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Differences in dietary composition between infants introduced to complementary foods using Baby-led weaning and traditional spoon feeding

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Abstract

Background: Baby-led weaning (BLW) is a method of introducing solid foods to infants, which centres around the infant self-feeding family foods. BLW has grown in popularity over the last 10 years; however, although research is starting to build around the safety and impact of the method, research examining intake is sparse. This is important because concerns have been raised by healthcare providers regarding the nutrient and energy sufficiency of BLW. The present study aimed to invstigate exposure to different food types based on different weaning approaches.
Methods: One hundred and eighty parents completed a 24-h recall of the foods given to their babies aged 6–12 months. Respondents were split into those following strict BLW, loose BLW and traditional spoon-feeding. Recalls were examined to ascertain the number of times in 24 h infants were given different types of foods, including iron-containing foods. The results were then compared between different weaning groups and age groups.
Results: Several significant differences were found between the frequency of foods eaten by different weaning and age groups: in the youngest age group, strict BLW infants were more likely to be exposed to vegetables (P = 0.000) and protein (P = 0.002) than traditionally weaned babies, whereas, at all age groups, the traditionally weaned group had the highest exposure to composite meals. However, no significant differences were found in reported exposure to iron-containing foods between weaning groups at any age. Maternal age, education and milk feeding method were controlled for throughout the analyses.
Conclusions: The findings add to a growing body of evidence that suggest a BLW approach may be safe and sufficient.

Introduction

The introduction of solid food to infants traditionally involves using purees or soft baby cereals spoon fed to the infant by a caregiver, gradually progressing through coarser textures until the infant is eating family foods at around 12 months. However, the last 10 years has seen the growth in popularity of an alternate method of introducing solids, Baby-led weaning (BLW), which promotes the self-feeding of finger foods from approximately 6 months of age, completely skipping the traditional parent-led spoon-feeding stage of weaning [1]. Anecdotally, BLW is now used by many parents, although no formal measurement of the frequency of this weaning approach has been conducted.

Despite its growth in popularity, BLW is not part of official UK weaning guidelines partly as a result of the limited evidence base and a lack of conclusive evidence for the efficacy or safety of the method [2]. Observational small scale research suggests that BLW does not increase the risk of choking [3,4], and may promote better appetite control [5,6], healthier weight trajectories [5,7] and lower fussiness [5]. However, in the only randomised controlled trial of the approach, no difference in weight was found between those following a baby-led or traditional approach to solids, although this was based on infant weight at 12 months old, rather than the weight of older children[8].

One of the key areas where research needs to focus is the impact of weaning approach upon nutrient intake in infants. Healthcare professionals have raised concerns that infants who are self-feeding may not consume sufficient energy or nutrients, in particular iron [6,9], although parents do not share this anxiety [10,11].

Data on food intake are sparse. In survey research with preschool children [7], those who had followed BLW were more likely to prefer carbohydrate-based food compared to the sweet foods preferred by those weaned traditionally. In New Zealand, a randomised controlled trial of a modified baby-led approach found that, at 6–8 months of age, infants who were following a strict baby-led approach consumed less iron, zinc and vitamin B_{12} in a weighed food study than traditionally weaned infants, although infants weaned with a mixed approach had nutrient intakes similar to the traditionally weaned group [12]. Infants in the baby-led group also consumed more energy overall, including a higher fat intake, although guidance for this group was to offer a modified version of BLW including energy dense, high-fat foods every day because of concerns reagarding undernutrition, which may have affected intake [8].

In later research from the same group, zinc intake and status were assessed at 12 months using a weighed food diary and plasma zinc concentration. No significant difference was found between the modified BLW (BLISS) group and the traditionally weaned group [13]. The most recent research from this group has found that, at 12 months, those babies following BLW had a lower saturated fat intake than the control group, although there were no differences between the groups at 24 months. However, most children in each group were consuming more than the recommended amounts of sodium (68% of children) and sugar (75% of children) [14].

