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Breastfeeding Duration and its Relation to Weight Gain, Eating Behaviours and Positive Maternal Feeding Practices in Infancy

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Abstract

Research examining the relationship between breastfeeding and infant weight has generated conflicting results. Few studies account for significant covariates and many suffer methodological problems such as retrospective self-report. The current study aimed to investigate relationships between breastfeeding duration, infant weight and eating and positive maternal mealtime behaviours, whilst overcoming many of the limitations of previous research. Eighty-one women on low-risk maternity units gave informed consent and were visited at home at 1-week, 1-, 6- and 12-months postpartum. Infants included 45 males and 36 females (mean birth-weight 3.52 kg [SD 0.39]). Mothers and infants were weighed and measured and feeding information was recorded at each visit. Infant weight was converted to a standard deviation score (SDS*), accounting for age and sex. Mothers reported infant eating behaviours at 12-months using the Children's Eating Behaviour Questionnaire and were observed feeding their infants solid food at home at 6- and 12-months. Partial correlations (covariates: maternal age, education, BMI, smoking during pregnancy, household income, infant birth weight SDS and age introduced to solid foods) revealed negative associations between breastfeeding duration and 1- to 6- and 1- to 12-month weight gain, and 6- and 12-month weight. Breastfeeding duration was also associated with a slower rate of infant eating and greater observed maternal vocalisations, appropriateness and sensitivity. Results support a dose-response relationship between breastfeeding and infant weight and suggest that breastfeeding may encourage the development of obesity-protective eating behaviours through learning to attend to internal hunger and satiety signals. Future research should investigate whether relationships between slowness in eating and weight extend to satiety responsiveness after infancy.

Key words: Breastfeeding duration; feeding practices; eating behaviours; weight gain; infancy

* **Abbreviations:** BMI – body mass index; CEBQ – Child Eating Behaviour Questionnaire; EPDS – Edinburgh Postnatal Depression Scale; SDS – standard deviation score

Introduction

For the last 30 years, research has investigated whether breastfeeding protects against rapid weight gain, overweight and obesity. Findings have revealed that breastfed infants gain less weight during the neonatal period than formula-fed infants (Heinig, Nommsen, Peerson, Lonnerdal, & Dewey, 1993), and that infants who gain less weight during this period have a reduced risk of becoming obese later in life (Stettler, Zemel, Kumanyika, & Stallings, 2002). Rapid weight gain in infancy is a risk factor for overweight/obesity in childhood and is associated with increased BMI and fat mass at 5- and 7- to 9-years (Sacco, de Castro, Euclydes, Souza, & Rondo, 2013; Zhou et al., 2016). Although studies have also provided evidence for a dose-dependent protective effect of breastfeeding (Arenz, Rückerl, Koletzko, & Von Kries, 2004; Hornell, Lagstrom, Lande, & Thorsdottir, 2013; Kramer, 1981; McCrory & Layte, 2012; Owen, Martin, Whincup, Smith, & Cook, 2005; Reynolds, Hennessy, & Polek, 2014; Skledar & Milosevic, 2015; Yan, Liu, Zhu, Huang, & Wang, 2014), there is considerable inconsistency in published findings.

Some studies claim the effect of breastfeeding on childhood obesity is small (Jiang & Foster, 2013; Umer et al., 2015) and others have found no effect at all (Davis et al., 2007; Martin et al., 2013; Novaes, Lamounier, Colosimo, Franceschini, & Priore, 2012; Oddy et al., 2004). It is possible that these null findings may have arisen due to a lack of control of covariates and a range of other methodological issues. There is wide variation between studies in the covariates accounted for; examples include infant birth weight, gender, gestational age, age introduced to solid food, maternal age, BMI, smoking status during pregnancy (and postnatally), maternal diabetes, postnatal depression, education and household income. Very few published studies account for all of these variables. Smithers, Kramer, and Lynch (2015) argue that poor

