Early influences on child satiety-responsiveness: the role of weaning style

A. Brown[1] and M. D. Lee[2]

[1]*Department of Public Health and Policy Studies, College of Human and Health Sciences, Swansea University, Swansea, UK;*
[2]*Department of Psychology, College of Human and Health Sciences, Swansea University, Swansea, UK*

Summary

Background: Nutrition during infancy may have a long-term impact upon weight gain and eating style. How infants are introduced to solid foods may be important. Traditionally, infants are introduced to solid foods via spoon-feeding of purees. However, baby-led weaning advocates allowing infants to self-feed foods in their whole form. Advocates suggest this may promote healthy eating styles, but evidence is sparse. The aim of the current study was to compare child eating behaviour at 18–24 months between infants weaned using a traditional weaning approach and those weaned using a baby-led weaning style.

Methods: Two hundred ninety-eight mothers with an infant aged 18–24 months completed a longitudinal, self-report questionnaire. In Phase One, mothers with an infant aged 6–12 months reported breastfeeding duration, timing of solid foods, weaning style (baby-led or standard) and maternal control, measured using the Child Feeding Questionnaire. At 18–24 months, post-partum mothers completed a follow-up questionnaire examining child eating style (satiety-responsiveness, food-responsiveness, fussiness, enjoyment of food) and reported child weight.

Results: Infants weaned using a baby-led approach were significantly more satiety-responsive and less likely to be overweight compared with those weaned using a standard approach. This was independent of breastfeeding duration, timing of introduction to complementary foods and maternal control.

Conclusions: A baby-led weaning approach may encourage greater satiety-responsiveness and healthy weight-gain trajectories in infants. However, the limitations of a self-report correlational study are noted. Further research using randomized controlled trial is needed.

Keywords: Baby-led, child weight, satiety-responsiveness, weaning.

Introduction

Childhood obesity remains a concern in the UK and USA (1,2) with many negative health and social implications (3). While there are multiple determinants of obesity (4), there is increasing recognition of the role of gene–environment interactions in the development of obesity (5). Recently, Wardle and colleagues have put forward the appetite–environmental interaction model of obesity suggesting that weight gain is the product of the interaction between genetically determined appetite traits and the environment (6). In a large cohort study, children's satiety-responsiveness was negatively related to body mass index (BMI) standard deviation (SD) scores (7). Evidence in support of satiety-

responsiveness as a heritable component of appetite comes from a subset of this cohort, who were homozygous for the high risk A allele variant of the *FTO* gene. Those with two copies of the A allele had higher BMI and were also lower in satiety-responsiveness as measured using the Child Eating Behaviour Questionnaire (CEBQ) (8).

Given the strong evidence in support of an appetite phenotype (6–8), which influences children's risk of obesity, it is especially important to understand the role the early feeding environment and to establish the characteristics of an environment that ameliorates the risk of obesity. For example, one key environmental factor is a controlling parental child-feeding style, which has been shown to lead to poorer appetite regulation (9,10). Controlling feeding

practices such as by restricting diet and pressuring children to eat are associated with a decreased ability to regulate intake according to appetite. Restricting intake of food can lead to increased intake when allowed free access (11,12), whereas pressure to eat can lead to increased fussiness (13,14). As a consequence, high levels of maternal control can affect children's BMI and weight-gain trajectories. Typically, restrictive practices have been linked to increased weight gain (15), while pressure to eat can lead to increased fussiness and subsequent underweight (16). However, it should be noted that not all studies have found conclusive evidence or rely on predominantly white, middle-class, US-based samples (17,18).

Another aspect of the early food environment is the choice of infant feeding method and the way in which the transition to solids progresses. It is already known that longer breastfeeding duration (19) and later introduction to complementary foods (20) are protective against later risk of becoming overweight. Breastfeeding may promote satiety-responsiveness in childhood (21), as breastfed infants have greater opportunity to self-regulate their own intake of milk (22). This may be due to lower maternal control during milk feeding (23), as the quantity of milk taken and duration of feeding is led by the infant. Indeed, breastfed infants have a lower risk of childhood obesity while infants who are bottle-fed with either formula or expressed milk are at greater risk of over-consumption and increased weight gain (24).

It is also important to understand the potential influence of weaning practices on the risk of obesity. Later introduction to complementary foods and maternal child-feeding style during this period are associated with infant weight (16,25,26). Interest is also growing in *how* infants are introduced to complementary foods. Traditionally, infants are weaned with puréed foods, which tend to be spoon-fed by a parent/carer along with a gradual introduction to finger foods (27). However, a recent popular trend in weaning, baby-led weaning (BLW; Google search of 'baby-led weaning' produces over 1.1 million hits: Accessed 24/06/12), emphasizes self-feeding rather than spoon-feeding by infants from 6 months old (28). Foods in their whole form are presented to the baby, who self-selects, grasps, brings to the mouth and consumes of its own volition (29,30). A reported characteristic of BLW is that maternal control over-feeding is minimal such that the infant decides which food item is selected, how much of it is consumed and the speed of consumption throughout an eating episode (31,32).