Given the increasing popularity of the baby-led approach coupled with concerns of healthcare professionals and the lack of official guidance, evidence examining the intake of infants introduced to foods in different ways is clearly needed. The present study aimed to address this knowledge gap by recording and comparing the exposure to different foods of infants aged 6–12 months weaned using traditional spoon-feeding and BLW via 24-h recall.

Materials and methods

Participants

Study participants comprised parents living in the UK with an infant aged 6–12 months old who had started complementary foods. Exclusion criteria included an inability to consent, significant infant health issues affecting the introduction of solids (e.g. failure to thrive) and premature birth (<37 weeks of gestation) or low birth weight (<2.5 kg) because these can affect timing and progression of solids. Parent ages ranged from 18 to 44 years, with a mean (SD) age of 32 (5.2) years, whereas babies ranged from 26 to 52 weeks, with a mean (SD) age of 38.1 (8.2) weeks. Approval for the study was granted by a University Research Ethics Committee. All participants provided their informed consent, and all aspects of the study were performed in accordance with the ethical standards set out in the 1964 Declaration of Helsinki.

Measures

Participants completed an online survey consisting of demographic information (age, level of education, employment, occupation), questions about feeding method from birth, the approach to the introduction to complementary foods and a 24-h food recall task.

To gather information on self-identified weaning approach, participants were given the following definition of the baby-led approach and asked whether they felt their method matched this strictly, loosely or not at all:

> BLW is the process of placing foods in front of your baby and letting them feed themselves – picking the food up themselves and putting it in their mouths unassisted, rather than being spoon-fed by a parent. This could involve them using a spoon themselves. BLW tends to involve offering the baby family foods rather than offering pureed foods

This self-identification was verified by asking follow up questions on how they were feeding their infants. Participants responded to how often their infant was spoon-fed by an adult [seven point scale: Always spoon-fed by adult through to Never spoon-fed by adult] and similarly for how often infants received pureed foods [seven point scale: Always pureed food through to Never pureed foods]. These questions were used to check whether participants' self-identified method matched their behaviour: Strict BLW was considered to include points 6 and 7 on the scale (e.g. Never or Rarely), whereas traditional weaning was considered to include points 1 and 2 on the scale (e.g. Always or Mostly always). Loose BLW fell in the middle of the scale. Participants remained self classified as strict BLW only if they 'never or rarely' offered purees or spoon-fed their infants, remained self classified as loose BLW if they 'occasionally or sometimes' used purees and spoon-feeding, and traditional if they 'often, mostly or always' used purees and spoon-feeding. All participants remained in their identified group.

For the 24-h diet recall, participants were asked to list all the foods and drinks, including milk feeds of breast or formula milk, offered to their baby over the previous 24 h. Participants were asked to give as much detail as they could about each type of food and drink consumed, such as brands and the amount of food offered and the time of day that they were consumed. Participants were given an example of the level of detail the recall might contain. Those breastfeeding were asked to note how long their baby nursed, and those formula feeding or giving cow's milk (or alternatives) were asked to report the quantities offered.

Dietary assessments using 24-h recalls are widely used in nutrition intake studies because they are cheap, relatively easy to administer and offer a 'snapshot' of a participant's diet. Other benefits are that they allow grouping of types of food, such as sweetened beverages or green vegetables, and totals can then be aggregated and compared between groups. They are particularly useful for population or group studies, have been validated for this purpose and have also used with babies [15–18].

Procedures

The questionnaire was hosted via SurveyMonkey (https://www.surveymonkey.co.uk). Adverts for the study containing brief information, inclusion criteria and researcher details were shared online in parenting forums [e.g. Mumsnet (https://www.mumsnet.com), Netmums (https://www.netmums.com)], baby and feeding groups on Facebook (https://www.facebook.com), and on Twitter (https://twitter.com). Permission was gained from web page/group moderators before sharing the adverts.

Potential participants clicked on the study link and were given full study information, including researcher contact details for further questions. Participants were also given details on how to request a paper copy of the questions and consent forms and how this could be returned to the researcher anonymously. The remainder of the questionnaire only loaded once consent items were completed, including giving the first three letters of postcode to ensure UK only completion. A debrief at the end of the questionnaire encouraged participants to seek advice from a healthcare provider if the survey had raised any concerns or questions about weaning, baby feeding, weight or general health, alongside a reminder of researcher contact details if needed.