92 measurement (or lack of adjustment) of such factors can result in biased effects of breastfeeding
93 being reported from longitudinal cohort studies. The current study attempted to address such
94 issues by measuring the most common covariates not controlled for in other studies. Extensive
95 demographic information was obtained and, if related to breastfeeding or infant weight,
96 controlled for in subsequent analyses.
97
98 Methodological problems in this area involve (but are not limited to) retrospective data
99 collection, inconsistent definitions of breastfeeding (including exclusivity and duration), small
100 sample sizes or the same data from larger samples being used several times, and maternal self-
101 report of infant/child height and weight and breastfeeding history. Michels et al. (2007), who did
102 not find an association between breastfeeding and overweight, obtained their sample from the
103 Nurses' Health Study II (whose children comprise the Growing Up Today Study). The same
104 environmental and genetic information has therefore contributed to more than one sample and
105 has been studied numerous times (Gillman et al., 2006; Gillman et al., 2001). Repeated use of the
106 same cohort partially explains the occurrence of repeated findings both for and against the
107 protective effect of breastfeeding on obesity. Furthermore, Michels et al. (2007) administered
108 questionnaires to nurses' mothers asking if they breastfed their daughters and when
109 breastfeeding stopped. Nurses' mothers were contacted when the nurses were aged between 37-
110 and 44-years. The time elapsed since breastfeeding cessation suggests it is likely that mothers
111 could not accurately recollect how they fed their infants and calls into question the accuracy of
112 retrospective self-report. The current study attempted to improve such methodological issues by
113 recruiting a new sample of participants and by avoiding the use of retrospective self-report of
114 information.
115

Despite inconsistencies within the literature, the protective effect of breastfeeding is often demonstrated in large, methodologically rigorous studies. For example, a large, well-controlled study using multivariate analysis included 7,798 children in Ireland and controlled for socio-demographic factors, child birth weight, gender, physical activity and parental BMI. Results demonstrated that children who had been breastfed for 13- to 25-weeks had a 38% reduction in the risk of being obese at 9-years-of-age, compared to those never breastfed (McCrory & Layte, 2012). Furthermore, breastfeeding for at least 26-weeks was associated with a 51% reduction in obesity risk at 9-years-of-age. These results also supported the dose-dependent effect of breastfeeding for durations greater than 4-weeks (McCrory & Layte, 2012). Furthermore, the protective effect of breastfeeding is also illustrated by a meta-analysis, which found that a longer duration of breastfeeding was associated with a reduced risk of becoming overweight (Harder, Bergmann, Kallischnigg, & Plagemann, 2005). However, as with individual studies, systematic reviews and meta-analyses may also suffer limitations with respect to the potential bias due to confounding (Smithers et al., 2015).

In addition to the effect of breastfeeding on weight, it is also related to the development of healthy eating behaviours, such as increased consumption of fruits and vegetables (Kudlová & Schneidrová, 2012; Mennella, Jagnow, & Beauchamp, 2001). Breastfed infants are also found to be more responsive to satiety (Brown & Lee, 2012) and greater satiety responsiveness is related to a lower risk of being overweight in childhood (Webber, Hill, Saxton, Van Jaarsveld, & Wardle, 2009). Increased responsiveness to satiety may arise because breastfed infants may learn to better self-regulate their intake than formula-fed infants due to having more control over the size of the feed (Birch & Fisher, 1998) and the ever-changing fat content of the milk (Jenness, 1979; Nommsen, Lovelady, Heinig, Lönnerdal, & Dewey, 1991).

Maternal sensitivity is associated with breastfeeding, infant weight gain and eating behaviours and is a potential candidate to explain the mechanism of the protective effects of breastfeeding on obesity. Breastfeeding mothers may be more sensitive and responsive to the hunger and satiety signals communicated by their infant and demonstrate less controlling feeding practices than formula-feeding mothers. Shloim, Rudolf, Feltbower, Mohebati, and Hetherington (2015) observed mealtime interactions between mothers and infants and found that breastfeeding mothers were more in tune with their infants' signals during feeding. Breastfeeding mothers also provided a more favourable feeding environment and fed their infants more responsively than mothers who fed solids or milk from a bottle (Shloim et al., 2015). More sensitive and less controlling behaviours during feeding allow infants to self-regulate their energy intake and learn to respond to internal hunger and satiety cues (Brown & Lee, 2012; Taveras et al., 2006). However, much of the literature to date has relied on maternal report of feeding practices, with few prospective studies of breastfeeding outcomes examining observed sensitivity in solid feeding interactions.

A recent systematic review by Bergmeier, Skouteris, and Hetherington (2015) argued that much of the literature that has investigated relationships between maternal feeding practices and children's weight and eating behaviours has relied on unidirectional self-report methods. It is possible that such methods alone may be biased and capture intended, rather than actual, feeding behaviours (Bergmeier, Skouteris, & Hetherington, 2015). In support of this, Bergmeier, Skouteris, Haycraft, Haines, and Hooley (2015) found that maternal reported restriction was negatively associated with observed restriction during a mealtime observation, and reported pressure was only positively associated with observed pressure in mothers of girls, not boys.