Both breastfeeding and BLW place the infant in control of intake (23,31,32). Given the positive association between breastfeeding and satiety-responsiveness, we hypothesize that BLW could potentially maximize satiety-responsiveness and be a positive environmental influence on the risk of obesity. To date, evidence for this notion is mainly anecdotal and based on small-scale studies (33,34). One study has suggested that children who followed a BLW approach during weaning are less likely to prefer sweet foods and less likely to be overweight, although sample size was small and based on self-report (35). Alternatively, we have previously suggested that low levels of maternal control encouraged by BLW and/or associated tendency for breastfeeding in mothers using BLW account for any improved outcomes rather than self-feeding and absence of purées *per se* (31,32). Furthermore, Sachs has questioned whether BLW is quantifiably different from many parents who introduce solid foods to their infant without considering themselves 'baby-led' (36).

The aim of this current study was twofold. Firstly, we set out to examine whether infants weaned with a baby-led approach exhibited differences in eating behaviour during the second year compared with those weaned using a standard approach. Secondly, we further explored the role of maternal control, breastfeeding duration and timing of introduction to solid foods in these relationships. Here we report the results of the second phase of a two-part study. In Phase One, we showed that a BLW style was associated with significantly lower levels of control compared with mothers who followed a standard weaning (SW) approach in babies between 6 and 12 months (32). In Phase Two, reported here, we collected follow-up data 12 months later in order to investigate how appetite traits such as satiety-responsiveness at 18–24 months of age are related to both weaning approach and maternal child-feeding style during the weaning period.

Methods

Participants

Approval for this study was granted by the Department of Psychology Research Ethics Committee. All participants gave informed consent prior to inclusion in the study. All aspects of this study have been performed in accordance with the ethical standards set out in the 1964 Declaration of Helsinki.

In Phase One, 604 mothers with an infant aged 6–12 months (mean age 8.34 months) whom had started consuming complementary foods completed a questionnaire examining weaning style. Consent

was sought from mothers to be contacted for potential follow-up. Four hundred twenty-three mothers (70.26%) consented to being contacted. Mothers were invited to take part in Phase Two when their children were between 18 and 24 months of age. Three hundred twenty-five mothers responded to the request (76.8% of consented sample, 53.98% of original sample). After exclusion criteria (child health problems or severe issues with weight such as failure to thrive, failure to give consent or incomplete survey entry), 298 mothers remained in the full analysis (70.45% of consented sample, 49.5% of original sample).

In Phase One, mothers were recruited via local mother-and-baby groups based in South West Wales (UK) and through online parenting forums based in the UK. For the groups, contact wa s made with group leaders who distributed questionnaires to group members. Questionnaires were returned to the leader in a sealed envelope or via post to the researcher. In addition, posters were placed in centres around the city asking participants to contact the researcher for further details via email, phone or post. Questionnaires had information letters attached with details of how to contact the researcher if further information was required. Study adverts were also placed on specific research request boards on online message boards on parenting forums based in the UK (e.g. http://www.mumsnet.com; http://www.bounty.com) with an online link to complete the questionnaire via survey monkey. All participants were, however, based in the UK. Details were given on how to contact the researcher if needed. Participants completing the questionnaire via paper or online copy were given a written debrief at the end of the questionnaire and given researcher contact details if they wanted further information. All participants were given instruction to contact their relevant health professional if completing the questionnaire had raised any questions or issues with regard to caring for their baby (32).

For Phase Two, data were collected predominantly via an online questionnaire designed and hosted using SurveyMonkey.com. Mothers who consented to follow-up at stage one were sent a link to complete the second part of the study online or offered a paper copy. Overall, 94.96% of participants completed the survey online.

Measures

In Phase One, mothers reported their weaning style in terms of degree of spoon and purée use. Mothers were classed as baby-led weaners (BLW) if they reported using both spoon feeding and purées 10% of the time or less. Alternatively, if mothers reported using both spoon-feeding and purées more than 10% of the time they were classified as SW. This categorization was made during Phase One based on the lack of formal definition of BLW. BLW is defined by a lack of puree use and allowing the infant to self-feed. Using a 10% cut-off for purée use and spoon-feeding reflected the main tenets of the method while allowing those who very occasionally used purees or spoon-feeding (for example when feeding a yoghurt or out in public) and identified as being baby-led as to be included in the BLW group. Further details are available in the initial study (31,32).

Based on this categorization, 351 (58.1%) participants in Phase One were classified as following a BLW feeding style and 253 (41.9%) as following a SW approach. Mothers also completed a copy of the Child Feeding Questionnaire (CFQ) (37), reported breastfeeding duration and timing of introduction to complementary foods.

In Phase Two, mothers completed a second copy of the CFQ (37) answering items targeting restriction, pressure to eat, monitoring, concern for child weight and perceived responsibility. Five scales of the CEBQ [food-responsiveness', 'enjoyment of food', 'satiety-responsiveness', 'slowness in eating' and 'food fussiness'] were also completed (38). The 'food-responsiveness' scale measures desire of the child to eat in response to food stimuli regardless of how hungry they are. 'Enjoyment of food' reflects a positive eating style and enjoyment of eating. 'Satiety-responsiveness' examines ability to regulate intake of food in relation to satiety. Linked to this, 'slowness in eating' reflects the speed at which a child eats. Finally, 'food fussiness' is defined by picky and limited food choices. Participants also self-reported the current weight of their child.