Data analysis

When the raw data were initially analysed, partially completed questionnaires and responses that had not fully complied with the 24-h recall, instructions were excluded.

The aim of the analysis was not to measure specific nutrient intake but, instead, to compare exposure to different food groups, such as how often the infant had eaten a certain type of food, rather than an analysis of individual nutrient intake. This method of assessing intake had previously been used in a UK study focused on BLW and infant preferences [7].

All items reported were therefore classified into a food group (Table 1) adapted from similar research examining nutrient intake in infants and young children [7,19,20]. The food groups comprised: carbohydrates, savoury snacks, sweet foods, proteins, dairy foods, vegetables, fruits, composite meals and iron-containing foods. Composite meals referred to jarred or homemade foods that contained a number of different items, although the items were not specified (e.g. 'chicken dinner'). Conversely, if the respondent had written 'chicken breast, potatoes, carrots and peas', the separate food groups would have been counted.

The frequency of exposure for each food group over the 24-h period was then calculated. Where multiple different foods were offered in the same meal, a count was made for every different item (e.g. a meal consisting of potatoes, fish, cheese sauce, peas and carrots would have been noted as having 1 carbohydrate, 1 protein, 1 dairy, 2 vegetables and 1 iron-containing food).

A further calculation was made for number of iron-containing foods offered, following the classifications used

Table 1 Food group classifications

Group	Examples
Milk feeds	Breast, formula, cow's milk, alternatives
Carbohydrates	Cereals, pasta, rice, potatoes or bread
Vegetables	All vegetables, including starchy varieties
Fruit	All fruits, whether tinned, fresh or frozen
Savoury snacks	Processed snacks such as baby crisps, breadsticks or crackers
Sweet foods	Desserts, chocolate and puddings
Protein	Meat, fish poultry, eggs, tofu, pulses and legumes
Dairy	Milk, cheese and yoghurts from cow's or goat's milk
'Infant meals'	Composite meals where the individual components were pureed or where the individual components could not be discerned, such as commercial pureed baby food or a simple description such as 'curry'
Iron containing foods	Beef, chicken, fish, ham, lamb, bacon, Liver (including pâté), (luncheon sausage or other sausage, pork, salami, processed meat sausages, iron-fortified infant cereal, baked beans, lentils, hummus, chickpeas (other than hummus)

by Cameron *et al.*, 2015. These foods were also counted in their primary food groups (e.g. strips of roast beef counted once in the protein category and again in the iron-rich foods category).

Data were analysed using SPSS, version 22 (IBM Corp. Armonk, NY, USA). Participants were split into three weaning groups based on their self-identified response (strict BLW, loose BLW and traditional) and checked against frequency of spoon and puree use. Participants were also split into three groups based on infant age. Infants aged 6–8 months were grouped together (representing the early months of solids introduction), 9–10 months (representing the middle period) and 11–12 months (when infants should be moving towards eating family foods at each meal).

Multivariate analysis of covariance (MANCOVA) was then used to explore differences in exposure between the three different groups separately for each age group (controlling for maternal demographic factors, such as age, occupation and education). Post-hoc Bonferroni tests were carried out to clarify any significant differences between the groups.

Results

Participant characteristics

One hundred and eighty parents (178 mothers and two fathers) completed the study. Of those, fifty-six were classified as strict BLW (31.1%), eighty-eight as loose BLW (48.9%) and thirty-six (20.0%) were using traditional spoon-feeding. Mean parental age was 32 (range 18–44) years. Further participant details, are provided in Table 2.

In terms of infant background, 83 infants were female (46.1%), 96 were male (53.3%) and one was undeclared (0.6%), with a mean (SD) age of 38.1 (8.197) weeks. Details of numbers in each weaning and age group are provided in Table 3. Within each age category, no significant difference in age was found between infants in the three weaning groups.

