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How different are Baby-Led Weaning and conventional complementary feeding? A cross-sectional study of 6 to 8 month old infants

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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: A cross-sectional study of dietary intake and feeding behaviours in 51 age- and sex-matched infants (n = 25 BLW, 26 TSF) 6-8 months of age.

Methods: Parents completed a questionnaire, and Weighed Diet Records (WDR) on 1-3 non-consecutive days, to investigate food and nutrient intakes, the extent to which infants were self- or parent-fed, and infant involvement in 'family meals'.

Results: BLW infants were more likely than TSF infants to have fed themselves (48% *vs* 8%), or eaten finger foods (60% *vs* 4%), (both p<0.001) when starting complementary feeding. Few differences were noted in the types of food offered, but across the groups 45% offered foods posing a choking risk on the first day of the WDR. No difference was observed in energy intake, but BLW infants consumed more total (36 *vs* 33% of energy, p=0.018) and saturated (21 *vs* 18% of energy, p=0.001) fat, and less iron (1.9 *vs* 3.6mg, p=0.001) and vitamin B12 (0.3 *vs* 0.5µg, p=0.018), than TSF infants. BLW infants were more likely to eat with their family at lunch (p=0.004) and at the evening meal (p=0.020), and the meals more closely resembled those eaten by their family.

Conclusions: Infants following BLW had similar energy intakes to those following TSF and were eating family meals more regularly, but had higher intakes of fat and saturated fat, and lower intakes of iron and vitamin B12. Of particular concern is the high proportion of both groups being offered foods posing a choking risk. Further education on foods posing a choking risk appears warranted for parents whether they are following BLW or TSF.

ARTICLE SUMMARY

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.

INTRODUCTION

Traditionally, parents have been advised to spoon-feed their infant puréed foods from 'around' 6 months of age, progressing to mashed, then chopped foods so that they are eating family foods by 12 months of age.[1 2] 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.[3 4]

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 breastfed. 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 months to 6 months of age,[2 5 6] most countries have not changed their advice on *how* to introduce foods.[3 7] The exception to this is the UK, where recent NHS advice is that first foods can include soft vegetables and fruit offered as finger food or mashed.[8]

Despite increasing enthusiasm about BLW on the internet (8,960,000 hits in May 2015) and in the social media, health governing bodies[9] and some healthcare professionals[10] 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.[11]

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

METHODS

Study design

This community-based, cross-sectional study of 6-8 month old infants 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).[12] 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. Ethical approval for the studies was obtained from the University of Otago Human Ethics Committee (Reference 13/270), and from the Lower South Regional Ethics Committee (Reference LRS/11/09/037). 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)[12] – 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. 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 the current study were invited to contribute their data (40 participants were approached, of whom 25 consented to contribute their data and met the age- and sex-matching criteria (see below)).

Inclusion criteria for the current study were: infant 6 to 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 plus or minus one 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 the current study.

Definition of baby-led weaning and traditional spoon-feeding

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 or a mixture of spoon-feeding and BLW were assigned to the BLW group. Parents who were spoon-feeding their child (without reporting BLW) were assigned to the Traditional Spoon-Feeding (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[13]), birth weight, and gestational age at birth; and maternal date of birth, and parity. The Feeding Questionnaire collected data on: duration of exclusive breastfeeding[2], age when complementary foods were introduced, extent of infant self-feeding *vs.* 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 one day (the "How to Measure Infant Feeding" Study: n=7). The diet record had three key components: (a) 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; (b) a description of any recipes used - raw amounts of ingredients, cooking method, and proportion of the total recipe fed to the child; and (c) 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 or different to 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, United Kingdom), accurate to within ± one gram.