Bergmeier, Skouteris, and Hetherington (2015) argued that longitudinal observational methods should be employed that examine the bi-directional dimensions of parent-child mealtime interactions.

Results of previous literature emphasise the importance of investigating the relationships between breastfeeding duration, infant weight gain and eating behaviours and observed maternal feeding behaviours in one study. Currently, there is no longitudinal study published that investigates all of these factors together over the first year of life. The aim of this study was to investigate the relationship between observed maternal feeding behaviour, breastfeeding duration and infant weight and eating behaviours during the first 12-months of life, in a sample of healthy infants of uncomplicated pregnancy, controlling for necessary covariates. Extensive demographic information was collected, which measured the most common covariates not controlled for in other studies and, if related to breastfeeding or infant weight, these were controlled for in subsequent analyses. It was hypothesised that infants breastfed for longer durations would: (1) show slower weight gain throughout the first year; (2) weigh less at 12-months; (3) demonstrate more obesity-protective eating behaviours at 12-months; and (4) have mothers who were observed to be more sensitive during feeding, than infants breastfed for shorter durations.

Materials and methods

The study protocol received full ethical approval from Birmingham East, North, and Solihull Research Ethics Committee, United Kingdom (reference number 10/H1206/67). Research and development approval was granted by Birmingham Women's National Health Service Foundation Trust (reference number 10/BWH/NO95).

Mothers were eligible to take part in the study if they had given birth on a low-risk maternity unit and if their infant was not born prematurely (prior to 36 weeks gestation) or small for gestational age (SGA). Premature and SGA infants were not included as these factors are associated with weight gain during the first 12-months of life. Mothers needed to be able to read and write English due to the requirement of completing questionnaires and the ability to communicate with the researcher. Midwives directed the researcher to women who met these criteria.

Two hundred and eighty-seven women were eligible to take part in the study and were approached after delivery on low-risk maternity units of Birmingham Women's Hospital. Of these, 81 mothers (28%) gave informed consent and agreed to be visited at home (mean age 29.42 years [SD 5.87]). Infants included 45 males and 36 females (mean birth-weight 3.52 kg [SD 0.39]).

Mothers and infants were visited at home at 1-week, 1-, 6- and 12-months postpartum. Demographics were reported at 1-week. Mothers and infants were weighed and measured at each visit. Mothers reported feeding information (exclusivity and duration of breastfeeding and when solids were first introduced) and completed questionnaires assessing symptoms of postnatal depression, at each visit. Mothers also reported their smoking and alcohol consumption and any medications they were taking at each visit. Mothers were observed feeding their infant solid food at 6- and 12-months and reported their infant's eating behaviours at 12-months.

Demographic and Additional Information

Mothers completed a demographic questionnaire at 1-week. It requested age, pre-pregnancy weight, ethnic background, household income, educational level and infant date of birth. It also asked the type of milk the mother intended to feed her baby (breast, formula or a mix of the two). Mothers completed an additional information sheet at each visit, which requested information regarding medications being taken and present smoking and alcohol consumption.

Feeding Information

At each visit, mothers reported whether infants were being breast or formula-fed, and the duration and exclusivity of feeding method. Bottle use among breastfeeding mothers was not measured. At the later time points, mothers were asked if and when they had introduced solid foods.

Edinburgh Postnatal Depression Scale (EPDS(Cox, Holden, & Sagovsky, 1987))

Postnatal depression is associated with maternal-infant interactions (Goodman, 2007) and breastfeeding duration (Henderson, Evans, Straton, Priest, & Hagan, 2003). The EPDS was therefore given to mothers at the 1-, 6- and 12-month visit to establish whether depression needed to be controlled for in the analyses. The EPDS consists of 10 short statements, each of which has four responses to choose from, indicating how the mother has felt during the previous week. Mothers who score 10 or greater are identified as showing symptoms indicative of possible depression.