Influence of milk feeding

Participants were asked whether they were currently breast, formula or mixed breast and formula feeding for milk feeds. Given associations between milk feeding and later eating behaviour, the association between weaning group and milk feeding was examined using chi-squared. A significant association was found (χ^2 = 24.136, P = 0.000). Table 4 shows that mothers who followed a strict baby-led style were more likely to be breastfeeding. Milk feeding type was therefore controlled throughout further analyses.

Table 2 Participant demographic background

Demographic	Group	*N*	%
Education	No formal education	2	1.1
	GCSE	3	1.7
	A Level	26	14.4
	Degree or equivalent	87	48.3
	Postgraduate qualification	61	33.9
Marital status	Married	136	75.6
	Widowed	1	0.6
	Divorced	2	1.1
	Separated	3	1.7
	Domestic partnership/civil union	31	17.2
	Single	6	3.3
Employment	Full time	31	17.2
	Part time	27	15.0
	Parental leave	91	50.6
	Not working	31	17.2
Occupation	Professional/managerial	80	44.4
	Skilled occupations	62	34.4
	Unskilled occupations	13	7.2
	Unemployed	0	0
	Stay at home parent	25	13.9

Table 3 Number of infants in each weaning and age group

Age group	Weaning group			Overall *N*
	Strict	Loose	Traditional	
Group 1: 6–8 months	19 (22.9%)	45 (54.2%)	19 (22.9%)	83
Group 2: 9–10 months	15 (33.3%)	22 (48.9%)	8 (17.8%)	45
Group 3: 11–12 months	22 (42.3%)	21 (40.4%)	9 (17.3%)	52
Overall	56 (31.1%)	88 (48.9%)	36 (20.0%)	180

For each age group, differences in frequency of food groups consumed were examined across the three weaning groups, using a MANCOVA, controlling for maternal demographic background (age, education), age of introduction to solids and milk feeding type. Post-hoc Bonferroni tests were used to explore differences between groups.

Infants aged 6–8 months

Significant differences were found in exposure to vegetables, protein and composite meals between the three weaning groups (see column 4 in Table 5). Post-hoc Bonferroni tests showed that, for vegetable portions, those in the strict BLW group had significantly higher exposure than the traditional group (P = 0.000). Those in the loose BLW group had higher exposure than those in the traditional group (P = 0.016). For protein, those in the strict

Table 4 Milk feeding style by weaning group

	Breast milk		Formula milk		Mixed		None*		
Weaning group	*N*	%	*N*	%	*N*	%	*N*	%	Total
Strict BLW	44	78.4%	7	12.5%	3	5.4%	2	3.6%	56
Loose BLW	55	62.5%	24	27.3%	5	5.7%	4	4.5%	88
Traditional	11	30.5%	19	52.8%	5	13.9%	1	2.8%	36
Total	110	60.5%	50	27.8%	13	7.2%	7	3.9%	180

*No breast or formula milk offered or noted on the recall. BLW, baby-led weaning.

BLW had a higher exposure compared to the traditional group ($P = 0.002$), whereas the loose BLW also consumed more than the traditional groups ($P = 0.001$). For composite meals, the strict BLW was offered significantly fewer portions than the traditional group ($P = 0.002$), whereas the loose BLW group also consumed less than the traditional group ($P = 0.000$). No further significant differences were seen.

Infants aged 9–10 months

Significant differences in exposure were only seen between the groups for number of milk feeds and dairy consumption (Table 5). Post-hoc Bonferroni tests showed that infants in the strict BLW group had significantly more milk feeds than those in the loose BLW group ($P = 0.006$); however, the significant difference in dairy exposure between groups did not survive post-hoc testing. No further significant differences were seen.

Infants aged 11–12 months

Significant differences were found between groups for exposure to savoury snacks, dairy products and composite meals (Table 5). For savoury snacks, post-hoc Bonferroni tests showed that infants in the loose BLW group had significantly higher exposure than those in the strict BLW group ($P = 0.015$). Again, for dairy, infants in the loose BLW group had significantly higher intake than those in the strict BLW group ($P = 0.009$). Composite meal exposure was significantly higher in the traditional group compared to the strict BLW group ($P = 0.045$). No further significant differences were seen.