Data analysis

Data analyses were carried out using Statistical Package for the Social Sciences (SPSS) v16 (SPSS UK Ltd., IBM, Surrey, UK) Data were checked for normal distribution and found adequate. The CFQ (37) and CEBQ (38) are typically used for pre-school aged and older children. Therefore, principal components analysis using varimax rotation was performed on both the CFQ and CEBQ to ensure that the original factor structures held within this new sample and age range (39). Factors with eigenvalues over 1 were retained. A threshold of 0.5 was used based on recommendations by Nunnally (40). Factors produced mirrored those on the original questionnaires. As a further test of reliability,

Cronbach's alpha was computed for items loading above the threshold onto each scale and found to be over 0.7 for each scale. Therefore both the CFQ and CEBQ were scored as per original instructions.

Infant birth and current weight were converted to z scores. Current infant weight was also classified as normal weight (5th–85th percentile), underweight (<5th percentile) or overweight/obese (>85th percentile) for infant age and gender according to the World Health Organization Child Growth Standard Charts (41).

A multivariate analysis of covariance (MANCOVA) was used to examine differences in child-eating behaviour for infants weaned using a BLW or SW approach while controlling for maternal education, breastfeeding duration and timing of introduction to complementary foods. The MANCOVA was then repeated, controlling additionally for maternal control at Phase One and Two.

Results

Weaning style

One hundred sixty-three (54.7%) of the Phase Two sample had been classified as following a BLW style, and 135 (45.3%) as following a SW style. This compared with 58.1% of the original sample following a BLW style and 41.9% following a SW style, suggesting similar uptake of the Phase Two questionnaire in the two weaning groups.

As found in Phase One, the BLW group had a significantly higher level of education [$F(287) = 3.2189$, $P < 0.01$] in comparison with those using a SW approach, although no significant difference was found for maternal age. Maternal education was therefore controlled for throughout. There was no significant difference in the age or education of mothers who completed the Phase Two follow-up compared with the whole sample in Phase One.

Mean current age of child was 21.46 months (SD: 3.05) ranging from 18 to 24 months. No significant difference in child age was seen between the BLW and SW groups. All children were considered fully weaned in that they were reported to be eating a wide range of family foods at regular meal times. Infants who were weaned using a SW approach were introduced to solid foods significantly earlier than those weaned following a BLW approach [$t(287) = 2.069$, $P < 0.01$].

Participants also indicated the age of their infant when they were first introduced to foods in their whole form [finger foods] (as opposed to purees, e.g. toast, cooked carrot stick). Children were introduced to finger foods (rather than first food *per se*) signifi-

cantly later [$t(287) = 3.018$, $P < 0.003$]. Therefore, age of introduction to solid foods and finger foods were also controlled for throughout.

Mean duration of breastfeeding in the sample was 26.11 weeks (SD: 23.27 weeks). No significant difference in breastfeeding duration was evident between the two weaning groups [$t(296) = -0.710$, $P = 0.478$], although mothers in the BLW group were significantly more likely to have initiated breastfeeding at birth [$t(296) = -3.211$, $P = 0.001$]. Breastfeeding initiation was therefore controlled for in comparisons between groups.

Maternal child-feeding style

Significant differences in current maternal child-feeding style were seen between those who weaned using a BLW or SW approach. Mothers who followed a BLW approach reported significantly current lower levels of concern for child weight [$F(1, 278) = 6.714$, $P < 0.01$], pressure to eat [$F(1, 278) = 5.273$, $P < 0.05$], restriction [$F(1, 278) = 15.383$, $P < 0.001$] and monitoring [$F(1, 278) = 5.808$, $P < 0.05$] compared with mothers who weaned using a SW approach. No significant difference was seen between the two groups for perceived responsibility.

Child eating behaviour

A MANCOVA found significant differences between those weaned following a BLW or SW style for the Child Eating Behaviour measures of food-responsiveness, satiety-responsiveness and food fussiness (Table 2). No significant difference was found for enjoyment of food. Those infants who had followed BLW were reported to be significantly less food-responsive and less fussy and significantly more satiety-responsive than those following SW style (see Table 1).

Breastfeeding duration was significantly associated with satiety-responsiveness (Pearson's $r = 0.134$, $P = 0.01$) and inversely associated with fussiness (Pearson's $r = -0.145$, $P = 0.007$). Infants who were breastfed for a longer duration were reported as significantly more satiety-responsive and significantly less fussy.

Timing of introduction to complementary foods was significantly inversely associated with fussiness (Pearson's $r = -0.179$, $P = 0.001$), but no other behaviour. Infants who were weaned at an earlier age were reported to be significantly more fussy at 18–24 months.

Age at which infants were introduced to finger foods was significantly associated with food-responsiveness (Pearson's $r = 0.182$, $P = 0.001$).

Table 1 Maternal sample distribution by demographic factors

Indicator	Group	BLW		SW	
		n	%	n	%
Age (years)	≤19	3	1.0	5	1.7
	20–24	21	7.0	26	8.7
	25–29	60	20.1	41	13.8
	30–34	53	17.8	46	15.4
	35 ≥	26	8.7	17	5.7
Education	School	34	11.4	30	10.0
	College	52	17.4	34	11.4
	Higher	41	13.8	47	15.8
	Post-graduate	36	12.1	24	8.1
Marital status	Married	110	36.9	91	30.5
	Cohabiting	15.4	15.4	36	12.1
	Partner	1	0.3	4	1.3
	Single	6	2.0	8	2.6
Maternal occupation	Professional / managerial	61	22.2	56	20.3
	Skilled	18	6.5	14	5.1
	Unskilled	43	15.6	30	10.9
	Stay-at-home mother	29	10.6	24	8.7

BLW, baby-led weaning group; SW, standard weaning group.