All diet records were entered into the dietary analysis software programme 'Kai-culator' version 1.11v (University of Otago, Dunedin, New Zealand). Kai-culator uses the New Zealand food composition database, FOODfiles;[14] nutrient data for commonly consumed recipes collated in the 2008/09 New Zealand Adult Nutrition Survey;[15] and nutrient data for commercial infant foods calculated by the research team.[16] Breast milk intake was assumed to be 750g/day based on a quadratic curve fitted to the breast milk volumes reported by Dewey and colleagues[17] 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 posing a choking risk (described below), iron-fortified infant cereal, red meat (defined as beef or lamb), foods with sugar added (i.e. more than 4g/100g of added sugar or honey[18]), foods that were high in sodium (i.e. more than 350mg sodium/100g[18]), fruits, vegetables, and commercial baby food. Foods posing a choking risk were identified using lists from the literature[19 20] and public health organisations,[21 22] and advice from a paediatric Speech-Language Therapist. Each weighed diet record day was reviewed against this list to determine which foods posing a choking risk were offered to infants.

Statistical Analysis

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

Participant characteristics were examined for differences between the two groups. Continuous variables (infant age, birth weight, gestational age, and maternal age at birth) were compared using unpaired, two-tailed t-tests. Categorical variables (infant sex, ethnicity, maternal parity, feeding practices, and when solids were introduced) were compared using chi-squared tests.

As data for current feeding practices were skewed, medians and interquartile ranges for each group were calculated and a Wilcoxon-Mann-Whitney test was used to determine if the groups differed in these behaviours.

For descriptive purposes, the number of infants in each group who consumed a food type of interest (e.g., foods posing a choking risk), a type of milk (e.g., breast milk), or shared meals with their family (e.g., breakfast) was summed using the first day of the diet record (this was because participants in all three studies had provided at least one day of diet record). To compare consumption patterns between groups over all three days of diet record, population-averaged generalised estimating equations for binary data were used with an exchangeable working correlation. Coefficients were back transformed to give odds ratios and 95% confidence intervals. 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.

Mean nutrient intake was calculated using the first day of the diet record (as participants in the "How to Measure Baby-Led Weaning" study only completed one day of diet record). As the data were mostly right-skewed, geometric means and 95% confidence intervals 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 percent difference between the groups along with 95% confidence intervals and p Values. The prevalence of inadequate zinc intakes was determined using the EAR cutpoint method.[23] 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.[23]

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 age was 33.8 (3.9) years and most mothers (86%) were multiparous. The infants were 6.0 to 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**).

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

	Traditional Spoon-Feeding (n = 26)	Baby-Led Weaning (n = 25)	p Value[2]
Infant age (months)	7.3 (0.7)	7.3 (0.7)	0.769
Infant sex, n (%)			0.676
Female	12 (46%)	13 (52%)	
Male	14 (54%)	12 (48%)	
Infant ethnicity, n (%)[3]			0.624
NZ European	20 (77%)	17 (71%)	
Other	6 (23%)	7 (29%)	
Infant birth weight (grams)	3528 (419)	3443 (496)	0.526
Gestational age at birth (weeks)[3]	39.8 (1.4)	39.5 (1.2)	0.471
Maternal age at birth (years)[3]	33.9 (4.4)	33.7 (3.5)	0.856
Maternal parity, n (%)			0.806
Primiparous	4 (15%)	3 (12%)	
Multiparous	22 (85%)	22 (88%)	
Mean duration of exclusive breastfeeding (weeks)	14.4 (8.6)	20.7 (7.7)	**0.007**
Number exclusively breastfed to 6 months, n (%)[4]	0	9 (36%)	**0.001**

Age when complementary foods were introduced (weeks)	21.3 (2.8)	23.2 (3.4)	**0.039**
Number introduced to complementary foods before 6 months, n (%)[4]	25 (96%)	15 (60%)	**0.002**

[1] Method of complementary feeding parents reported using at the time the weighed diet record was completed.
[2] p Values were calculated for differences between the BLW group and the TSF group using unpaired t-test for continuous variables and chi-squared test for categorical variables.
[3] Missing values: Ethnicity = 1 participant (BLW); Gestational age = 3 participants (1 TSP, 2 BLW); Maternal age = 2 participants (BLW).
[4] 6 months defined as 180 days (26 weeks).