Child Eating Behaviour Questionnaire (CEBQ; (Wardle, Guthrie, Sanderson, & Rapoport, 2001)

The CEBQ is a reliable and valid parent-rated questionnaire measuring eating styles of children using a five-point rating scale. A modified age-appropriate version of the CEBQ was given at the

12-month visit to assess maternal perception of infants' obesogenic and obesity-protective eating behaviours. Subscales measuring emotional over- and under-eating were deemed not appropriate for infants aged 12-months and so were not included. The original CEBQ consists of 35-items and the current modified version consists of 23-items. The modified version was piloted on 59 mothers of infants with a mean age of 7.5-months. Overall reliability was shown to be good to moderate (.62). The Cronbach's alphas for the six subscales were .83 for enjoyment of food and satiety responsiveness, .74 for slowness in eating, .84 for food fussiness, .85 for responsiveness and .88 for desire to drink.

Mealtime observation

The Feeding Interaction Scale (FIS; (Wolke, Sumner, McDermott, & Skuse, 1992) was used to code positive maternal behaviours and some infant eating behaviours during the feeding observations (Table 1 details subscales used and behaviours assessed). In order to investigate observable warm and sensitive feeding behaviours, maternal vocalisations and appropriateness were chosen in addition to sensitivity. The FIS has clinical validity and has been used to assess maternal-infant feeding interactions and diagnose feeding problems (Farrow & Blissett, 2005; Lindberg, Bohlin, Hagekull, & Palmerus, 1996; Skuse, Wolke, & Reilly, 1992).

Feeding sessions took place at participants' homes and were recorded using a video-camcorder and tripod. Feeding observations of solid food took place at either lunch or dinnertime and did not include milk feeds. Mothers informed the researcher what time the meal would be and decided what to feed their infant. There was no restriction imposed regarding when the child last ate. Videos were watched and scored later by the researcher and research assistant. Intra-class

correlation coefficients were all greater than .76.

Table 1. Subscales and behaviours utilised from the FIS (Wolke et al., 1992).

Subscale	Behaviour	Scoring
Maternal verbal involvement	Proportion of session mother is talking to infant including initiating conversation and spontaneous comments	1 (never talks to infant) to 9 (very much)
Appropriateness of maternal mealtime behaviour	Feeding is appropriate if it is pleasurable for mother and infant.	1 (very inappropriate) to 5 (very appropriate)
Maternal sensitivity	Infant in sensible position including freedom of arm movement and eye contact with mother, close proximity to mother, feedback on infant's behaviour, variation of stimulation	1 (highly insensitive) to 9 (highly sensitive)
Frequency of offers	Offers (mother-to-infant or infant-to-self) semi-solid or solid food. An offer is defined as food which reaches within 5 inches of the infant's mouth	
Frequency of acceptances	Food is counted as accepted when it is kept in the mouth for longer than 5 seconds	

Anthropometric Measures

Infants were weighed naked with Seca electronic baby scales by the researcher at each home visit. Infant weight was then converted to a standard deviation score (SDS), which adjusts measurements for age and sex (Freeman et al., 1995). Mothers were weighed at each home visit

wearing light indoor clothing, without shoes, using electronic scales; maternal height was measured at 1-week postpartum using a portable stadiometer.

Data analysis

Kolmogorov-Smirnov tests and histograms indicated that breastfeeding duration, demographic factors and postnatal depression were not normally distributed. Two-tailed non-parametric Spearman's rho correlations were therefore used to assess whether these variables were associated with breastfeeding duration.

One-tailed partial correlations (controlling for: household income category, maternal age, education, BMI and quantity of cigarettes smoked during pregnancy, infant birth weight SDS and age at which introduced to solids) were used to assess the relationship between: (1) breastfeeding duration and infant weight SDS at 1-week, 1-, 6-, and 12-months, weight gain SDS from 1- to 6- and 1- to 12-months; (2) breastfeeding duration and infant eating behaviours at 12-months. One-tailed partial correlations (controlling for: household income category, maternal age, education and quantity of cigarettes smoked during pregnancy, and infant age introduced to solids) were used to assess the relationships between breastfeeding duration and observed positive maternal feeding behaviours. Post hoc analyses included partial correlations to assess whether controlling for maternal sensitivity, in addition to aforementioned covariates, affected the relationship between breastfeeding duration, infant weight and eating behaviours.