Infants who were introduced to whole foods at an earlier stage were significantly less food-responsive.

Child eating behaviour and maternal child-feeding style

The association between maternal child-feeding style at Phase One and Phase Two and current eating behaviour was examined. Analyses were performed separately for those in the BLW and SW groups (Table 3). Phase One control was placed as a covariate when examining the relationship between control and eating behaviour at Phase Two.

Significant associations were found between maternal control at Phase One and current eating behaviour, but only for those in the SW group. High levels of restriction were significantly associated with lower levels of satiety-responsiveness, whereas concern for infant weight was significantly associated with higher levels of food fussiness. High levels of pressure to eat were also associated with significantly lower levels of enjoyment of food.

For Phase Two control, pressure to eat was significantly positively associated with food-responsiveness for both weaning groups while restriction was

Behaviour	Mean (standard error)		Significance
	BLW	SW	
Food-responsiveness	2.85 (.50)	3.18 (.45)	$F(1, 268) = 16.143$, $P < 0.001$
Satiety-responsiveness	2.61 (.43)	2.42 (.38)	$F(1, 268) = 5.492$, $P < 0.05$
Food fussiness	3.26 (.37)	3.03 (.32)	$F(1, 268) = 5.535$, $P < 0.05$
Enjoyment of food	1.91 (.86)	1.84 (.73)	$F(1, 268) = .546$, $P > 0.05$

Table 2 Differences in child eating behaviour for infants at 18–24 months weaned following a baby-led weaning (BLW) or standard weaning (SW) style

Table 3 Association between maternal control and later child eating behaviour at 18–24 months

		Food-responsiveness		Satiety-responsiveness		Food fussiness		Enjoyment of food	
		BLW	SW	BLW	SW	BLW	SW	BLW	SW
Maternal control during Phase One	Concern for infant weight	0.041	–0.118	–0.037	–0.017	–0.101	0.210**	–0.011	–0.044
	Restriction	–0.077	–0.034	–0.120	–0.212**	–0.167	0.091	0.069	0.009
	Pressure to eat	0.071	–0.130	–0.025	0.022	–0.018	0.065	0.029	–0.327**
	Monitoring	–0.130	–0.017	–0.045	0.018	–0.100	0.046	0.019	–0.094
Maternal control during Phase Two	Concern for infant weight	–0.012	0.188	0.041	0.008	–0.022	0.071	0.086	–0.64
	Restriction	0.059	0.157*	–0.171*	–0.279**	–0.012	0.135*	0.014	–0.113
	Pressure to eat	0.212**	0.227**	0.112	0.017	0.071	0.035	–0.084	–0.044
	Monitoring	0.052	–0.051	–0.106	–0.113	–0.005	–0.184*	–0.061	0.103

*$P < 0.05$, **$P < 0.01$. BLW, baby-led weaning group; SW, standard weaning group.

significantly associated with higher levels of food-responsiveness (for the SW group) and lower levels of satiety-responsiveness for both weaning groups. Finally, among the SW group, both higher levels of monitoring and concern for infant weight were associated with increased food fussiness.

Child weight

No significant difference in birth weight or weight at 6 months was found between the two groups.

Current child weight was examined and compared for the two weaning groups. Overall, 10.1% of the sample ($n = 30$) did not provide a current weight for their infant. Of the remaining, infants in the sample were predominantly within normal weight expectations for their age (74.5%, $n = 222$). Of the sample, 11.7% were overweight ($n = 35$) and 3.7% were underweight ($n = 11$).

Infants in the SW group were however significantly currently heavier than those in the BLW group [$F(1, 225) = 7.931$, $P = 0.005$]. This relationship was independent of birth weight, breastfeeding duration, age of introduction to solid foods and maternal control at both Phase One and Phase Two. Mean weight in kilogram of infants in the SW group was 12.86 (SD: 3.73) compared with 11.79 (SD: 3.53) in the BLW group.

Pearson's chi-square also revealed a significant association between current weight category and weaning style [χ^2 (2, 268) = 8.100, $P < 0.017$]. For the BLW group, 86.5% were of normal weight, 8.1% overweight and 5.4% underweight. In comparison, 78.3% of those in the SW group were normal weight, 19.2% overweight and 2.5% underweight. A greater percentage of those infants who were overweight followed a SW approach.

Infant birth weight, weight at 6 months and current weight were unrelated to current child satiety or food-responsiveness. However, current child weight was significantly inversely associated with perceived fussy eating (Pearson's $r = -0.171$, $P = 0.003$).

Child eating behaviour, maternal child-feeding style and weaning style

As child eating behaviour was associated with weaning style, maternal child-feeding style, child weight and weaning behaviours, the analyses between weaning approach and later child eating behaviour were performed for a second time, placing maternal education, maternal child-feeding style, breastfeeding duration, timing of introduction to complementary and finger foods, birth weight and current weight as covariates in the analysis.

