

# BMJ Open How different are baby-led weaning and conventional complementary feeding? A cross-sectional study of infants aged 6–8 months

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## ABSTRACT

**Objectives:** To compare the food, nutrient and ‘family meal’ intakes of infants following baby-led weaning (BLW) with those of infants following a more traditional spoon-feeding (TSF) approach to complementary feeding.

**Study design and participants:** Cross-sectional study of dietary intake and feeding behaviours in 51 age-matched and sex-matched infants (n=25 BLW, 26 TSF) 6–8 months of age.

**Methods:** Parents completed a questionnaire, and weighed diet records (WDRs) on 1–3 non-consecutive days, to investigate food and nutrient intakes, the extent to which infants were self-fed or parent-fed, and infant involvement in ‘family meals’.

**Results:** BLW infants were more likely than TSF infants to have fed themselves all or most of their food when starting complementary feeding (67% vs 8%,  $p<0.001$ ). Although there was no statistically significant difference in the large number of infants consuming foods thought to pose a choking risk during the WDR (78% vs 58%,  $p=0.172$ ), the CI was wide, so we cannot rule out increased odds with BLW (OR, 95% CI: 2.57, 0.63 to 10.44). No difference was observed in energy intake, but BLW infants appeared to consume more total (48% vs 42% energy,  $p<0.001$ ) and saturated (22% vs 18% energy,  $p<0.001$ ) fat, and less iron (1.6 vs 3.6 mg,  $p<0.001$ ), zinc (3.0 vs 3.7 mg,  $p=0.001$ ) and vitamin B<sub>12</sub> (0.2 vs 0.5 µg,  $p<0.001$ ) than TSF infants. BLW infants were more likely to eat with their family at lunch and at the evening meal (both  $p\leq 0.020$ ).

**Conclusions:** Infants following BLW had similar energy intakes to those following TSF and were eating family meals more regularly, but appeared to have higher intakes of fat and saturated fat, and lower intakes of iron, zinc and vitamin B<sub>12</sub>. A high proportion of both groups were offered foods thought to pose a choking risk.

## INTRODUCTION

Traditionally, parents have been advised to spoon feed their infant puréed foods from ‘around’ 6 months of age, progressing to

## Strengths and limitations of this study

- First study to compare the dietary intake of children following baby-led weaning (BLW) with that of infants following a more traditional spoon-feeding (TSF) approach to complementary feeding.
- Weighed diet records with careful recording of foods offered and foods eaten.
- Age and sex matching of children following BLW and those following TSF.
- Small sample size.
- Participants defined themselves as following BLW or TSF.

mashed, then chopped foods, so that they are eating family foods by 12 months of age.<sup>1 2</sup> However, anecdotal reports suggest that an alternative method of complementary feeding, known as baby-led weaning (BLW), is becoming popular in New Zealand, the UK and Canada. In BLW, infants are not spoon fed at all, but instead feed themselves whole pieces of food, preferably from the family meal, from the onset of complementary feeding.<sup>3 4</sup>

Proponents of this baby-led approach suggest that it allows the infant to be in control of how much food they eat, as they are in the first few months of life if they are breast fed. It is proposed that this control over their own feeding may allow the infant who is following BLW to respond better to hunger and satiety cues than a baby who is spoon fed by someone else. It has also been pointed out that although the age at which it is recommended that parents start feeding their infant ‘solids’ has increased from 4 to 6 months of age,<sup>2 5 6</sup> most countries have not changed their advice on *how* to introduce foods.<sup>3 7</sup> The exception to this is the UK,

where recent National Health Service (NHS) advice is that first foods can include soft vegetables and fruit offered as finger food or mashed.<sup>8</sup>

Despite increasing enthusiasm about BLW on the internet (8 960 000 hits in May 2015) and in the social media, health governing bodies<sup>9</sup> and some healthcare professionals<sup>10</sup> have expressed considerable concern that infants following a baby-led approach to infant feeding may be at an increased risk of choking and inadequate iron and energy intakes. Therefore, it is important to determine what infants following BLW are actually eating. The only study to date that has collected dietary information about BLW was a pilot study in just 11 families that focused on parental diet. Although some of the foods eaten by infants were reported, infant nutrient intakes were not analysed, and there was no comparison group of families following traditional spoon feeding (TSF).<sup>11</sup>

Therefore, the aims of the current study were: first, to determine whether there are differences in nutrient intakes and food intakes (particularly foods thought to pose a choking risk, foods high in iron, and foods containing added sugars or salt) between infants following BLW and those following TSF; and, second, to describe the 'family meals' offered to infants following BLW and TSF.

## METHODS

### Study design

This community-based cross-sectional study of infants aged 6–8 months combined data from three sources: two small cross-sectional studies (the 'Infant Feeding Study' and the 'How to Measure Infant Feeding' study), and the control group of a randomised controlled trial (the 'Baby-Led Introduction to Solids' (BLISS) study).<sup>12</sup> All participants completed a pretested demographic questionnaire and a feeding questionnaire, and a 3-day or 1-day weighed diet record (WDR) depending on the study. All adult participants provided written informed consent.

### Participants

As many eligible participants as possible were recruited from the following three studies (with BLW and TSF infants being recruited from each study):

1. 'Infant Feeding Study' (December 2013 to June 2014), Dunedin and Auckland (New Zealand)—advertisements in local newspapers and on social media sites, posters placed in a range of community areas, word of mouth in local parent support networks (29 mother–child pairs expressed interest, of whom 19 were eligible for this study);
2. 'How to Measure Infant Feeding' study (April 2013), Dunedin (New Zealand)—advertisements on social media sites, posters placed in a range of community areas, word of mouth in local parent support networks (11 participants were recruited, of whom 7 were eligible for this study);
3. BLISS study (September 2013 to June 2014), Dunedin (New Zealand)<sup>12</sup>—all women booking into

the only birthing facility in Dunedin, the Queen Mary Maternity Unit, Dunedin Hospital, were invited to participate in the BLISS study (23% of those eligible volunteered). All those who were eligible for, and had consented to participate in, the BLISS study, had been randomised to the control group and had completed the WDR administered at 7 months of age at the time we were recruiting for this study were invited to contribute their data (40 participants were approached, of whom 25 consented to contribute their data and met the age-matching and sex-matching criteria (see below)).