Results

Descriptive statistics

Eighty-one mother-infant dyads were initially recruited; at the 12-month visit 12 had withdrawn, resulting in a dropout rate of 15%. Mothers who withdrew reported leaving the study due to moving away or having other demands on their time (e.g. caring for other children, returning to work [data not shown]). Table 2 shows the number of mother-infant dyads seen at each home visit, the mean age of infants (weeks) and the percentage of infants being breastfed at each time point (includes exclusive and any breastfeeding). Of the 73% breastfeeding at 1-week, 75% of these were exclusively breastfeeding. Of the 65% breastfeeding at 1-month, 76% of these were exclusively breastfeeding. Of the 52% breastfeeding at 6-months and 32% at 12-months, 71% and 64% had not introduced formula or cow's milk respectively. There was no difference in breastfeeding duration between male (M = 24.34, SE = 3.58) and female (M = 30.58, SE = 4.03) infants $t(67) = -1.16$, $p = .25$.

Group comparisons between 'exclusive' 'partial' and 'no' breastfeeding were not conducted due to the small group sizes. Infants partially fed breast milk may have received formula twice per week or multiple times per day and so it was deemed inappropriate to group such infants together in one category. Furthermore, five infants were introduced to solid food before 12-weeks and an additional 59 were introduced to solids before 24-weeks. Timing of introduction of solid food added to the complexity of generating 'pure' groups in terms of breastfeeding exclusivity.

311 Table 2 also shows that no infants were below the 2nd centile for weight at 1-, 6-, or 12-months.
312 These centiles were plotted using the UK-WHO growth charts. There were no significantly
313 underweight infants in the current sample. As meal content can affect interactions during
314 mealtimes, mothers rated infant familiarity and liking of the food presented. Infants were
315 generally given food they liked and were familiar with (Table 3). The mean age infants were
316 introduced to solid food was 20.41 weeks (SD 3.39). There was no difference between male (M
317 = 20.20, SE = 0.60) and female (M = 20.65, SE = 0.51) infants in the age at which they were
318 introduced to solid food $t(71) = -.57$, $p = .57$.
319

Table 2. Number of infants, mean age (weeks), percentage receiving any breast milk and weight and centile range at each home visit (according to the UK-WHO growth charts).

Visit	**N**	**Mean age (weeks)**	**Any breastfeeding**	**Weight range (kg)**		**Centile range**	
				Males	*Females*	*Males*	*Females*
1-week	81	1.32 (SD 0.36)	73%	2.72 – 4.88	2.81 – 4.37	n/a[§]	n/a[§]
1-month	77	4.77 (SD 0.62)	65%	3.43 – 6.00	3.74 – 5.39	2nd – 98th	9th – 91st
6-months	73	26.67 (SD 0.99)	52%	6.46 – 10.50	6.59 – 9.38	2nd – 98th	25th – 98th
12-months	69	52.83 (SD1.73)	32%	8.00 – 12.81	7.71 – 11.82	2nd – 99.6th	9th – 98th

[§]UK-WHO growth charts provide centiles for males and females from 2-weeks to 4-years-old

Table 3. Maternal ratings of infant's familiarity and liking of food given during feeding sessions

	Familiarity				Liking (Mean and S.D.)
	Never	Once	A few times	Often	
6-months	5.2%	10.3%	32.8%	51.7%	82.4% (S.D. 17.0%)
12-months	3.6%	5.5%	25.5%	65.5%	80.1% (S.D. 17.0%)

Covariates

EPDS score was not significantly associated with breastfeeding duration at: 1-month r=.21; 6-months r=.06; or 12-months r=.16, all p>.05. Therefore, postnatal depression was not controlled for in any further analyses.

One-tailed Spearman's rho correlations revealed that maternal age and educational level were significantly associated with breastfeeding duration at each visit (see Table 4). There were positive associations between breastfeeding duration and household income at 1-week, 1-month and 6-months; positive associations between breastfeeding at 6-months and 12-months and the age that infants were introduced to solid food; and negative associations between breastfeeding duration and cigarettes smoked during pregnancy at 1-week, 1- and 6-months. The aforementioned variables were controlled in further analyses. Birth weight was not related to breastfeeding duration at any point.

Table 4. Spearman's Rho bivariate correlations (one-tailed) between breastfeeding duration and covariates at each time point of the study.