A MANCOVA showed significant differences for food-responsiveness [$F(1, 249) = 4.778$, $P < 0.01$] and satiety-responsiveness [$F(1, 249) = 4.500$, $P < 0.01$] remained between those following BLW or SW approach. Infants weaned using a BLW approach were rated as significantly less food-responsive and significantly more satiety-responsive than those weaned following a SW approach, independently of maternal education, maternal control, breastfeeding duration, child weight and timing of introduction to complementary foods.

No significant difference between the two groups remained for food fussiness once covariates were accounted for.

Discussion

These results demonstrate for the first time the impact of weaning approach and maternal behaviour during the weaning period (6–12 months) on later child eating behaviour at 18–24 months old. Mothers who used BLW (infant self-feeds foods in their solid form) had children who were perceived at follow-up as having better appetite control and had a lower BMI than children weaned using a SW style (spoon-feeding puréed foods). These findings indicate that the approach adopted at the time of weaning, coupled with maternal feeding style, affect child eating behaviour 12 months later.

In this sample, use of the BLW approach predicted lower levels of food-responsiveness and higher satiety-responsiveness compared with a SW approach. High levels of food-responsiveness (desire to eat in response to food stimuli regardless of hunger) (42) and low levels of satiety-responsiveness (ability to regulate intake of food in relation to satiety) (43) have been associated with greater risk of childhood overweight. We suggest therefore that adoption of a BLW approach provides an environment during the development of eating patterns that promotes eating according to appetite. Indeed, infants in the SW group were significantly heavier than those in the BLW group, with a greater proportion of SW infants with a weight over the 85th percentile (although it has to be recognized that the overall number of infants above this centile was low).

There are a number of possible explanations why infants following a BLW approach are more satiety-responsive and less food-responsive. Firstly, it could be argued that BLW is merely associated with other behaviours that have been linked to specific appetitive traits. For example, mothers who follow a BLW style are more likely to breastfeed, introduce complementary foods at a later date and use lower

levels of control over their infants intake of food, (29,31) all of which are all associated with a decreased risk of obesity (19–21). Mothers who adopt BLW have consistently been shown to have a high level of education, which is typically associated with healthier child diet and weight (44) and this was also reflected in this sample. However, we found that use of BLW was associated with satiety-responsiveness at 18–24 months *independently* of maternal control, breastfeeding duration, timing of introduction to complementary foods and maternal demographic background.

Moreover, when exploring the association between maternal control and eating style (where previous literature has shown a link between high levels of maternal control and a breakdown in self-regulation (9,10)), BLW appeared to protect the infant from high levels of maternal control. Whereas for those infants weaned using a SW approach, maternal control both during infancy and the current time period was associated with poorer self-regulation, these relationships did not exist, or were weaker, among the BLW group, suggesting an intervening factor.

Potentially therefore, there is something unique about BLW that sets it apart from SW methods. Although speculative, it is plausible that by allowing infants to choose which food offering to grasp and bring to the mouth without much parental involvement the pace and duration of eating episodes are optimal for the development of satiety-responsiveness. Infants are given greater opportunity to determine the end point of a meal compared with spoon-feeding where the parent may consciously or subconsciously wish the set portion-size to be consumed. Even when maternal desire for control is higher, the ability of the infant to control the pace and size of the meal may overcome this. Moreover, greater participation in family meal times (30,45) may extend meal duration and decrease overall eating speed, which has been associated with increases in physiological signs of satiety (46). Babies have no notion of portion sizes or habitual plate clearing, and when given the opportunity will likely determine when the meal finishes without regard to how much food remains uneaten. Ability to eat to satiety rather than finishing the portion available may be an important element in protection against overweight (47). Evidence shows that pre-school children are less likely to finish a larger-than-needed portion-size (48), but that this ability reduces by later childhood and adulthood (49). A BLW approach may thus prolong or protect this ability, increasing the likelihood of continued satiety-responsiveness into older childhood and adulthood.

It is also possible that one of the benefits of BLW is that it maximizes learning about the post-ingestive consequences of food. Numerous studies have demonstrated that sensory properties of food can over a number of exposures become associated with post-ingestive effects, e.g. visual cues, flavours and textures become associated with how satiating that food is (47). In turn, learned food experience influences food selection and portion-size choices appropriately (50). With BLW, foods are presented in their whole form such as an apple or piece of chicken rather than in a less-recognizable puréed form. Moreover, infants are often given a selection of discrete food pieces to choose from (e.g. a piece of toast, slices of banana). This contrasts with purées which often consist of different foods and flavours mixed together (e.g. a sweet potato, parsnip and carrot purée) (31). For commercially prepared purées, the main ingredient may not fit in with the main flavour of the purée (e.g. a potato-based purée having a predominant broccoli flavour), setting up a relationship between flavour and post-ingestive consequences that will later change again as the transition is made from purées to discrete food items. We postulate that perhaps BLW enables early and more stable learning about the satiating capacity of foods, thus promoting satiety-responsiveness. This of course needs to be tested empirically and it will be important to establish if enhanced satiety-responsiveness continues further into childhood.

Infants who followed a BLW style were also rated as significantly less fussy than infants following a SW style, supporting speculation that BLW fosters positive appetitive traits (34). However, once maternal control was accounted for, this relationship disappeared and weaning style did not remain predictive of fussiness in the regression analysis. This is not to say a BLW approach is not associated with a wider acceptance of foods, but that it may be explained by the low level of maternal control involved in the method. Indeed, lower levels of maternal control over child diet have been associated with lower levels of pickiness and fussiness in older children (51). This is an interesting finding as it not only highlights the impact of weaning style, but suggests that for those who adopt a SW approach, doing so in a responsive way may be beneficial to later food preferences in children.