Inclusion criteria for this study were: infant 6–8 months of age when the WDR was completed, mother able to communicate in English or Te Reo Māori (the language of the indigenous people of New Zealand) and mother 16 years of age or older. Exclusion criteria were: infant born before 37 weeks gestation; or presence of a congenital abnormality, physical condition or intellectual disability likely to affect the infant's feeding or growth. Infant participants were matched to within  $\pm 1$  week of age and, wherever possible, for sex. BLISS study participants were used as a pool of prospective matches with the first match that was identified being recruited into this study.

### Definition of BLW and TSF

Mothers were asked to state "...what approach to infant feeding you were using around the time you completed the food diary: 'Spoon-feeding' or 'Baby-Led Weaning' or 'Other'." Parents who reported following BLW were assigned to the full BLW group, whereas those who reported following a mixture of spoon feeding and BLW were assigned to the partial BLW group. Parents who were spoon feeding their child (without reporting BLW) were assigned to the TSF group.

### Questionnaires

The same questions were asked of all participants. The demographic questionnaire collected information on: infant date of birth, sex, ethnicity (New Zealand Census questions<sup>13</sup>), birth weight and gestational age at birth; and maternal date of birth and parity. The feeding questionnaire collected data on: duration of exclusive breast feeding,<sup>2</sup> age when complementary foods were introduced, extent of infant self-feeding versus parent feeding (and puréed vs finger foods) on the first complementary feeding occasion, ages when iron-fortified infant cereal and red meat were first introduced, and whether breast milk or infant formula was currently being consumed.

### Dietary assessment

All three studies used the same WDR which was collected on three random non-consecutive days including two weekdays and one weekend day over a month (the 'Infant Feeding Study' and the BLISS study:  $n=44$ ) or on 1 day (the 'How to Measure Infant Feeding' study:  $n=7$ ).

The diet record had three key components: (1) a record of the foods eaten—time of day, type and brand of food or drink, preparation method, weight of food or drink, consistency of food or drink (puréed, mashed, diced, whole), who fed the child (parent, child, both), and total weight and estimated proportions of any leftover food or drink; (2) a description of any recipes used—raw amounts of ingredients, cooking method and proportion of the total recipe fed to the child and (3) an ‘end of day questionnaire’ which determined, for each meal and snack, whether the child ate with at least one adult, and whether the meal ingredients and preparation were the same as or different from the family meal. Resources were also provided to assist with estimating food portions when outside the home or in early childhood education.

Parents were given detailed oral and written instructions on how to complete the WDR, and were provided with a set of electronic scales (Salter Electronic Model 1017, Kent, UK), accurate to within  $\pm 1$  g.

All diet records were entered into the dietary analysis software program ‘Kai-culator’ V.1.11v (University of Otago, Dunedin, New Zealand). Kai-culator uses the New Zealand food composition database, FOODfiles;<sup>14</sup> nutrient data for commonly consumed recipes collated in the 2008/2009 New Zealand Adult Nutrition Survey;<sup>15</sup> and nutrient data for commercial infant foods calculated by the research team.<sup>16</sup> Breast milk intake was assumed to be 750 g/day based on a quadratic curve fitted to the breast milk volumes reported by Dewey *et al*<sup>17</sup> with the

amount of infant formula consumed subtracted from this total if infants were mixed fed. After the diet records had been entered in Kai-culator, a registered dietitian blinded to the BLW or TSF status of the infant checked each diet record, and made corrections when required.

Diet record data were used to determine nutrient intake, the percentage of foods currently adult or self-fed, the percentage of foods currently fed as purées or finger foods, and whether any of the following foods were offered: foods thought to pose a choking risk (described below), iron-fortified infant cereal, red meat (defined as beef or lamb), foods with sugar added (ie,  $>4$  g/100 g of added sugar or honey<sup>18</sup>), foods that were high in sodium (ie,  $>350$  mg sodium/100 g<sup>18</sup>), fruits, vegetables and commercial baby food. Foods thought to pose a choking risk were identified using lists from the literature<sup>19–20</sup> and public health organisations,<sup>21–22</sup> and advice from a paediatric speech-language therapist. Each WDR day was reviewed against this list to determine which foods thought to pose a choking risk were offered to infants.

### Statistical analysis

The data were analysed using Stata V.13.1 (StataCorp, College Station, Texas, USA). A two-sided  $p < 0.05$  was considered to indicate statistical significance.

Participant characteristics were examined for differences between the full BLW and TSF groups (table 1). Continuous variables (infant age, birth weight, gestational age and maternal age at birth) were compared using unpaired, two-tailed t tests. Categorical variables (infant

**Table 1** Demographic and early feeding characteristics of participants according to method of complementary feeding\* (mean (SD) unless stated otherwise)

