweight/obesity in these children. Another reason could be selection bias, as we cannot rule out that significant differences observed in study characteristics (e.g. parental education) between those children's mothers who did and did not provide information on breast-feeding duration could have influenced our results. Further, we did not have data available on the exclusivity of breast-feeding; given that exclusive breast-feeding could influence infant BMI[4,6,7], we cannot rule out residual confounding from this unmeasured factor. Finally, there could be potential subgroups of children with a specific genetic makeup that makes them more susceptible to the dose-dependent effects of breast-feeding than others[5].

Our observation of a strong linear association of breast-feeding with BMI and waist circumference in the younger age groups, but not among 5–6-year-old children, concurs with the findings reported by Burke *et al.*[9]. In that Australian study it was observed that measures of adiposity with breast-feeding tended to converge with increasing age of children. At the age of 5–6 years, patterns of dietary intake and physical activity probably have more of an impact on weight status than infant feeding[18], thus explaining the non-significant observation in this age group. Nevertheless, further longitudinal studies with adequate study power are needed to examine the temporal association between breast-feeding and BMI during childhood.

We observed a differential sex response to breast-feeding on weight status, i.e. breast-fed girls rather than boys were less likely to be overweight/obese. These results parallel those from the US National Longitudinal Study of Adolescent Health (n 11 998)[13], which demonstrated that ever breast-feeding was associated with a reduced likelihood of overweight in girls (OR = 0·83; 95 % CI 0·72, 0·95), but not among boys (OR = 0·90; 95 % CI 0·76, 1·05). It is unclear as to why the association is stronger in girls than boys of pre-school age in our study sample; however, one possible explanation is that the effects of hormones potentially involved in the metabolic imprinting effects of breast-feeding in infants[20,21] could be influenced by sex and this indirectly/directly influences weight status[12]. Nevertheless, these results could also reflect residual confounding e.g. by unmeasured behavioural attributes or a loss of power due to stratification by sex, hence further research is needed to confirm this differential gender response to breast-feeding.

The strengths of the present study include its population-derived design, a satisfactory response rate and standardized anthropometric measurement protocols. Limitations include the fact that the data come primarily from a survey of eye disease in Australian pre-school children, and not of obesity. The parental questionnaire did not target adiposity as a key study outcome; hence, exhaustive information was not collected on some variables such as maternal BMI, physical activity or sedentary pursuits. Therefore, we cannot rule out the possibility of residual confounding from these unmeasured parameters. Finally, the study is also limited by the presentation of only cross-sectional analyses and we cannot infer cause-and-effect relationships.

Conclusions

We observed a modest, inverse association between breast-feeding duration and mean BMI during early childhood. Children aged 1–6 years who were breast-fed had a 46 % reduced likelihood of being overweight/obese compared with those who were never breast-fed. Associations

between breast-feeding and mean BMI were more marked in the younger age groups and among girls than boys. Our findings add to the growing evidence base that any salutary effects of breast-feeding on weight status are modest among children of pre-school age.

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