Finally, infants who followed a BLW approach were significantly less likely to have a weight centile > 85th than those who followed a SW approach, supporting previous findings (35). Placing the infant in control of food intake and greater acceptance of a wider variety of tastes may promote a healthier weight trajectory.

However, this association must be taken with caution as weight was self-reported by parents and numbers of infants in the overweight range were small. Further research clearly needs to examine impact of BLW on longer term weight trajectories.

These findings do need to be considered in light of limitations. Firstly, the sample was self-selecting both in terms of participation and decision to follow a certain approach to weaning. It may be that parents who are especially concerned with infant weight and eating style or their own health choose to adopt a BLW approach as they have heard anecdotal stories about its benefits. Indeed, mothers in the BLW group had a higher level of education, although this was controlled for in the analyses. Another possibility is that parents who follow a BLW approach are more aware of the importance of eating to appetite and the health benefits of and have a strong belief in the ability of BLW to lead to positive eating styles and thus influencing the way they complete the questionnaire. Further research should consider a population-based sample or indeed a randomized controlled trial.

Criticisms could also be made on the methodology used, although in light of the dearth of research in the area the sample and methodology were considered appropriate for initial exploration. The current study relied on self-report of child eating behaviour and weight which could have been open to responder bias or error. Analyses were also correlational and cannot determine causality. Further research should seek to observe child eating behaviour and measure intake of nutrients and weight rather than rely on parental report. Again, a randomized controlled trial may be needed to ascertain impact of the approach among other wider factors.

Additionally, measures to categorize BLW vs. SW were devised for the study (see Methodology). In the absence of a clinical definition of BLW, these measures were considered appropriate and felt to reflect definitions in popular literature and discussion with parents. Finally, the CFQ and CEBQ are also typically used for older children (although the CFQ is considered valid from two years (37)). However recent work in the area has employed (and validated (51)) these measures in reference to children under the age of 2 years both for the CEBQ (53–55) and CFQ (16,25,56,57). Child eating behaviour (58) and maternal child-feeding style (59) are also considered stable for older children.

It is also important to consider the role of infant characteristics. Much emphasis is placed on intake of food and infant weight gain during the weaning period with mothers concerned about their infants progress (60). If an infant is perceived as a fussy eater, mothers may not feel confident in adopting a BLW approach or allowing the infant opportunity to Cself-regulate appetite. Instead, they may choose to use traditional methods of purées and spoon-feeding to have greater control and measure of what their infant is consuming. Alternatively, they may start the weaning process using a BLW approach, but struggle and move to spoon-feeding. Child weight and eating style can drive maternal child-feeding style for older children (9,10), thus it is likely for younger infants. Rather than BLW leading to an infant who is more responsive and less fussy, perhaps infants who are less fussy and more responsive are more likely to start or continue following a BLW approach.

Linked to this, maternal personality may also play a role. Previous work has shown that mothers who follow BLW are lower in anxiety and feel more relaxed specifically in relation to the weaning process than mothers following a SW approach (30). Mothers who are high in anxiety are more likely to use a restrictive and controlling feeding style (61) and mothers who are controlling in their parenting style are more likely to use a controlling maternal-feeding style (62) and have overweight children (63). Perhaps therefore, mothers who are more anxious in general gravitate to a SW approach as it allows greater control and measurement, which in turn impacts upon child weight and eating style.

Limitations aside, these findings raise important questions not only in regard to the timing when infants are introduced to complementary foods, but how this process takes place. Evidence is starting to build that a BLW approach may encourage a satiety-responsive eating style to develop; understanding how this works in greater detail may be an important step in developing early interventions to combat rising childhood obesity. Data, however, now needs to move away from relying on parental self-report (e.g. utilizing observations of child intake such as an eating in the absence of hunger task) while subject selection issues also need to be reduced through randomization.

In summary, babies who transition from a milk diet to solid foods using the BLW method show greater satiety-responsiveness and decreased likelihood of overweight at 18–24 months compared with those using the standard spoon-and-purée approach. Influences on childhood weight gain are complex and driven at least partly by genetics. However, potentially the BLW approach may provide a protective environment to ameliorate the overall risk of obesity. Further research is needed.

References

1. James PT, Leach R, Kalamara E, Shayeghi M. The worldwide obesity epidemic. *Obes Res* 2001; 9: 228S–233S.

2. Carroll MD, Kit BK, Flegal KM. Prevalence of obesity in the United States, 2009–2010. 2012.

3. Baker JL, Olsen LW, Sorensen TIA. Childhood body mass index and the risk of coronary heart disease in adulthood. *N Eng J Med* 2007; 357: 2329–2337.

4. Wright SM, Arone LJ. Causes of obesity. *Abdom Imaging* 2012; 37(5): 730–732.

5. Wynne K, Stanley S, McGowan B, Bloom S. Appetite control. *J Endocrinol* 2005; 184: 291–318.

6. Wardle J, Carnell S. Appetite is a heritable phenotype associated with adiposity. *Ann Behav Med* 2009; 38: 25–30.

7. Carnell S, Wardle J. Appetite and adiposity in children – evidence for a behavioral susceptibility theory of obesity. *Am J Clin Nutr* 2008; 88: 22–29.