	TSF (n=26)	BLW		p Value†
		Partial (n=7)	Full (n=18)	
Infant age (months)	7.3 (0.7)	7.3 (0.4)	7.4 (0.8)	0.690
Infant sex, n (%)				0.540
Female	12 (46%)	3 (43%)	10 (56%)	
Male	14 (54%)	4 (57%)	8 (44%)	
Infant ethnicity, n (%)‡				0.383
NZ European	20 (77%)	6 (86%)	11 (65%)	
Other	6 (23%)	1 (14%)	6 (35%)	
Infant birth weight (grams)	3528 (419)	3883 (508)	3288 (400)	0.071
Gestational age at birth (weeks)‡	39.8 (1.4)	40.4 (1.2)	39.2 (1.1)	0.156
Maternal age at birth (years)	33.9 (4.4)	35.1 (2.8)	33.1 (3.7)	0.542
Maternal parity, n (%)				0.685
Primiparous	4 (15%)	1 (14%)	2 (11%)	
Multiparous	22 (85%)	6 (86%)	16 (89%)	
Mean duration of exclusive breast feeding (weeks)	14.4 (8.6)	17.1 (7.3)	22.2 (7.6)	<b>0.003</b>
Number exclusively breast fed to 6 months, n (%)§	0	1 (14%)	8 (44%)	<b>&lt;0.001</b>
Age when complementary foods were introduced (weeks)	21.3 (2.8)	19.5 (3.5)	24.6 (2.0)	<b>&lt;0.001</b>
Number introduced to complementary foods before 6 months, n (%)§	25 (96%)	6 (86%)	9 (50%)	<b>0.001</b>

Bold typeface indicates a statistically significant difference ( $p < 0.05$ ).

\*Method of complementary feeding parents reported using at the time the weighed diet record was completed.

†p Values were calculated for differences between the full BLW and TSF groups using unpaired t test for continuous variables and  $\chi^2$  test for categorical variables.

‡Missing values: ethnicity=1 participant (full BLW); gestational age=2 participants (1 partial BLW, 1 full BLW).

§Six months defined as 180 days (26 weeks).

BLW, baby-led weaning; NZ, New Zealand; TSF, traditional spoon feeding.

sex, ethnicity, maternal parity, feeding practices and when solids were introduced) were compared using  $\chi^2$ , and Fisher's exact tests where cell numbers were low (<5).

Differences in BLW-associated behaviours between the full BLW and TSF groups when 'solids' were first introduced were determined using  $\chi^2$  test for proportions (table 2). Since current feeding practices were skewed, medians and IQRs for each group were calculated and a Wilcoxon-Mann-Whitney test was used to determine if the groups differed.

The number of infants in each group who consumed a food type of interest (eg, foods thought to pose a choking risk) or a type of milk (eg, breast milk) on any day of the diet record was recorded and ORs with a  $\chi^2$  test comparing the two groups were calculated (table 3).

Mean nutrient intake was calculated using the mean of all available days of the diet record for each participant (table 4). Since the data were mostly right-skewed, geometric means and 95% CIs are presented. To determine the mean difference between groups in nutrient intake, all days of the diet record were used in a mixed-effects model with group as a fixed effect and participant identification number as a random effect. Log-transformed nutrient amounts were used as the outcome variable and regression coefficients back-transformed and presented as mean per cent difference between the groups along with 95% CIs and p values.

The prevalence of inadequate zinc intakes was determined using the Estimated Average Requirement (EAR) cut-point method.<sup>23</sup> Whether the group was likely to have adequate intakes of the other nutrients was determined by comparing the group mean intake to the adequate

intake (AI). The AI cannot be used to calculate the prevalence of inadequate nutrient intake; however, when groups have a mean intake at or above the AI, it can generally be assumed that there is a low prevalence of inadequate nutrient intake for that population group.<sup>23</sup>

In table 5, for descriptive purposes, the number of infants in each group who shared meals with their family (eg, breakfast) was summed using the first day of the diet record. To compare consumption patterns between groups over all 3 days of the diet record, population-averaged generalised estimating equations for binary data were used with an exchangeable working correlation. Coefficients were back transformed to give ORs and 95% CIs. This same technique was used to compare the number of infants who had the same or nearly the same meal ingredients and preparation as the family at mealtimes. An unstructured working correlation was used for these analyses.

## RESULTS

### Participant characteristics

Of the 80 families who were identified as potentially eligible to participate in the study, 13 were excluded because: their child was born before 34 weeks gestation (n=2), their child was not aged between 6 and 8 months (n=8) or the participant could not be contacted (n=3); and 16 declined or were not required for age and sex matching. The final sample consisted of 26 infants reported to be following TSF and 25 reported to be following BLW either in part (n=7) or fully (n=18) at the time the diet record was collected. Mean (SD) maternal

**Table 2** BLW-associated behaviours of infants when complementary foods were first introduced, and currently, according to method of complementary feeding

	TSF (n=26)	BLW		p Value*
		Partial (n=7)	Full (n=18)	
Number of infants fed by an adult or self-fed when 'solids' first introduced, n (%)†				<b>&lt;0.001</b>
Infants all or mostly fed by adult	23 (88%)	5 (71%)	3 (17%)	
Infants half fed by adult, half self-fed	1 (4%)	2 (29%)	3 (17%)	
Infants all or mostly self-fed	2 (8%)	0 (0%)	12 (67%)	
Number of infants fed foods as purées or finger foods when 'solids' first introduced, n (%)†				<b>&lt;0.001</b>
Infants given all or mostly puréed (or mashed) foods	24 (92%)	5 (71%)	4 (22%)	
Infants given half puréed (or mashed) foods, half finger foods	1 (4%)	0 (0%)	1 (6%)	
Infants given all or mostly finger foods	1 (4%)	2 (29%)	13 (72%)	
Percentage of foods fed by an adult or self-fed currently, median (25th, 75th centiles)‡				
Percentage of foods fed by adult	0 (0, 13)	16 (4, 29)	2 (0, 17)	0.759
Percentage of foods fed by adult and infant	50 (32, 63)	7 (0, 26)	0 (0, 5)	<b>0.001</b>
Percentage of foods fed by infant	18 (12, 47)	48 (42, 65)	77 (39, 98)	<b>0.001</b>
Percentage of foods fed as purées or finger foods currently, median (25th, 75th centiles)‡				
Percentage of foods naturally liquid	3 (0, 27)	12 (0, 26)	0 (0, 7)	0.152
Percentage of foods puréed or mashed	17 (7, 25)	7 (3, 13)	4 (0, 13)	<b>0.002</b>
Percentage of foods as finger foods	33 (14, 53)	65 (27, 74)	77 (58, 100)	<b>&lt;0.001</b>

Bold typeface indicates a statistically significant difference (p<0.05).