Feeding behaviours

Women following BLW exclusively breastfed their infants for approximately 6 weeks longer (p = 0.007), and introduced solid foods 2 weeks later (p = 0.039), than women following TSF (Table 1). In fact, 36% of those following BLW exclusively breastfed their infant to 6 months, compared with none in the TSF group.

When complementary foods were first introduced, the TSF group were more likely (p < 0.001) to have puréed or mashed food (92% *vs*. 36%) and to be fed by an adult (88% *vs*. 32%) than those following BLW (**Table 2**). Although the BLW group were more likely to have finger foods as first foods (60% *vs*. 4%) which the infant self-fed (48% *vs*. 8%) than the TSF group, a considerable number of participants in the BLW group gave their infant puréed or mashed food (40%) and a third fed their infant (rather than the infant feeding themself) when 'solids' were introduced.

The diet record data suggest that when infants were 6 to 8 months of age most infants following BLW fed themselves more than half of their foods (a median of 65% 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 BLW group (71%; p=0.001). At the time the study was conducted, parents reported that 44% of the BLW infants were feeding themselves all their food, compared to 12% of those in the TSF group (p=0.032). Interestingly, 62% of parents following TSF reported that their infant was feeding themself some solids at least once a day (compared to 76% of those following BLW; p=0.327).

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

	Traditional Spoon-Feeding (n=26)	Baby-Led Weaning (n=25)	p Value[1]
Number of infants fed by an adult or self-fed *when 'solids' first introduced*, n (%)[2]			**<0.001**
Infants all or mostly fed by adult	23 (88%)	8 (32%)	
Infants half fed by adult, half self-fed	1 (4%)	5 (20%)	
Infants all or mostly self-fed	2 (8%)	12 (48%)	
Number of infants fed foods as purées or finger foods *when 'solids' first introduced*, n (%)[2]			**<0.001**
Infants given all or mostly puréed (or mashed) foods	24 (92%)	9 (36%)	
Infants given half puréed (or mashed) foods, half finger foods	1 (4%)	1 (4%)	
Infants given all or mostly finger foods	1 (4%)	15 (60%)	
Percentage of foods fed by an adult or self-fed *currently*, median (25^{th}, 75^{th} percentile)[3]			
Percentage of foods fed by adult	0 (0, 13)	5 (0, 19)	0.353
Percentage of foods fed by adult and infant	50 (32, 63)	0 (0, 24)	**<0.001**
Percentage of foods fed by infant	18 (12, 47)	65 (42, 95)	**<0.001**
Percentage of foods fed as purées or finger foods *currently*, median (25^{th}, 75^{th} percentile)[3]			
Percentage of foods naturally liquid	3 (0, 27)	0 (0, 12)	0.302
Percentage of foods puréed or mashed	17 (7, 25)	6 (0, 13)	**0.002**
Percentage of foods as finger foods	33 (14, 53)	71 (50, 95)	**0.001**

[1] p Values were calculated for differences between the BLW group and the TSF group using chi-squared test for proportions, and Wilcoxon-Mann-Whitney test for median percentage of foods.
[2] Data from the Feeding Questionnaire.
[3] Data from the weighed diet record collected when participants were between 6 and 8 months of age.

Foods

In total, almost half (45%) of participants offered foods posing a choking risk to their child, over a third (37%) offered sweetened foods, and more than half (61%) offered foods high in sodium on the first day of the WDR; this did not differ between groups (**Table 3**). There were also no differences in the number consuming fruit (82%), vegetables (86%), and, interestingly, the number using commercial baby foods (45%). However, infants following BLW were introduced to iron-fortified infant cereal on average 3.1 weeks later than those following TSF, and had only one third 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 on the first day of the diet record

Considerable differences were observed in breast milk and infant formula consumption between the two groups, with significantly more participants in the BLW group currently breastfeeding (and not offering infant formula), than in the TSF group (84% *vs*. 58%; p = 0.005). More participants in the TSF group than in the BLW group were having both breast milk and infant formula (31% *vs*. 12%; p = 0.037).