8. Wardle J, Carnell S, Haworth C, Farooqi S, O'Rahilly S, Plomin R Obesity-associated genetic variation in FTO is associated with diminished satiety. *JCEM* 2008; 93: 3640–3643.

9. Ventura AK, Birch LL. Does parenting affect children's eating and weight status? *Int J Behav Nutr Phys Act* 2008; 5/15: 1–12.

10. Benton D. Role of parents in the determination of the food preferences of children and the development of obesity. *Int J Obes* 2004; 28: 858–869.

11. Joyce JL, Zimmer-Gembeck MJ. Parent feeding restriction and child weight. The mediating role of child disinhibited eating and the moderating role of the parenting context. *Appetite* 2009; 52: 726–734.

12. Lee Y, Mitchell D, Smiciklas-Wright H, Birch L. Diet quality, nutrient intake, weight status and feeding environment of girls meeting or exceeding recommendations for total dietary fat of the American Academy of Paediatrics. *Paediatrics* 2001; 107: 45–52.

13. Farrow CV, Galloway AT, Fraser K. Sibling eating behaviours and differential child feeding practices reported by parents. *Appetite* 2009; 52: 307–312.

14. Galloway A, Fiorito L, Lee Y, Birch LL. Parental pressure, dietary patterns and weight status among girls who are picky eaters. *J Am Diet Assoc* 2005; 105: 541–548.

15. Faith MS, Scanlon KS, Birch LL, Francis A, Sherry B. Parent child-feeding strategies and their relationships to child eating and weight status. *Obes Res* 2004; 2: 1711–1722.

16. Farrow C, Blissett J. Controlling feeding practices: cause or consequence of early child weight? *Pediatrics* 2008; 121: 1–6.

17. Haycraft EL, Blissett JM. Maternal and parental controlling feeding practices: reliability and relationships with BMI. *Obesity* 2008; 16: 1552–1558.

18. Wardle J, Sanderson S, Guthrie C, Rapoport L, Plomin R. Parenting feeding style and the intergenerational transmission of obesity risk. *Obes Res* 2002; 10: 453–462.

19. Harder T, Bergmann R, Kallischnigg G, Plagemann A. Duration of breastfeeding and risk of overweight: a meta analysis. *Am J Epidemiol* 2005; 162: 397–403.

20. Moorcroft KE, Marshall JL, McCormick FM. Association between timing of introducing solid foods and obesity in infancy and childhood: a systematic review. *Matern Child Nutr* 2011; 7: 3–26.

21. Brown A, Lee M. Breastfeeding during the first year promotes satiety responsiveness in children aged 18–24 months. *Int J Pediatr Obes* 2012; 7: 382–390.

22. Bartok CJ, Ventura AK. Mechanisms underlying the association between breastfeeding and obesity. *Int J Pediatr Obes* 2009; 4: 196–204.

23. Brown A, Raynor P, Lee M. Maternal control of child-feeding during breast and formula feeding in the first 6 months post-partum. *J Hum Nutr Diet* 2012; 24(2): 177–186.

24. Li R, Fein S, Grummer-Strawn L. Do Infants fed from bottles lack self regulation of milk intake compared with directly breastfed infants. *Pediatrics* 2010; 125: 1286–1293.

25. Brown AE, Lee MD. Maternal child-feeding style during the weaning period: association with infant weight and maternal eating style. *Eat Behav* 2011; 12: 108–111.

26. Farrow C, Blissett J. Breastfeeding, maternal feeding practices and mealtime negativity at 1 year. *Appetite* 2006; 46: 49–56.

27. Seaman C, D'Alessandro S, Swannie M. Choice of weaning foods. *Br Food J* 1996; 98: 13–16.

28. Rapley G, Murkett T. Baby-led weaning: helping your baby to love good food. *Vermillon* 2008.

29. Rapley G. Baby-led weaning: transitioning to solid foods at the baby's own pace. *Community Pract* 2011; 84: 20–23.

30. Brown AE, Lee MD. A descriptive study investigating the use and nature of baby-led weaning in a UK sample of mothers. *Matern Child Nutr* 2011; 7: 34–47.

31. Brown AE, Lee MD. An exploration of the experiences of mothers following a baby-led weaning style: developmental readiness for complementary foods. *Matern Child Nutr* 2011. doi: 10.1111/j.1740-8709.2011.00360.x.

32. Brown AE, Lee MD. Maternal control during the weaning period: differences between mothers following a baby-led or standard weaning approach. *Matern Child Health* 2011; 15: 1265–1271. doi: 10.1007/s10995-010-0678-4.

33. Rapley G. 2003) Can babies initiate and direct the weaning process? Unpublished MSc Interprofessional Health and Community Studies (Care of the Breastfeeding Mother and Child). Canterbury Christ Church University College, Kent.

34. Rapley G. Baby-led weaning: a developmental approach to the introduction of complementary foods. In: Moran V, Dykes F (eds). *Maternal and Infant Nutrition and Nurture Controversies and Challenges*. Gutenberg Press Ltd: Malta, 2006.

35. Townsend E, Pitchford N. Baby knows best? The impact of weaning style on food preferences and body

mass index in early childhood in a case-controlled sample. *BMJ Open* 2012; 2: e000298.