\*p Values were calculated for differences between the full BLW and TSF groups using  $\chi^2$  test for proportions, and Wilcoxon-Mann-Whitney test for median percentage of foods.

†Data from the feeding questionnaire.

‡Data from the weighed diet record collected when participants were between 6 and 8 months of age.

BLW, baby-led weaning; TSF, traditional spoon feeding.

**Table 3** Types of foods eaten by infants according to method of complementary feeding (n (%) unless stated otherwise)

	BLW			OR (95% CI)*	Mean difference (95% CI)	p Value†
	TSF (n=26)	Partial (n=7)	Full (n=18)			
Foods thought to pose a choking risk						
Number that consumed foods thought to pose a choking risk‡,§	15 (58%)	6 (86%)	14 (78%)	2.57 (0.63 to 10.44)	–	0.172
Foods high in iron						
Age iron-fortified infant cereal¶ introduced (weeks), mean (SD)**	21.7 (3.3)	22.3 (4.9)	26.8 (2.2)	–	5.1 (2.6 to 7.5)	<b>&lt;0.001</b>
Number not yet introduced to iron-fortified infant cereal¶, **	3 (12%)	0 (0%)	8 (44%)	6.13 (1.17 to 32.20)	–	<b>0.014</b>
Number that consumed iron-fortified infant cereal‡, ¶	16 (62%)	5 (71%)	4 (22%)	0.18 (0.04 to 0.80)	–	<b>0.011</b>
Age red meat†† introduced (weeks), mean (SD)**	26.2 (3.5)	24.1 (2.3)	27.5 (2.4)	–	1.2 (–1.3 to 3.8)	0.332
Number not yet introduced to red meat**, ††	9 (35%)	1 (14%)	8 (44%)	1.51 (0.43 to 5.29)††	–	0.515
Number that consumed red meat‡, ††	15 (58%)	6 (86%)	7 (39%)	0.47 (0.13 to 1.64)††	–	0.225
Foods with sugar added						
Number that consumed foods with sugar added‡, ††	11 (42%)	5 (71%)	7 (39%)	0.86 (0.25 to 3.00)	–	0.823
Foods high in sodium						
Number that consumed foods high in sodium‡, §§	20 (77%)	5 (71%)	14 (78%)	1.05 (0.25 to 4.50)	–	0.948
Other foods						
Number that consumed fruit‡	25 (96%)	7 (100%)	17 (94%)	0.68 (0.04 to 12.05)	–	0.791
Number that consumed vegetables‡	25 (96%)	7 (100%)	16 (89%)	0.32 (0.03 to 4.04)	–	0.353
Number that consumed commercial infant food‡, ¶¶	15 (58%)	7 (100%)	8 (44%)	0.59 (0.17 to 2.02)	–	0.393
Breast milk and infant formula						
Number currently having breast milk (not infant formula)**,**	11 (42%)	4 (57%)	18 (100%)	–	–	<b>&lt;0.001</b>
Number currently having infant formula (not breast milk)**,**	3 (12%)	0	0	–	–	0.258
Number currently having breast milk and infant formula**,**	12 (46%)	3 (43%)	0	–	–	<b>&lt;0.001</b>

Bold typeface indicates a statistically significant difference ( $p < 0.05$ ).

\*ORs compare those following full BLW with those following TSF.

†p Values were calculated for (1) ORs using population-averaged generalised estimating equations for binary data from the 3-day diet records and for questionnaire data, and (2) for mean differences using unpaired t tests for continuous variables, unless stated otherwise.

‡The number that consumed a food was determined using all 3 days of the diet record (except for 7 participants who completed a 1-day diet record: 4 full BLW, 3 TSF).

§Foods thought to pose a choking risk were identified using lists from the literature<sup>19 20</sup> and from public health organisations.<sup>21 22</sup>

¶Commercial infant cereals were assumed to be fortified with iron (this was the case for all infant cereals available for sale in Dunedin, NZ, in April 2015).

\*\*Data from the feeding questionnaire.

††Red meat was defined as beef and lamb.

‡‡Foods that contained  $>4$  g/100 g of added sugar or honey.

§§Foods that contained  $>350$  mg sodium/100 g.

¶¶Commercial infant foods excluded iron-fortified infant cereals.

\*\*Fisher's exact test used to calculate p values.

BLW, baby-led weaning; NZ, New Zealand; TSF, traditional spoon feeding.

**Table 4** Mean nutrient intake from weighed diet records of infants according to method of complementary feeding\* (geometric mean (95% CI))