Discussion

The present study examined differences in exposure to different food groups over a 24-h period for infants aged 6–12 months who were introduced to solids using strict BLW, a looser version of BLW and a traditional spoon-feeding approach. Overall, the findings showed several significant differences. Broadly, infants following a stricter BLW approach had increased exposure to key foods such as vegetables and proteins, whereas traditionally weaned infants had a greater reliance on composite meals. No significant differences were found in the intake of iron-containing foods for any of the groups. Although there are limitations, these findings will be of interest to those with concerns around nutrient intake in infants following a baby-led approach.

For the youngest infants aged 6–8 months, there were several significant differences in exposure. Vegetables were offered most often in the strict BLW group and least in the traditional group. Although causation cannot be established, it may be that the baby-led approach encourages higher intake of vegetables. Infants following BLW are typically offered chunky finger foods, with foods such as cooked broccoli stalks and carrot sticks being recommended as suitable first foods [1]. Alternatively, parents who choose to follow BLW may be more likely to offer more vegetables, although maternal age and education were controlled for throughout the analysis.

Traditionally weaned infants reliant on commercial foods may be exposed to a lower vegetable intake as a result of the composition of commercial infant foods. A recent study examining the contents of commercial infant food in the UK found that most first commercial pureed infant foods are based around fruits rather than vegetables, even when vegetables were in the product name. When vegetables were included in products, they tended to be sweet varieties such as carrots [21]. Thus, parents following a traditional approach, who may be more likely to rely on jars or pouches [22], may be offering vegetable foods that are higher in sugars, rather than less palatable green vegetables because of wider availability. A tendency for a higher consumption of vegetables may therefore be a benefit of BLW because early and frequent exposure to the bitter tastes in vegetables may increase greater acceptance of these tastes when babies are older [22–25].

Protein exposure (excluding milk intake) was also significantly different between the groups, with the strict and loose BLW groups having a similar exposure of just under one portion a day and the traditional group having