For those following BLW, the most commonly consumed food types posing a choking risk were: raw vegetables, raw apple, and rusks (which were offered on 13, 6, and 6 days respectively of the 67 days recorded by participants in their WDRs); whereas for those following TSF, the most commonly consumed foods posing a risk were: rusks, meat (other than sausages and similar processed meats, or battered fish), crackers, and corn (which were offered on 10, 5, 4, and 4 days respectively of the 72 days recorded by participants in their WDRs).

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

	Traditional Spoon-Feeding (n = 26)	Baby-Led Weaning (n = 25)	Odds ratio (95% CI)[1]	Mean difference (95% CI)	p Value[2]
Foods posing a choking risk:					
Number consuming foods posing a choking risk[3,4]	10 (38%)	13 (52%)	1.89 (0.85, 4.23)	-	0.120
Foods high in iron:					
Age iron-fortified infant cereal[5] introduced (weeks), mean (SD)[6]	21.7 (3.3)	24.8 (4.2)	-	3.1 (0.7, 5.6)	**0.014**
Number not yet introduced to iron-fortified infant cereal[5,6]	3 (12%)	8 (32%)	3.61 (0.78, 16.67) [7]	-	0.079
Number consuming iron-fortified infant cereal[3,5]	11 (42%)	6 (24%)	0.33 (0.12, 0.95)	-	**0.040**
Age red meat[7] introduced (weeks), mean (SD)[6]	26.2 (3.5)	26.2 (2.9)	-	0.0 (-2.3, 2.2)	0.984
Number not yet introduced to red meat[6,7]	9 (35%)	9 (36%)	1.06 (0.33, 3.39) [7]	-	0.918
Number consuming red meat[3,7]	11 (42%)	10 (40%)	0.74 (0.31, 1.76)	-	0.493
Foods with sugar added:					
Number consuming foods with sugar added[3,8]	9 (35)	10 (40)	1.80 (0.67, 4.83)	-	0.244
Foods high in sodium:					
Number consuming foods high in sodium[3,9]	14 (54)	17 (68)	1.60 (0.61, 4.17)	-	0.338
Other foods:					
Number consuming fruit[3]	23 (88)	19 (76)	0.80 (0.27, 2.36)	-	0.681
Number consuming vegetables[3]	23 (88)	21 (84)	0.71 (0.24, 2.10)	-	0.531
Number consuming commercial infant food[3,10]	10 (38)	13 (52)	1.63 (0.62, 4.26)		0.323
Breast milk and infant formula:					
Number currently having breast milk (not infant formula)[6]	15 (58)	21 (84)	6.76 (1.80, 25.37)	-	**0.005**

Number currently having infant formula (not breast milk)[6]	3 (12)	0	-	-	-
Number currently having breast milk and infant formula[6]	8 (31)	3 (12)	0.22 (0.05, 0.91)	-	**0.037**

[1] Odds ratios compare those following BLW with those following TSF and are calculated using 3 days of diet record data (unless stated otherwise). They may not, therefore, reflect differences on the first day of the diet record (7 participants completed a one day diet record: 4 BLW, 3 TSF).

[2] p Values were calculated for (a) odds ratios using population-averaged generalised estimating equations for binary data from the 3-day diet records and for questionnaire data, and (b) for mean differences using unpaired t-tests for continuous variables.

[3] The number consuming a food was determined using the first day of the diet records because 7 participants completed a one day diet record (4 BLW, 3 TSF).

[4] Foods posing a choking risk were identified using lists from the literature[19 20] and from public health organisations.[21 22]

[5] 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).