Nutrients	Nutrient reference value†	TSF (n=26)‡	BLW		Mean per cent difference between groups§ (95% CI)	p Value¶
			Partial (n=7)	Full (n=18)‡		
Energy (kJ)	Boys: 2800**; girls: 2500**	2897 (2718 to 3088)	3073 (2682 to 3521)	2800 (2518 to 3115)	-3.7 (-13.5 to 7.3)	0.500
Protein (g)	14 g	17 (15 to 19)	18 (14 to 23)	15 (12 to 17)	-14.4 (-28.3 to 2.3)	0.087
Protein (% energy)	-	10 (9 to 11)	10 (9 to 11)	9 (8 to 10)	-11.3 (-20.6 to -1.0)	<b>0.033</b>
Total fat (g)	30 g	33 (31 to 35)	36 (33 to 38)	36 (33 to 39)	10.6 (0.4 to 21.9)	<b>0.042</b>
Total fat (% energy)	-	42 (39 to 44)	43 (39 to 47)	48 (46 to 50)	15.1 (6.9 to 23.9)	<b>&lt;0.001</b>
Saturated fat (g)	-	14 (13 to 16)	16 (15 to 17)	17 (15 to 18)	15.6 (3.7 to 28.8)	<b>0.009</b>
Saturated fat (% energy)	-	18 (17 to 20)	19 (17 to 22)	22 (21 to 23)	20.0 (8.9 to 32.2)	<b>&lt;0.001</b>
Total carbohydrate (g)	95 g	82 (75 to 90)	86 (70 to 105)	72 (64 to 82)	-12.1 (23.8 to 1.4)	0.076
Total carbohydrate (% energy)	-	48 (46 to 50)	47 (44 to 51)	44 (42 to 46)	-8.9 (-14.0 to -3.5)	<b>0.001</b>
Sugars (g)	-	46 (35 to 61)	54 (36 to 81)	62 (57 to 68)	42.3 (-2.4 to 107.3)	0.067
Dietary fibre (g)	-	3.6 (2.2 to 5.8)	3.7 (2.1 to 6.3)	2.0 (1.2 to 3.4)	-50.7 (-73.3 to -9.1)	<b>0.023</b>
Iron (mg)	7 mg	3.6 (2.7 to 4.9)	3.3 (1.3 to 8.0)	1.6 (1.2 to 2.1)	-59.0 (-72.5 to -38.9)	<b>&lt;0.001</b>
Zinc (mg)	2.5 mg††	3.7 (3.3 to 4.1)	4.0 (2.9 to 5.4)	3.0 (2.6 to 3.3)	-20.5 (-31.1 to -7.4)	<b>0.001</b>
Vitamin C (mg)	30 mg	66 (57 to 76)	67 (53 to 86)	46 (38 to 55)	-29.6 (-40.0 to -12.9)	<b>0.001</b>
Vitamin B <sub>12</sub> (µg)	0.5 µg	0.5 (0.3 to 0.8)	0.6 (0.3 to 1.1)	0.2 (0.1 to 0.3)	-60.2 (-76.2 to -33.5)	<b>&lt;0.001</b>
Calcium (mg)	270 mg	382 (352 to 436)	437 (311 to 616)	318 (290 to 349)	-19.1 (-29.4 to -7.3)	<b>0.002</b>
Sodium (mg)	170 mg	235 (200 to 275)	235 (171 to 323)	232 (178 to 302)	-1.5 (-24.3 to 28.2)	0.911

Bold typeface indicates a statistically significant difference ( $p < 0.05$ ).

\*Method of complementary feeding parents reported using at the time the weighed diet record was completed.

†Nutrient reference values are the AI from food and breast milk (or infant formula) for infants 7–12 months of age (unless stated otherwise).<sup>24</sup>

‡Geometric mean and 95% CI calculated using the mean of all available days of the diet record (7 participants completed a 1-day diet record: 4 full BLW, 3 TSF).

§Mean per cent difference between the BLW and TSF groups calculated using the mean of all available days of the diet record (7 participants completed a 1-day diet record: 4 full BLW, 3 TSF).

¶p Values are calculated for mean difference between the full BLW and TSF groups using mixed-effects regression models of log-transformed nutrient intakes.

\*\*EER for infants 7 months of age.

††EAR.

AI, adequate intake; BLW, baby-led weaning; EAR, Estimated Average Requirement; EER, Estimated Energy Requirement; TSF, traditional spoon feeding.

**Table 5** Relationship between the foods eaten by the infant and the meals eaten by their family (ie, family meals) according to method of complementary feeding (n (%))\*<sup>†</sup>

	TSF (n=26)	BLW		OR (95% CI) <sup>‡</sup>	p Value <sup>§</sup>
		Partial (n=7)	Full (n=18)		
Number of infants eating their meal with the family					
Breakfast	16/20 (80%)	6/6 (100%)	12/15 (80%)	1.99 (0.48 to 8.31)	0.344
Lunch	13/21 (50%)	1/4 (25%)	12/14 (86%)	10.29 (2.67 to 39.65)	<b>0.001</b>
Evening meal	12/23 (52%)	5/6 (83%)	12/15 (80%)	4.75 (1.27 to 17.75)	<b>0.020</b>
Number of infants with ingredients the same as the family meal <sup>¶</sup>					
Breakfast	5/19 (19%)	0/6 (0%)	5/14 (36%)	1.60 (0.44 to 5.78)	0.473
Lunch	1/20 (4%)	0/6 (0%)	6/14 (43%)	10.56 (2.51 to 44.39)	<b>0.001</b>
Evening meal	4/22 (15%)	0/6 (0%)	9/15 (60%)	9.00 (2.64 to 30.62)	<b>&lt;0.001</b>
Number of infants with meal preparation the same as the family meal <sup>¶</sup>					
Breakfast	2/19 (8%)	2/6 (33%)	6/13 (46%)	2.27 (0.59 to 8.70)	0.232
Lunch	1/20 (4%)	0/3 (0%)	7/13 (54%)	10.31 (2.87 to 37.09)	<b>&lt;0.001</b>
Evening meal	3/22 (12%)	1/6 (17%)	8/14 (57%)	8.18 (2.66 to 25.14)	<b>&lt;0.001</b>

Bold typeface indicates a statistically significant difference (p<0.05).

\*Summary numbers presented are from the first day of the diet record.

<sup>†</sup>Missing values: breakfast n=10; lunch n=12; evening meal n=7. Most data were missing because: the infant was not offered the meal, only infant milk was consumed at the meal or the infant was not with the parent for the meal.

<sup>‡</sup>ORs compare those following full BLW with those following TSF and are calculated using all 3 days of the diet record (except for 7 participants who completed a 1-day diet record: 4 full BLW, 3 TSF). They may not therefore reflect exactly the same differences on the first day of the diet record.