Table 5 Differences in food groups offered between weaning groups

Age group	Food group	Strict BLW, mean (SD)	Loose BLW, mean (SD)	Traditional, mean (SD)	Significance
6–8 months	Milk feeds	6.05 (1.75)	5.62 (1.97)	4.68 (2.24)	$F_{2,75}$ = 2.413, P = 0.096
	Carbohydrates	1.47 (0.96)	1.65 (1.10)	1.11 (0.81)	$F_{2,75}$ = 1.895, P = 0.157
	Vegetables	2.58 (1.64)	1.78 (1.64)	0.58 (0.90)	$F_{2,75}$ = 8.637, P = 0.000*
	Fruit	1.68 (1.29)	1.50 (1.13)	1.68 (0.75)	$F_{2,75}$ = 0.275, P = 0.760
	Savoury snacks	0.05 (0.23)	0.22 (0.42)	0.16 (0.50)	$F_{2,75}$ = 1.159, P = 0.319
	Sweet foods	0.26 (0.56)	0.30 (0.72)	0.47 (0.70)	$F_{2,75}$ = 0.552, P = 0.578
	Protein	0.89 (0.81)	0.85 (0.83)	0.05 (0.23)	$F_{2,75}$ = 8.939, P = 0.000†
	Dairy	0.53 (0.61)	0.75 (0.78)	0.74 (0.93)	$F_{2,75}$ = 0.567, P = 0.570
	Meals	0.32 (0.58)	0.32 (0.47)	1.05 (0.91)	$F_{2,75}$ = 9.646, P = 0.000‡
	Iron-rich foods	0.74 (0.73)	0.67 (0.66)	0.47 (0.77)	$F_{2,75}$ = 0.759, P = 0.472
9–10 months	Milk Feeds	5.60 (2.53)	3.55 (1.50)	3.71 (0.76)	$F_{2,41}$ = 5.873, P = 0.006§
	Carbohydrates	2.00 (1.20)	2.50 (0.96)	2.14 (1.07)	$F_{2,41}$ = 1.084, P = 0.360
	Vegetables	2.00 (1.73)	1.59 (1.40)	2.43 (2.30)	$F_{2,41}$ = 0.739, P = 0.484
	Fruit	2.13 (1.41)	2.05 (1.29)	2.43 (1.13)	$F_{2,41}$ = 0.227, P = 0.798
	Savoury snacks	0.67 (1.23)	0.68 (0.72)	0.71 (0.76)	$F_{2,41}$ = 0.006, P = 0.994
	Sweet foods	0.27 (0.46)	0.50 (0.60)	0.43 (0.54)	$F_{2,41}$ = 0.825, P = 0.445
	Protein	1.53 (0.99)	1.23 (1.48)	1.57 (0.54)	$F_{2,41}$ = 0.375, P = 0.690
	Dairy	0.80 (0.68)	1.68 (1.17)	1.71 (1.50)	$F_{2,41}$ = 3.303, P = 0.050¶
	Meals	0.33 (0.49)	0.64 (0.66)	0.86 (1.07)	$F_{2,41}$ = 1.610, P = 0.212
	Iron rich foods	1.13 (0.64)	1.14 (0.71)	1.86 (0.90)	$F_{2,41}$ = 2.970, P = 0.062
11–12 months	Milk feeds	4.00 (2.25)	3.53 (2.09)	2.89 (2.09)	$F_{2,47}$ = 0.873, P = 0.425
	Carbohydrates	2.55 (1.01)	2.42 (0.90)	2.11 (0.78)	$F_{2,47}$ = 0.691, P = 0.506
	Vegetables	1.77 (1.41)	1.79 (1.13)	1.11 (1.27)	$F_{2,47}$ = 0.998, P = 0.376
	Fruit	2.18 (1.53)	2.89 (1.60)	2.11 (0.93)	$F_{2,47}$ = 1.469, P = 0.241
	Savoury snacks	0.32 (0.72)	1.05 (0.91)	0.67 (0.71)	$F_{2,47}$ = 4.349, P = 0.018**
	Sweet foods	0.45 (0.60)	0.53 (0.61)	0.11 (0.33)	$F_{2,47}$ = 1.714, P = 0.191
	Protein	1.55 (0.91)	1.16 (0.83)	0.78 (0.67)	$F_{2,47}$ = 2.861, P = 0.067
	Dairy	1.14 (1.13)	2.47 (1.43)	2.22 (1.72)	$F_{2,47}$ = 5.365, P = 0.008††
	Meals	0.27 (0.55)	0.58 (0.69)	0.89 (0.60)	$F_{2,47}$ = 3.437, P = 0.040‡‡
	Iron rich foods	1.45 (0.67)	1.11 (0.74)	1.33 (0.50)	$F_{2,47}$ = 1.389, P = 0.259

Superscripts denote post-hoc Bonferroni test results:
*Strict baby-led (BLW) weaning had higher exposure than traditional group (P = 0.000). Loose BLW group had higher exposure than the traditional group (P = 0.016).
†Strict BLW group had higher exposure than traditional group (P = 0.16). Loose BLW also had higher exposure than traditional group (P = 0.002).
‡Traditional group had higher exposure than both strict BLW (P = 0.002) and loose BLW (P = 0.000).
§Strict BLW had more milk feeds than the loose BLW group (P = 0.006).
¶Differences in dairy consumption did not survive the Bonferroni test.
**Loose BLW group had higher exposure than the strict BLW group (P = 0.015).
††Loose BLW group had higher exposure than the strict BLW group (P = 0.009).
‡‡Traditional group had higher exposure than the strict BLW group (P = 0.045).

just 0.05 portion a day. Again, this is probably a result of the different types of foods encouraged in the different weaning methods. BLW babies may be offered a strip of omelette or piece of meat as part of a meal. Conversely spoon-fed babies may not be given high protein foods until later in the weaning process, perhaps because traditional first weaning foods may be based around fruit and vegetable purees or infant cereal. Indeed, no significant difference in protein exposure was found for older babies, with all increasing over time.