Visit		Birth weight SDS	Household income	Maternal age	Maternal education	Cigarettes smoked during pregnancy	Age infant introduced to solids
1-week	*r*	-.02	.28	.38	.38	-.21	n/a[§]
	p	.44	.01	<.0001	<.0001	.03	n/a[§]
	n	81	81	81	81	81	n/a[§]
1-month	*r*	-.12	.34	.41	.43	-.26	n/a[§]
	p	.15	.001	<.0001	<.0001	.01	n/a[§]
	n	77	77	77	77	77	n/a[§]
6-months	*r*	-.06	.26	.42	.37	-.27	.26
	p	.31	.01	<.0001	.001	.01	.01
	n	73	73	73	73	73	73
12-months	*r*	-.08	.15	.25	.26	-.13	.21
	p	.26	.11	.02	.02	.14	.04
	n	68	68	68	68	68	68

n/a[§] No infants had been introduced to solid food at 1-week or 1-month

Breastfeeding and observations

One-tailed partial correlations were conducted to investigate the relationship between breastfeeding duration and observed positive maternal mealtime behaviours at 12-months. Table 5 shows that after accounting for covariates, breastfeeding duration was associated with more positive maternal vocalisations and sensitivity during the meal at 12-months and more appropriateness at 6- and 12-months.

Breastfeeding and infant weight

One-tailed partial correlations were conducted to investigate the relationship between breastfeeding duration and infant weight SDS. Table 6 shows that (concurrent) breastfeeding duration was negatively associated with infant weight SDS at 6- and 12-months and weight gain SDS from 1- to 6- and 1- to 12-months, but not with infant weight SDS at 1-week or 1-month. The effects seen here are substantial. For example, a 6-month-old boy on the 50th centile weighs 8.05kg, a reduction of 1 SD at this time results in a weight of 7.74kg, representing a total reduction in weight of 0.32kg.

Given the relationship between maternal behaviours and breastfeeding duration, post hoc tests were conducted to investigate whether controlling for maternal sensitivity affected the relationship between breastfeeding duration, infant weight and eating behaviours. Maternal behaviours were highly correlated so, for parsimony and to protect power, only sensitivity was controlled. Controlling for maternal sensitivity did not change the pattern of these results.

Breastfeeding and infant eating behaviours

One-tailed partial correlations were conducted to investigate the relationship between breastfeeding duration and infant eating behaviours at 12-months. Table 7 shows that after accounting for covariates, breastfeeding duration was positively associated with slowness in eating at 12-months. Breastfeeding duration was also negatively associated with the number of times mothers offered their infants food at 12-months. There were no other relationships between duration of breastfeeding and maternally reported or observed infant eating behaviours. Controlling for maternal sensitivity did not change the pattern of these results.

388 **Table 5.** Partial correlations (one-tailed) between breastfeeding duration and observed positive
389 maternal mealtime behaviours. Covariates include: maternal age, education, number of cigarettes
390 smoked during pregnancy, household income and age introduced to solids.
391

		Vocalisations	**Appropriateness**	**Sensitivity**
6-months	Breastfeeding Duration	.12	.26	.22
	p	.21	.03	.07
	df	48	48	48
12-months	Breastfeeding Duration	.24	.32	.29
	p	.05	.01	.02
	df	48	48	48

392

Table 6. Partial correlations (one-tailed) between concurrent breastfeeding duration and infant weight SDS controlling for maternal age, education, concurrent BMI, number of cigarettes smoked during pregnancy, household income, infant birth weight SDS and age introduced to solids.

	1-week weight SDS	**1-month weight SDS**	**6-month weight SDS**	**12-month weight SDS**	**1- to 6-month SDS weight gain**	**1- to 12-month SDS weight gain**
Breastfeeding Duration	-.001	-.15	-.33	-.39	-.30	-.38
p	.50	.12	.004	.001	.01	.001
df	64	64	63	58	63	58
Breastfeeding Duration (cont. sensitivity)			-.47	-.45	-.44	-.41
p			<.0001	.001	.001	.002
df			45	44	45	44

412
413 **Table 7.** Partial correlations (one-tailed) between breastfeeding duration and infant eating behaviours. Covariates include: maternal age,
414 education, BMI, number of cigarettes smoked during pregnancy, household income, infant birth weight SDS and age introduced to solids.
415

		Maternal report of infant eating behaviours (CEBQ)						**Observed eating behaviours (FIS)**			
		Satiety responsiveness	Food enjoyment	Food responsiveness	Slowness in eating	Food fussiness	Desire to drink	Self offers	Self acceptances	Maternal offers	Maternal acceptances
12-months	Breastfeeding Duration	.11	-.08	-.11	.25	.04	.03	.17	.17	-.25	-.19
	p	.19	.27	.21	.03	.39	.41	.13	.13	.04	.10
	df	59	59	59	59	59	59	46	46	46	46
	Breastfeeding Duration (cont. sensitivity)	.09	-.12	-.07	28	.01	.05	.16	.16	-.20	-.13
	p	.28	.22	.32	.03	.47	.36	.14	.14	.09	19
	df	45	45	45	45	45	45	45	45	45	45