<sup>§</sup>p Values were calculated for ORs using population-averaged generalised estimating equations for binary data.

<sup>¶</sup>The 'same as' was defined as the participant answering 1=exactly the same, or 2=almost the same, on a four-point scale (other values were 3=similar, 4=mostly different).

BLW, baby-led weaning; TSF, traditional spoon feeding.

age was 33.8 (3.9) years and most mothers (86%) were multiparous. The infants were 6.0–8.8 months of age and more than half were New Zealand European (74%). There were no significant differences between the groups in any of the demographic variables collected (table 1).

### Feeding behaviours

Women from the full BLW group exclusively breast fed their infants for ~8 weeks longer (p=0.003), and introduced solid foods 3 weeks later (p<0.001), than women following TSF (table 1). In fact, 44% of the full BLW group exclusively breast fed their infant to 6 months, compared with none in the TSF group.

When complementary foods were first introduced, the TSF group was more likely (p<0.001) to have puréed or mashed food (92% vs 22%) and to be fed by an adult (88% vs 17%) than the full BLW group (table 2). Although the full BLW group was more likely to have finger foods as first foods (72% vs 4%) which the infant self-fed (67% vs 8%) than the TSF group, almost a third of participants in the full BLW group gave their infant puréed or mashed food (28%) and a third fed their infant (rather than the infant feeding themselves) when 'solids' were introduced. As would be expected, the partial BLW group was intermediate between the TSF and full BLW groups.

The diet record data suggest that when infants were 6–8 months of age, most infants in the full BLW group fed themselves more than half of their foods (a median of 77% of their foods were self-fed), whereas feeding was predominantly shared by the adult and infant in the TSF group (a median of 50% of food; p<0.001; table 2).

Considerable differences were observed in the form in which foods were offered to the infants: while TSF babies consumed many finger foods (a median of 33% of their food intake was finger foods), this proportion was considerably lower than that observed in the full BLW group (77%; p<0.001). At the time the study was conducted, parents reported that 50% of the full BLW infants were feeding themselves all their food, compared with 12% of those in the TSF group (p=0.015). Interestingly, 62% of parents following TSF reported that their infant was feeding themselves some solids at least once a day (compared with 78% of those following full BLW; p=0.290).

### Foods

In total, two-thirds (69%) of participants offered foods thought to pose a choking risk to their child, almost half (45%) offered sweetened foods, and three-quarters (76%) offered foods high in sodium on at least one occasion during the WDR; this did not differ between groups (table 3). However, although there was no statistically significant difference between the full BLW and TSF groups in the number of infants consuming foods thought to pose a choking risk (78% vs 58%, p=0.172), the CI for the OR was wide, so we cannot rule out higher odds of offering these foods in the full BLW group (OR, 95% CI: 2.57, 0.63 to 10.44).

There were no differences in the number consuming fruit (96%), vegetables (94%) and, interestingly, the number using commercial baby foods (59%). However, infants in the full BLW group were introduced to iron-fortified infant cereal on average 5.1 weeks later than those following TSF, and had only one-fifth the odds of

consuming iron-fortified infant cereal during the WDR. There were no differences in the age when red meat was introduced, the number not yet introduced to red meat (35% overall), or the number who consumed it during the diet record.

Considerable differences were observed in breast milk and infant formula consumption between the full BLW and TSF groups, with significantly more participants in the full BLW group currently breast feeding (and not offering infant formula), than in the TSF group (100% vs 42%;  $p < 0.001$ ). More participants in the TSF group than in the full BLW group were having both breast milk and infant formula (12% vs 0%,  $p < 0.001$ ).

For those following full BLW, the most commonly consumed food types thought to pose a choking risk were: raw vegetables, raw apple and dried fruit (which were offered on 10, 3 and 3 days, respectively, of the 46 days recorded by participants in their WDRs), whereas for those following TSF, the most commonly consumed foods thought to pose a risk were: rusks, small pieces of meat (other than sausages and similar processed meats, or battered fish), crackers and corn kernels (which were offered on 10, 5, 4 and 4 days, respectively, of the 72 days recorded by participants in their WDRs).

### Nutrients

Table 4 shows significantly higher mean intakes of total fat, saturated fat and percentage energy from fat and saturated fat in the full BLW group. In contrast, mean intakes of iron, zinc, vitamin B<sub>12</sub>, vitamin C, dietary fibre and calcium were lower in the full BLW group than in the TSF group. No differences in mean dietary intake of energy, sugar or sodium were detected between the two groups. The 95% CI for energy suggests that, at most, the energy intake of infants following full BLW is likely to be 13% lower to 7% higher than that in those following TSF. For most nutrients, the intake of the partial BLW group appeared to be similar to that of the TSF group.

In the absence of anthropometric data (eg, body mass index), it is not possible to determine whether energy intake was adequate, although the mean intakes for both groups were higher than the Estimated Energy Requirement (EER). Overall, 13.7% of participants had inadequate intakes of zinc (5 from the full BLW group, 2 from the TSF group and 0 from the partial BLW group). Study participants are likely to have sufficient intake of protein, fat, vitamin C and calcium because the mean intakes of these nutrients were higher than the AI. However, carbohydrate, iron and vitamin B<sub>12</sub> adequacy cannot be determined because the group mean intakes were below the AI. There is no nutrient reference value for dietary fibre at this age.

### Family meals

The relationship between the foods consumed at the three main meals (breakfast, lunch and evening meal) by the infant and those consumed by the family is reported in table 5. BLW was associated with greater

infant involvement in family meal times, with full BLW infants significantly more likely to sit with the family during lunch and evening mealtimes. However, breakfast eaters in all three groups were likely to share breakfast with the family (83% of the infants consuming the meal). Compared with those following TSF, mothers following a full BLW approach were more likely to offer foods that were similar to or the same (both ingredients and preparation) as those eaten by the rest of the family at lunch and at the evening meal.