[6] Data from the Feeding Questionnaire.

[7] Red meat was defined as beef and lamb.

[8] Foods that contained more that 4g/100g of added sugar or honey.

[9] Foods that contained more than 350mg sodium/100g.

[10] Commercial infant foods excluded iron-fortified infant cereals.

Nutrients

Table 4 shows significantly higher mean intakes of total fat, saturated fat, and percentage energy from fat and saturated fat in the BLW group. In contrast, mean intakes of iron, vitamin C, and vitamin B12 were lower in the BLW group than in the TSF group. No differences in mean dietary intake of energy, protein, sugar, dietary fibre, calcium or sodium were detected between the two groups. There was a marginally statistically significant (p=0.05) difference in zinc intake with those in the BLW group having a lower intake. The 95% confidence interval for energy suggests that, at most, energy intake of infants following BLW is likely to be 10% lower to 9% higher than that in those following TSF.

In the absence of anthropometric data (e.g., 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, 15.7% of participants had inadequate intakes of zinc (5 from the BLW group and 3 from the TSF group). Study participants are likely to have had adequate intakes of protein, fat, vitamin C, and calcium because the mean intakes of these nutrients were higher than the AI. However, carbohydrate, iron, and vitamin B12 adequacy cannot be determined because the group mean intakes were below the AI.

Table 4 Mean nutrient intake from weighed diet records of infants according to method of complementary feeding[1] (geometric mean (95%CI))

Nutrients	Nutrient Reference Value[2]	Traditional Spoon-Feeding (n = 26)[3]	Baby-Led Weaning (n = 25)[3]	Mean % difference between groups[4] (95% CI)	p Value[5]
Energy (kJ)	Boys: 2800[6] Girls: 2500[6]	2897 (2718, 3088)	2874 (2647, 3121)	-0.9 (-10.0, 9.2)	0.861
Protein (g)	14g	17 (15, 19)	16 (14, 18)	-8.7 (-22.4, 7.5)	0.276
Protein (% energy)	-	10 (9, 11)	9 (9, 10)	-7.9 (-16.7, 1.7)	0.102
Total fat (g)	30g	33 (31, 35)	36 (34, 38)	10.6 (1.8, 20.3)	**0.017**
Total fat (% energy)	-	42 (39, 44)	46 (45, 48)	11.6 (4.3, 19.4)	**0.002**
Saturated fat (g)	-	14 (13, 16)	16 (16, 17)	14.8 (4.7, 25.9)	**0.003**
Saturated fat (% energy)	-	18 (17, 20)	21 (20, 22)	15.8 (6.0 26.5)	**0.001**
Total carbohydrate (g)	95g	82 (75, 90)	76 (68, 84)	-7.7 (-19.0, 5.3)	0.233
Total carbohydrate (% energy)	-	48 (46, 50)	45 (43, 46)	-7.0 (-11.7, -1.5)	**0.007**
Sugars (g)	-	46 (35, 61)	60 (53, 67)	36.1 (-2.1, 89.3)	0.067
Dietary fibre (g)	-	3.6 (2.2, 5.8)	2.4 (1.6, 3.5)	-40.3 (-65.3, 2.9)	0.063
Iron (mg)	7mg	3.6 (2.7, 4.9)	1.9 (1.4, 2.6)	-48.3 (-65.6, -22.4)	**0.001**
Zinc (mg)	2.5mg[7]	3.7 (3.3, 4.1)	3.2 (2.9, 3.6)	-13.5 (-25.2, 0.0)	0.050
Vitamin C (mg)	30mg	66 (57, 76)	51 (43, 60)	-11.5 (-35.6, -4.3)	**0.016**
Vitamin B12 (µg)	0.5µg	0.5 (0.3, 0.8)	0.3 (0.2, 0.4)	-45.4 (-66.9, -9.8)	**0.018**

Calcium (mg)	270mg	382 (352, 436)	348 (310, 391)	-11.2 (-23.3, 2.9)	0.114
Sodium (mg)	170mg	235 (200, 275)	235 (191, 284)	-0.9 (-21.4, 24.9)	0.938

[1] Method of complementary feeding parents reported using at the time the weighed diet record was completed.