This finding challenges the assumption that baby-led weaned babies are not receiving nutrient-dense foods such as protein when solids are first introduced [6,9]. However, it should also be noted that babies can get most of their protein requirements from milk at this stage [26], with the recommended intake of breast or formula milk providing the majority of protein needed [27,28]. Milk should still form the major part of the diet through the first year, and breast milk intake at 7 months has been estimated at 875 mL per day (93% of kcal required) [29]. This means that complementary foods would need to provide just 7% of total energy intake. Exposure to different tastes and textures is likely more important than volume at this stage.

Finally, in the youngest age group, the traditional group had a higher exposure to composite meals. A higher consumption of composite meals would be expected in the traditionally weaned group at this age because pureed family meals or baby food jars are often used in traditional spoon-feeding. Indeed, composite meal exposure was highest in the traditional weaning group for all ages, following findings in previous research, which found parents using a traditional approach tended to use more commercial products [30].

This is important because concerns have been raised over a high intake of commercial baby food products [31–35]. Specifically, this may have implications for energy and sugar intake as commercial jarred baby food may provide portion sizes that provide more calories from solid foods than a child of this age requires [32]. For babies aged 7–9 months, studies found that 61% of products aimed at this age group contained more energy than necessary yet, at the same time, many infant foods were not as energy dense as they should be, providing little energy but lots of bulk. Commercial baby foods may also contain excess sugar: one UK study found that sweet, spoonable foods contained twice as many sugars as breast milk and dry, nonfruit snacks, such as rusks, contained four times as much sugar [31]. As noted above, commercial foods tend to be more similar in taste, with a reliance on sweet foods [23].

In the 9–10 months age group, significant differences between weaning groups were only seen for the number of milk feeds and dairy exposure. The highest number of milk feeds was seen in the strict BLW group. Over 86% of this group were breastfeeding, with studies showing that breastfed infants tend to feed more frequently and irregularly than bottle-fed infants [30,36–38]. It is difficult to determine milk intake for breastfed infants, although volume at each feed is typically lower than for a formula-fed infant [39]. Therefore, this finding may be a result of those in the strict BLW group feeding more frequently, rather than having greater intake. This would fit with findings that those following a BLW approach tend to be more responsive in their overall feeding style [10]. However, it may also indicate that those in the BLW group are following recommendations to move more gradually to a family diet. Further research could explore the proportion of energy intake attributed to milk through the weaning process. Dairy food exposure was also found to be significantly different, with the loose BLW and traditional weaning groups being exposed twice as many times compared to the strict BLW group, although the results were not significant when a Bonferroni post-hoc test was applied.

In the oldest 11–12 months group, significant differences were found in exposure to dairy products. Infants in the strict BLW group had the lowest exposure, with the loose BLW and traditional groups consuming over twice as many portions. One explanation for this difference is the popularity of dairy products aimed at infants including yoghurt and fromage frais, which are usually eaten with a spoon. Although babies of this age may be starting to use spoons themselves, it may be that parents following a strict BLW approach avoid the mess of this approach and prefer not to spoon feed the infant. Indeed, when the source of dairy was examined between the groups, the main sources of dairy products for the infants in the strict BLW group at this age were soft cheese on toast or in sandwiches, whereas, for those in the traditional group, fromage frais and yogurt were more common offerings. Given the sugar content of yoghurts aimed at young children, [e.g. Petit Filous (Yoplait UK Ltd, Uxbridge, UK) at almost 10% sugar by weight, which provides 45% of its energy] and the fact that breast milk or formula would be supplying most of the calcium needs at this age [36,39], the lack of sweetened, commercial dairy products in the diets of BLW babies may not be such a bad thing.

A significant difference was also found in composite meals again for this age range, with traditionally weaned infants still being offered the highest amounts. This has the same concerns as for younger infants, with the additional issue that, by 12 months of age infants should be moving towards eating a family diet, rather than relying on specific baby foods. For example, the National Health Service Start4Life website (https://www.nhs.uk/start4life) states that, by the time a baby is 12 months old, they should be eating the same foods as the rest of the family but in smaller portions [40]. Further research may wish to explore whether this difference remains for older infants.