Discussion

The results of this study supported the hypothesis that a longer duration of breastfeeding is associated with slower weight gain from 1- to 6- and 1- to 12-months and lower weight at 6- and 12-months. Findings are supportive of previous research (Arenz et al., 2004; Harder et al., 2005; Hornell et al., 2013; Kramer, 1981; McCrory & Layte, 2012; Owen et al., 2005) and are consistent with a dose-response relationship between breastfeeding and infant weight during the first 12-months of life, which most clearly manifests in the latter half of the first year.

Results of the current study also show that infants breastfed for longer are perceived by their mothers to eat solid food more slowly at 12-months. It is possible that breastfeeding influences the development of slower eating styles, which may in turn enhance satiety responsiveness in early childhood. Previous research with adults has found that that slower eating increases self-reported satiety (Andrade & Melanson, 2007; Ferriday et al., 2015; Shah et al., 2014). Further research is required to establish whether breastfeeding helps infants develop obesity-protective eating behaviours. This is likely, given that breastfed infants adjust their intake according to the ever-changing fat content of the milk (Tyson et al., 1992) and may therefore better learn their internal cues of hunger and satiety (Birch & Fisher, 1998) than those fed formula milk. Breastfeeding may also encourage a slower rate of eating due to breastfed infants having to work harder for their food than formula-fed infants; introducing a bottle may speed-up feeding rate (Cao et al., 2009).

Although previous research has found significant relationships between breastfeeding duration and satiety responsiveness (Brown & Lee, 2012), infants were 6- to 12-

441 months younger in the current study. Further research is required to investigate
442 whether relationships between slowness in eating and weight extend to satiety
443 responsiveness after infancy.
444
445 It is also important to consider that such research did not control for the age at which
446 infants were introduced to solid food (Brown & Lee, 2012). Previous research has
447 found that breastfed infants, and those breastfed for longer, tend to be introduced to
448 solid food later than those breastfed for shorter durations or not at all (Huh, Rifas-
449 Shiman, Taveras, Oken, & Gillman, 2011). Furthermore, earlier introduction of solid
450 food has also been related to greater weight gain during the first year of life (Baird et
451 al., 2008; Baker, Michaelsen, Rasmussen, & Sorensen, 2004; Forsyth, Ogston, Clark,
452 Florey, & Howie, 1993; Kramer et al., 1985; Lande et al., 2005). Timing of
453 introduction of solid food was controlled for in the current study as it was related to
454 both breastfeeding duration and infant weight.
455
456 The current research did not find any significant relationships between breastfeeding
457 duration and food enjoyment, food responsiveness, fussiness or desire to drink, as
458 measured by parental report at 1 year. Future studies are required to investigate
459 whether relationships between breastfeeding duration and these eating behaviours
460 emerge after infancy, once children have more control during feeding and are more
461 able to feed themselves. Furthermore, in the current study, measures were taken
462 before the stage at which increases in fussy/picky eating and neophobia are seen
463 (Taylor, Wernimont, Northstone, & Emmett, 2015). Future studies could explore
464 these factors in early childhood as it is possible that some of these infants may go on
465 to develop fussier eating habits with time.

Although it is possible that longer breastfeeding may promote slower weight gain resulting in lower weight at 12-months, it is important to consider that causality cannot be assumed. Less hungry infants, or those with smaller appetites, may be less demanding and easier to breastfeed, and so are breastfed for longer. Indeed, it has been reported that one of the main reasons why mothers stop breastfeeding is because they perceive their infant was no longer satisfied by breast milk alone (Li, Fein, Chen, & Grummer-Strawn, 2008). In addition, mothers who feed to comfort and soothe their infant may also breastfeed for shorter durations (Paul et al., 2011). It is possible that these infants may gain weight more slowly and may develop slower eating styles due to their smaller appetite rather than it being due to breastfeeding alone. However, weight at birth, 1-week and 1-month was not related to breastfeeding duration in the current study, which suggests that it was not only the smaller infants who were breastfed for longer in this sample. Neither did breastfeeding duration relate to observations of infant eating behaviour such as the frequency of infant self-offering or accepting of food, suggesting that breastfeeding as not related to this index of infant appetite.