[2] Nutrient Reference Values are the Adequate Intake (AI) from food and breast milk (or infant formula) for infants 7-12 months of age (unless stated otherwise).[24]

[3] Geometric mean and 95% confidence interval calculated using the first day of the diet record (7 participants completed a one day diet record (4 BLW, 3 TSF).

[4] Mean difference between the BLW group and the TSF group calculated from 3 days of diet record.

[5] p Values are calculated for mean difference between the BLW group and the TSF group using mixed effects regression models of log-transformed nutrient intakes.

[6] Estimated Energy Requirement (EER) for infants 7 months of age.

[7] Estimated Average Requirement (EAR).

Family meals

The relationship between the foods consumed at the three main meals (breakfast, lunch, evening meal) by the infant and those consumed by the family is reported in **Table 5**. Baby-Led Weaning was associated with greater infant involvement in family meal times, with infants significantly more likely to sit with the family during lunch and evening meal times. However, both groups of infants were likely to share breakfast with the family (83% of the infants consuming the meal). Compared to those following TSF, mothers following a BLW approach were more likely to offer foods that were similar or the same (both ingredients and preparation) to those eaten by the rest of the family at lunch and the evening meal.

Table 5 Relationship between the foods eaten by the infant and the meals eaten by their family (i.e. 'family meals') according to method of complementary feeding (n (%))[1]

	Traditional Spoon-Feeding (n = 26)	Baby-Led Weaning (n = 25)	Odds ratio (95% CI)[2]	p Value[3]
Number of infants eating their meal with the family:				
Breakfast	16/20 (80)	18/21 (86)	3.06 (0.74, 12.63)	0.121
Lunch	13/21 (50)	13/18 (72)	5.64 (1.75, 18.24)	**0.004**
Evening meal	12/23 (52)	17/21 (81)	4.01 (1.24, 12.94)	**0.020**
Number of infants with ingredients the same as family meal:[4]				
Breakfast	5/19 (19)	5/20 (20)	1.20 (0.36, 4.00)	0.762
Lunch	1/20 (4)	6/18 (24)	8.53 (2.17, 33.61)	**0.002**
Evening meal	4/22 (15)	9/21 (36)	4.78 (1.41, 16.15)	**0.012**
Number of infants with meal preparation the same as family meal:[4]				
Breakfast	2/19 (8)	8/19 (32)	2.59 (0.78, 8.62)	0.122
Lunch	1/20 (4)	7/16 (28)	7.50 (2.15, 26.19)	**0.002**
Evening meal	3/22 (12)	9/20 (36)	4.68 (1.55, 14.11)	**0.006**

[1] 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.
[2] Odds ratios compare those following BLW with those following TSF and are calculated using 3 days of diet record data (unless stated otherwise). They may not, therefore, reflect differences on the first day of diet record (7 participants completed a one day diet record (4 BLW, 3 TSF).
[3] p Values were calculated for odds ratios using population-averaged generalized estimating equations for binary data.
[4] The "same as" was defined as the participant answering 1=exactly the same, or 2=almost the same, on a 4-point scale (other values were 3=similar, 4=mostly different).

DISCUSSION

Our findings demonstrate that there are several differences in foods, nutrients, and eating behaviours between children following Baby-Led Weaning and those following a more traditional spoon-feeding approach. Baby-Led Weaning was associated with a number of health-related behaviours that would be expected to be beneficial: longer duration of exclusive breastfeeding, later introduction of complementary foods, and greater participation in family meals. However, the iron intakes of BLW infants were even lower than those of infants following TSF, and intakes of zinc and vitamin B12 may also be marginal. Although total energy intakes were similar in both groups of infants, the sources of that energy differed with BLW infants consuming more saturated and total fat than TSF infants. Of particular concern, however, is the high proportion of both groups being offered foods posing a choking risk.