### DISCUSSION

Our findings suggest that there may be several differences in foods, nutrients and eating behaviours between children following BLW and those following a more TSF approach. In this small study, BLW was associated with a number of health-related behaviours that would be expected to be beneficial: longer duration of exclusive breast feeding, later introduction of complementary foods and greater participation in family meals. However, the iron intakes of full BLW infants appeared to be even lower than those of infants following TSF, and intakes of zinc and vitamin B<sub>12</sub> may also be marginal. Although total energy intakes were similar, the sources of that energy differed with full BLW infants appearing to consume more saturated and total fat than TSF infants. It is clear that a high proportion of all three groups were consuming foods thought to pose a choking risk, and it is not possible, in this study, to exclude the possibility that infants following BLW infants may consume more of these foods.

The two major strengths of this study are (1) the recruitment of groups of infants following BLW and TSF who were closely matched for age and sex and other demographic variables and (2) the careful measurement of dietary intake, with information collected on all foods and drinks consumed for up to 3 days, taking into account leftovers. Furthermore, the collection of information on whether the infant fed themselves, and the form the food was in, for each food item in the diet record, allowed us to determine the true extent of baby-led feeding in families who consider themselves to be following BLW or TSF.

The major limitation of our study was its small sample size that may not be representative of the wider population, and that decreased our ability to detect differences between the feeding styles. However, a number of statistically significant differences were detected between the two complementary feeding styles, and CIs have been reported which enable the reader to determine the magnitude of possible differences in the population as a whole for those variables that were not statistically significantly different. The maternal participants were older,<sup>25</sup> and more likely to be multiparous,<sup>26</sup> than typical New Zealand mothers. However, they were just as likely as New Zealand mothers to be of non-European ethnicity,<sup>27</sup> and the participants in the TSF group had a similar very



low rate of exclusive breast feeding to 6 months.<sup>27</sup> Although there were some differences, therefore, between the study participants and the general public, the groups were closely matched for age, sex and the demographic variables measured, so differences in the diets of the infants studied are not likely to be due to differences in demography. Another limitation was the use of estimated breast milk volume. It was not feasible to use test weighing or stable isotopes to measure intake in each individual, and estimated volumes are commonly used in dietary studies in infants.<sup>28–30</sup> It is also somewhat reassuring that the energy intakes in the full BLW and TSF groups were not statistically significantly different, and were also very similar (a difference of just 3.7%.) If the breast milk value we used underestimated breast milk volume, then overall energy intake would be higher in BLW—this is unlikely as studies to date have suggested lower rather than higher BMI in infants following BLW.<sup>31 32</sup> If the breast milk value we used overestimated breast milk volume, then the differences in nutrient intakes would be even greater than what we have reported. However, it must be borne in mind that breast milk provided the majority of the energy intake in the BLW group (~77% of energy), and that breast milk intake was not individually measured. Finally, families were assigned to the full BLW, partial BLW and TSF groups based on parental report of the complementary feeding approach used, rather than on an objective definition. Although this means that many in the full BLW group were not following the approach fully, the differences in feeding behaviours were substantial, and the use of the parents' categorisation enabled us to determine the dietary characteristics of infants whose parents would describe them as following BLW.

Three major concerns have been raised regarding the use of a baby-led approach to complementary feeding, namely whether the infant will consume sufficient energy and iron, and whether they will be at increased risk of choking.<sup>10</sup> It has been proposed that infants may not have the motor skills or motivation to feed themselves enough food to meet their energy needs for growth if they are following BLW.<sup>10</sup> This may be particularly relevant if low energy finger foods such as fruit and vegetables predominate in the diet.<sup>33</sup> Since this study did not measure infant body mass index, growth faltering could not be identified, but the reported energy intakes were similar for the two feeding styles, were comparable to those reported for New Zealand infants<sup>34</sup> and met the recommendations.<sup>24</sup>

In contrast, iron intakes appeared to be very different. Achieving adequate iron intake is problematic for infants worldwide because by 6 months of age substantial amounts of iron are needed from complementary foods.<sup>1 35 36</sup> Iron-fortified infant cereals are recommended as a suitable first food to help address this.<sup>2 37</sup> It has been proposed that the BLW infant may be at particular risk of iron deficiency because the texture of infant cereal makes it difficult for infants to self-feed,

and because foods that are easier to grasp tend to be naturally low in iron (eg, fruits and vegetables).<sup>10</sup> Our results would suggest that these concerns may have some value given that, on average, infants following full BLW appeared to have less than half the daily dietary iron intake of infants following TSF. The full BLW group introduced fortified infant cereal 5 weeks later and were considerably less likely to consume fortified infant cereal during the WDR. Although the adequacy of intakes below the AI cannot be determined,<sup>23</sup> the iron intakes of all three groups were considerably lower than the AI of 7 mg<sup>24</sup> (3.6, 3.3 and 1.6 mg for TSF, partial BLW and full BLW, respectively). Half of the infants (51%) consumed no fortified infant cereal over the 3 days of WDR, 45% consumed no red meat and 22% consumed neither fortified cereal nor red meat. It is important that these results are confirmed in other studies, particularly studies determining iron status as well as intake, so that it can be determined whether infants following BLW have poorer iron status. In the meantime, healthcare professionals should emphasise the importance of including iron-rich food sources in infants' diets in the complementary feeding period because of the well-accepted challenges of achieving adequate iron intake at this age, whether BLW or TSF is being followed. It is important to note that it is possible that the choice of infant milk may have contributed to these differences in total iron intake—none of the infants in the full BLW group were having infant formula, whereas more than half were consuming formula in the TSF group (n=15; 58%), and infant formulas have a higher iron concentration than breast milk.