Additional differences were seen for savoury snack exposure in this age group. Notably, it was the loose baby led group, which had the highest exposure to savoury snack items such as breadsticks, crackers and crisps. This could demonstrate one potential disadvantage of BLW: finger foods could be interpreted as processed, carbohydrate-rich snack foods, of which there are many marketed especially to infants. However, these can be deceivingly high in sodium and often sugar, particularly if they are targeted at adults. This could also encourage preference for these tastes and one UK study that examined the later food preferences of BLW infants found a preference for carbohydrates [7], although no difference for carbohydrate exposure (classed as potatoes, bread, rice and pasta, rather than snack foods) arose.

Potentially, those unsure of BLW may be choosing a loose approach and offering ready prepared 'finger foods', or perceiving guidance to offer finger foods to mean that anything finger food shaped would be acceptable. Industry has also taken advantage of this, with high numbers of finger-food snack bags available [41]. Greater information and awareness are needed for parents in choosing what products they give their infant and how often.

Notably, there were no differences in the exposure to iron-containing foods between weaning groups in any age category, challenging concerns of healthcare professionals that infants following BLW will not be offered sufficient iron [6,9]. This of course does not mean that infants who are BLW are consuming sufficient iron, and further research is needed here, although it does suggest that insufficient iron intake in BLW infants may not be a problem. Indeed, the strict BLW group even had a non-significant trend to be offered more iron rich foods. This may quite possibly have arisen as a result of concerns voiced that infants following the method might not be consuming sufficient iron.

There are limitations to the present study, including the self-selecting nature of the respondents. Previous research has found that mothers who chose BLW are more likely to be older and have a higher level of education than those following a traditional weaning approach, which may affect their choice of food [6,30], although, in the present study, demographic background was not significantly different between weaning groups. Mothers following BLW were more likely to breastfeed as has been shown in most BLW research [2], and levels of breastfeeding amongst the sample were higher than average [42]. Breastfeeding has been associated with lower levels of fussy eating [43] and a wider diet variety in childhood [44]; therefore, differences in intake might be seen with a more diverse sample. However, milk-feeding approach was controlled for throughout analyses.

Second, there are limitations with the methodology of 24-h recalls. They may not be useful for accurate nutrient intake because participants generally do not always weigh food and participants may feel judged or only note selected food choices as a result of bias, leading to potential under-reporting of total energy intake for example. They also rely on memory, albeit it only for the last 24 h, and are just a snapshot of a participant's diet [45,46]. However, 24-h recalls have been validated against weighed food records and shown to be accurate [47,48]. They have been used previously in infant feeding research [18,49,50], although one review study found weighed food records to be the most accurate compared to the doubly-labelled water method (a measurable biomarker) with respect to recording energy intake in younger children aged 6 months to 4 years of age [48].

Limitations aside, the findings have important implications for those researching and supporting parents with the BLW approach. There is little evidence-based information to guide healthcare providers and parents in making the choice to support or use BLW, although this research suggests that, at least in this sample, little negative impact was seen on the food choices offered by parents, with BLW giving greater exposure to vegetables, coupled with lower reliance on commercial products. Therefore, the present study adds to the limited existing evidence base for the nutritional sufficiency of BLW as a method for complementary feeding. The findings around a higher use of snack foods for the loose BLW group are noteworthy and point to a need for further education around what constitutes a healthy baby-led approach. Simply because a food can be self-fed, does not make it a suitable food for an infant. Likewise, the lower incidence of dairy exposure may or may not be a concern for BLW babies, given the balance between need for calcium versus the high sugar content of many infant dairy products. Further research is now needed to examine specific nutrient intake between weaning groups to extend the results of the present study.

Transparency declaration

The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned (please add in the details of any organisation that the trial or protocol has been registered with and the registration identifiers) have been explained.

Conflict of interests, source of funding and authorship

The authors declare that they have no conflicts of interest.
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HR was responsible for study design, data collection, data analysis, draft report writing and critical revisions. ML was responsible for critical revisions. AB was responsible for study design, data analysis support and critical revisions.

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