The two major strengths of this study are (a) the recruitment of groups of infants following BLW and TSF who were closely matched for age and sex and other demographic variables, and (b) 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 themself, 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 results are consistent with our earlier survey in New Zealand parents[25] that showed that many parents who report following BLW in fact feed their infant a significant proportion of their food. The major limitation of our study was its small sample size that may not be representative of the wider population, and decreased our ability to detect differences between the feeding styles. However, a number of differences were detected between the two complementary feeding styles, and confidence intervals 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. Finally, families were assigned to the 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 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.[10] 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.[10] This may be particularly relevant if low energy finger foods such as fruit and vegetables predominate in the diet.[26] While the current study did not measure infant body mass index, so growth faltering could not be identified, the reported energy intakes were similar for the two feeding styles, were comparable to those reported for New Zealand infants,[27] and met recommendations.[24]

In contrast, iron intakes were 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.[1 28 29] Iron fortified infant cereals are recommended as a suitable first food to help address this.[2 30] 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 (e.g., fruits and vegetables).[10] Our results would suggest that these concerns may have some value given that infants following BLW had approximately half the daily dietary iron intake of infants following TSF. The BLW group introduced fortified infant cereal 3 weeks later and were considerably less likely to consume fortified infant cereal during the weighed diet record. Although the adequacy of intakes below the AI cannot be determined,[23] the iron intakes of both groups were considerably lower than the AI of 7mg[24] (3.6mg and 1.9mg for TSF and BLW respectively). Half of the infants (51%) consumed no fortified infant cereal over the three days of WDR, 45% consumed no red meat, and 22% consumed neither fortified cereal or red meat, suggesting the need for health care professionals to emphasise the importance of including iron rich food sources in infants' diets in the complementary feeding period. This applies particularly to those following BLW, but also to those following traditional spoon-feeding. It is possible that the choice of infant milk may also have contributed to these differences in iron intake - the infants in the BLW group were less likely to be having infant formula (n=3; 12%) than those in the TSF group (n=11; 42%), 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.[10 31 32] Although our sample size was too small to investigate actual choking incidents, we observed that a worryingly high number of parents in both groups were offering foods posing a choking risk. Further education for parents on how to minimize the risk of choking is therefore warranted - no matter what approach to complementary feeding is used. This advice needs to refer not just to types of food that are commonly considered to pose a choking risk (e.g., 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 (e.g., corn), and to ways in which foods posing a choking risk can be modified to make them safer (e.g., 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).

Concern has been expressed that infant self-feeding of family meals is only of benefit if the family meals themselves are nutritionally adequate.[10] While previous studies have reported that infants following BLW are more likely to eat with their family,[26 31] 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.[33] Certainly, in our study, total and saturated fat intakes were significantly higher for those following BLW. It is recommended that total fat intakes should be 30 to 45% of energy,[1] and the mean intake of those following BLW was slightly above this (46% of energy). It is not clear, however, whether the saturated fat intakes are of concern. Both the TSF (18% energy) and BLW (21% energy) saturated fat intakes are lower than mature breast milk which has 25% energy from saturated fat.[14] It is also possible that family meals do not provide sufficient zinc and vitamin B12 to meet the relatively high requirements of infants. There is considerable controversy about the Estimated Average Requirement (EAR) for zinc for infants,[34] and although 20% of the infants in the BLW group in this study had a zinc intake less than the EAR of 2.5mg for Australian and New Zealand infants,[24] 56% had an intake less than the EAR set by IZiNCG of 3.0mg/day.[35] A prevalence of 25% or higher is considered to indicate an elevated risk of zinc deficiency.[35] It is not possible to state that the mean vitamin B12 intake in the BLW group of 0.3µg/day is inadequate even though it is below the AI,[23] however, intakes would need to more than double by the age of 12 months to meet the EAR for that age (0.7µg/day[24]). As our study was cross-sectional 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.[2] However, we suggest that advice on BLW should stress 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.