It has been suggested that infants following BLW may be at increased risk of choking because they are feeding themselves whole foods during the early stages of complementary feeding, while they are still learning to chew and swallow.<sup>10 38 39</sup> Although our sample size was too small to investigate actual choking incidents, we observed that a worryingly high number of parents in all three groups were offering foods thought to pose a choking risk. These results suggest that further education for parents on how to minimise the risk of choking may be needed—no matter what approach to complementary feeding is being used. This advice would need to refer not just to types of food that are commonly considered to pose a choking risk (eg, one parent offered their infant whole nuts), but also to foods that do not pose a risk to older children and adults so may form part of the family meal (eg, corn); and to ways in which foods thought to pose a choking risk can be modified to make them safer (eg, chicken is safer if it is offered in pieces that can be chewed on but not put in the mouth whole, or if it is chopped finely). It is not clear from our study sample whether the population of infants following BLW is more likely to be exposed to foods thought to pose a choking risk. Although there was no statistically significant difference between the groups, the CI for the OR was wide, so we cannot rule out higher odds of

exposure in the full BLW group. It is therefore extremely important that exposure to foods thought to pose a choking risk, and choking prevalence, are investigated in future larger studies of BLW.

Concern has been expressed that infant self-feeding of family meals is only of benefit if the family meals themselves are nutritionally adequate.<sup>10</sup> While previous studies have reported that infants following BLW are more likely to eat with their family,<sup>33 38 40</sup> we extend these findings to show that the foods eaten also tend to more closely resemble those eaten by the family. Thus, it appears that BLW infants do follow a more 'adult' food pattern. This may be an issue given that exposure to a variety of 'unhealthy' family foods might lead to negative impacts on eating behaviours later in life.<sup>41</sup> Certainly, in our study, total and saturated fat intakes were significantly higher for those following full BLW. It is recommended that total fat intakes should be 30–45% of energy,<sup>1</sup> and the mean intake of those in the full BLW group appeared to be slightly above this (48% of energy). It is not clear, however, whether the saturated fat intakes are of concern. Both the TSF (18% energy) and BLW (22% energy) saturated fat intakes are lower than mature breast milk, which has 25% energy from saturated fat.<sup>14</sup> It is also possible that family meals do not provide sufficient zinc and vitamin B<sub>12</sub> to meet the relatively high requirements of infants, particularly given the small portion sizes consumed by infants. There is considerable controversy about the EAR for zinc for infants,<sup>42</sup> but 28% of the infants in the full BLW group in this study appeared to have a zinc intake less than the EAR of 2.5 mg for Australian and New Zealand infants.<sup>24</sup> It is not possible to state that the mean vitamin B<sub>12</sub> intake in the BLW group of 0.2 µg/day is inadequate, even though it is below the AI;<sup>23</sup> however, intakes would need to more than triple by the age of 12 months to meet the EAR for that age (0.7 µg/day<sup>24</sup>). There were a number of other differences in nutrient intakes between the full BLW infants and those using TSF, but these are of less concern. Although the percentage energy from protein and carbohydrate was lower in the full BLW group, the gram amounts eaten were not significantly different, and although vitamin C and calcium intakes were lower, they were still well above the AI. Dietary fibre intake was also significantly lower in the full BLW group, but no recommended intake has been set for this age group because breast milk does not contain dietary fibre, and there are 'no functional criteria for dietary fibre in infants'.<sup>43</sup> It is important to note when interpreting these dietary data that our study was small, cross-sectional and not from a random sample of families, and that we cannot determine whether these differences would still be apparent at older ages, given that by 12 months of age, all children should be eating predominantly family foods.<sup>2</sup> If confirmed, these results suggest that the current complementary feeding guidelines for infants, which were after all developed to meet the needs of traditionally spoon-fed infants, may need to be

modified to account for parents who choose to follow BLW. Modifications would most likely include an emphasis on the importance of the family adopting healthy eating behaviours with a variety of nutrient-dense foods that both the family and the infant can enjoy, and the inclusion of foods that are rich sources of iron, zinc and vitamin B<sub>12</sub>.

In conclusion, this study suggests that BLW may be associated with a number of health-related behaviours that would be expected to be beneficial: exclusive breast feeding to 6 months, waiting until 6 months to introduce solids and greater involvement in family meals; however, further research is required to determine whether BLW infants may be at higher risk of iron, zinc and vitamin B<sub>12</sub> deficiencies. It would also be useful to determine the relative importance of the delayed introduction of solids and the high breastfeeding rates seen in infants following BLW, compared with BLW itself, in determining nutrient intakes in 6–8-month olds. The extent to which differences in total and saturated fat intake remain at 12 months also needs to be determined. Although BLW children did not appear to be offered more foods thought to pose a choking risk, it is of concern that two-thirds of the infants were offered at least one food thought to pose a choking risk during the diet record, and we cannot rule out the possibility that those following BLW may be more likely to offer such foods. Given the widespread interest and debate regarding the suitability of BLW as an alternative infant feeding method, further research in a larger, ideally representative, sample of children, preferably with measurements of growth, biochemical nutrient status and rate of choking, is required to confirm these findings. In the meantime, our findings suggest that families of infants following BLW should be encouraged to include a variety of nutrient-dense foods in family meals, and to offer their infants foods rich in iron, zinc and vitamin B<sub>12</sub>; and that all parents, no matter what approach they take to complementary feeding, should be given advice on how to minimise their infant's exposure to foods thought to pose a choking risk—ideally by changing methods of food preparation rather than by excluding foods, many of which make an important contribution to the diet if offered in safe shapes and textures.

**Contributors** A-LMH and RWT conceived the idea for the study and designed the research. BJM, CJS, AL, LWE and EAF collected the data and analysed the diet records. LJF designed the approach used to determine the consumption of foods thought to pose a choking risk. JJH completed all statistical analyses. BJM wrote the first draft of the manuscript. All authors contributed to the interpretation of the results and revision of the manuscript, and approved the final manuscript. A-LMH is the guarantor.

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