Whilst considering the results of this study it is important to take into account that infant feeding cues are influenced by environmental, physical and psychological factors; perception of these cues is affected by both maternal and infant characteristics (McNally et al., 2016). Mothers perceive hunger signals more easily than satiety signals, but interpretation of feeding cues does get easier as children age (McNally et al., 2016). Future research into early weight gain and eating should therefore move forward by investigating the impact of observed infant characteristics on feeding

491 behaviours. An improved understanding of the factors affecting the interpretation of,
492 and response to, infant feeding cues will aid the development of interventions to
493 promote sensitive and responsive feeding.
494
495 Results of the current study show that increased maternal positive vocalisations and
496 greater observed maternal appropriateness and sensitivity during a mealtime at 12-
497 months are significantly associated with a longer duration of breastfeeding. This
498 supports previous research that found mothers who demonstrate greater maternal
499 sensitivity during infancy and higher quality interactions at 12-months, breastfeed for
500 longer (Britton, Britton, & Gronwaldt, 2006; Gutman, Brown, & Akerman, 2009;
501 Tharner et al., 2012). Results are also supportive of research that has found
502 breastfeeding mothers provide a more ideal feeding environment and feed more
503 responsively than those who bottle feed or feed solids (Shloim et al., 2015). Although
504 causality cannot be inferred from these analyses, it is possible that breastfeeding
505 increases positive maternal behaviours. However, it is also true that more sensitive
506 mothers choose to breastfeed (Tharner et al., 2012). Breastfeeding for at least 6-
507 months may therefore be a practice that more sensitive mothers undertake. It is
508 interesting to highlight here that post hoc analyses demonstrated controlling for
509 maternal sensitivity did not remove the significance of the relationship between
510 breastfeeding duration and weight or slowness in eating. Whilst maternal sensitivity is
511 an important correlate of breastfeeding duration, it does not entirely explain the
512 relationship between breastfeeding and weight/eating behaviour.
513
514 Interestingly, previous research has found that the majority of mothers observed to be
515 responsive to their child during a mealtime had children who were highly responsive

to their mothers in return (Hodges et al., 2013). Future research should therefore evaluate parenting sensitivity and responsiveness from a bidirectional perspective, using longitudinal observational methods (Bergmeier, Skouteris, & Hetherington, 2015).

One limitation of the current study is that the sample size is small for the number of variables that were controlled. In addition to this, it is uncertain whether all relevant confounders have been included. However, the current study did assess and control for a large number of important confounders, unlike many previous studies, and has still found some evidence for the relationship between breastfeeding and weight in infancy.

Although participants were from a variety of demographic, socioeconomic and cultural backgrounds, the educational level achieved by mothers in the current study was significantly higher than the national average (Statistics, 2011). In 2011, 27% of the UK adult population had a Level 4 qualification or above (degree, higher degree or professional qualification), compared to 63% of the mothers in the current study. Furthermore, although fewer women in the current study initiated breastfeeding compared to the national average (75% versus 81%), a higher proportion of women in the current study were breastfeeding at 6-months compared to the UK average (52% versus 34%) (McAndrew, 2010). It is therefore possible that selection bias may have affected whether or not participants continued with the study.

In addition to this, the current study did not measure the feeding of expressed breast milk via bottles. It is therefore assumed that breastfed infants were fed directly from

the breast. Given the increase of feeding expressed milk in recent years (Labiner-Wolfe, Fein, Shealy, & Wang, 2008), when investigating health outcomes in infancy and childhood, future studies should assess the mode by which breast milk is fed as well as the exclusivity and duration of breastfeeding.

Conclusions

The current study contributes to the published literature suggesting that breastfeeding is significantly associated with slower weight gain and lower weight and BMI throughout the first year of life. Furthermore, breastfeeding may also encourage the development of obesity-protective eating behaviours through the development of slower eating styles. Slower eating styles may help infants and mothers in the attention, communication and perception of internal signals of hunger and satiety. Future research into breastfeeding and weight gain should move forward by investigating whether relationships between slowness in eating and weight extend to satiety responsiveness after infancy.

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Jackie Blissett: Professor Blissett conceptualised and designed the study, supervised data collection, contributed to analysis and interpretation of data, critically reviewed the manuscript, and approved the final manuscript as submitted.

Both authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Both authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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