36. Sachs M. Baby-led weaning and current UK recommendations – are they compatible? *Matern Child Nutr* 2011; 7: 1–2.

37. Birch LL, Fisher JO, Grimm-Thomas K, Markey CN, Sawyer R, Johnson SL. Confirmatory factor analysis of the Child Feeding Questionnaire: a measure of parental attitudes, beliefs and practices about child feeding and obesity proneness. *Appetite* 2001; 36: 201–210.

38. Wardle J, Guthrie CA, Sanderson S, Rapoport L. Development of the Children's Eating Behaviour Questionnaire. *J Child Psychol Psychiatry* 2001; 42: 963–970.

39. Tabachnick BG, Fidell LS. *Using Multivariate Statistics*, 5th edn. Allyn & Bacon: Boston, 2006.

40. Nunnally JC. *Psychometric Theory*, 2nd edn. McGraw-Hill: New York, 1978.

41. UK WHO neonatal and infant close monitoring charts UK WHO NICM. 2013. [WWW document]. URL http://www.rcpch.ac.uk/child-health/research-projects/uk-who-growth-charts/uk-who-growth-chart-resources-0-4-years/uk-who-0.

42. Carnell S, Wardle J. Measuring behavioural susceptibility to obesity: validation of the child eating behaviour questionnaire. *Appetite* 2007; 48: 104–113.

43. Johnson S, Birch L. Parents and children's adiposity and eating style. *Paediatrics* 1994; 94: 653–661.

44. Knai C, Lobstein T, Darmon N, Rutter H, McKee M. Socioeconomic patterning of childhood overweight status in Europe. *Int J Environ Res Public Health* 2012; 9: 1472–1489.

45. Rowan H, Harris C. Baby-led weaning and the family diet. A pilot study. *Appetite* 2012; 58: 1046–1049.

46. Sclafani A. Learned controls of ingestive behaviour. *Appetite* 1997; 29: 153–158.

47. Brunstrom J. Dietary learning in humans: directions for future research. *Physiol Behav* 2005; 85: 57–65.

48. Birch LL, Johnson SL, Jones MB, Peters JC. Effects of a nonenergy fat substitute on children's energy and macronutrient intake. *Am J Clin Nutr* 1993; 58: 326–333.

49. Rolls BJ, Row LS, Meengs JS. Larger portion sizes lead to a sustained increase in energy intake over 2 days. *J Am Diet Assoc* 2006; 104: 367–372.

50. Stuart RB. Behavioral control of overeating. *Behav Res Ther* 1967; 5: 357–365.

51. Fisher JO, Mitchell DC, Smiciklas-Wright H, Birch LL. Parental influences on young girls' fruit and vegetable, micronutrient, and fat intakes. *J Am Diet Assoc* 2002; 102: 58–64.

52. Svensson V, Lundborg L, Cao Y, Nowicka P, Marcus C, Sobko T. Obesity related eating behaviour patterns in Swedish preschool children and association with age, gender, relative weight and parental weight – factorial validation of the Children's Eating Behaviour Questionnaire. *Int J Behav Nutr Phys Act* 2011; 8: 134.

53. Powers SW, Chamberlin LA, van Schaick KB, Sherman SN, Whitaker RC. Maternal feeding strategies, child eating behaviors, and child BMI in low-income African-American preschoolers. *Obesity* 2006; 14: 2026–2033.

54. Mallon K, Liu W, Mehta R, Daniels L, Magarey A, Battistutta D. Maternal report of young children's eating styles. Validation of the Children's Eating Behaviour Questionnaire in three ethnically diverse Australian samples. *Appetite* 2013; 64: 48–55.

55. Stifter C, Anzman-Frasca S, Birch L, Voegtline K. Parent use of food to soothe infant/toddler distress and child weight status. An exploratory study. *Appetite* 2013; 57: 693–699.

56. Farrow C, Blissett J. Does maternal control during feeding moderate early infant weight gain? *Pediatrics* 2006; 118: 293–298.

57. Taveras E, Scanlon K, Birch L, Rifas-Shiman S, Rich-Edwards J, Gillman M. Association of breastfeeding with maternal control of infant feeding at age 1 year. *Paediatrics* 2004; 114: 577–583.

58. Ashcroft J, Semmler C, Carnell S, van Jaarsveld C, Wardle J. Continuity and stability of eating behaviour traits in children. *Eur J Clin Nutr* 2007; 62: 985–990.

59. Blissett J, Farrow C. Predictors of maternal control of feeding at 1 and 2 years of age. *Int J Obes* 2007; 31: 1520–1526.

60. Arden M. Conflicting influences on UK mothers decisions to introduce solid foods to their infants. *Matern Child Nutr* 2010; 6: 159–173.

61. Farrow C, Blissett J. Maternal psychopathology and obesigenic feeding practices. *Obes Res* 2005; 13: 1999–2005.

62. Hubbs-Tait L, Kennedy TS, Page MC, Topham GL, Harrist AW. Parental feeding practices predict authoritative, authoritarian and permissive parenting styles. *J Am Diet Assoc* 2008; 108: 1154–1161.

63. Rhee KE, Lumeng JC, Appugliese DP, Kaciroti N, Bradley RH. Parenting styles and overweight status in first grade. *Pediatrics* 2006; 117: 2047–2054.