In conclusion, while BLW appears to be associated with a number of health-related behaviours that would be expected to be beneficial: exclusive breastfeeding to 6 months, waiting until 6 months to introduce solids, and greater involvement in family meals, further research is required to determine whether BLW infants may be at higher risk of iron and vitamin B12 deficiencies. 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 posing a choking risk, it is of concern that 45% of the infants had been offered a food posing a choking risk on the first day of the diet record. 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, it is important that families of infants following BLW are encouraged to include a variety of nutrient dense foods in family meals, and to offer their infants iron rich foods (such as iron-fortified infant cereal and red meat); and that all parents, no matter what approach they take to complementary feeding, are given advice on how to minimise their infant's exposure to foods that pose a choking risk.

STATEMENTS

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Author contributions:

ALMH 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 posing 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. ALMH is the guarantor.

Data sharing statement: Data are not available for sharing.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	5, 6, 7
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	5-6
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Tables
Outcome data	15*	Report numbers of outcome events or summary measures	Tables
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 3-5
		(*b*) Report category boundaries when continuous variables were categorized	Tables
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	22
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	22
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-25
Generalisability	21	Discuss the generalisability (external validity) of the study results	22-23
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	26

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

How different are Baby-Led Weaning and conventional complementary feeding? A cross-sectional study of 6 to 8 month old infants

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How different are Baby-Led Weaning and conventional complementary feeding? A cross-sectional study of 6 to 8 month old infants

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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- and sex-matched infants (n = 25 BLW, 26 TSF) 6-8 months of age.

Methods: Parents completed a questionnaire, and Weighed Diet Records (WDR) on 1-3 non-consecutive days, to investigate food and nutrient intakes, the extent to which infants were self- 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 posing a choking risk during the WDR (78% *vs* 58%, p=0.172), the confidence interval was wide so we cannot rule out increased odds with BLW (odds ratio, 95% CI: 2.57, 0.63-10.44). No difference was observed in energy intake, but BLW infants consumed 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* 3.6mg, p<0.001), zinc (3.0 *vs* 3.7mg, p=0.001) and vitamin B12 (0.2 *vs* 0.5µg, p<0.001), than TSF infants. BLW infants were more likely to eat with their family at lunch and evening meal (both p≤0.020).

Conclusions: Infants following BLW had similar energy intakes to those following TSF and were eating family meals more regularly, but had higher intakes of fat and saturated fat, and lower intakes of iron, zinc and vitamin B12. Of particular concern is the high proportion of both groups being offered foods posing a choking risk. Further education on foods posing a choking risk appears warranted for BLW and TSF parents.

ARTICLE SUMMARY

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.

INTRODUCTION

Traditionally, parents have been advised to spoon-feed their infant puréed foods from 'around' 6 months of age, progressing to mashed, then chopped foods so that they are eating family foods by 12 months of age.[1 2] 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.[3 4]

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 breastfed. 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 months to 6 months of age,[2 5 6] most countries have not changed their advice on *how* to introduce foods.[3 7] The exception to this is the UK, where recent NHS advice is that first foods can include soft vegetables and fruit offered as finger food or mashed.[8]

Despite increasing enthusiasm about BLW on the internet (8,960,000 hits in May 2015) and in the social media, health governing bodies[9] and some healthcare professionals[10] 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.[11]

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

METHODS

Study design

This community-based, cross-sectional study of 6-8 month old infants 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).[12] 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. Ethical approval for the studies was obtained from the University of Otago Human Ethics Committee (Reference 13/270), and from the Lower South Regional Ethics Committee (Reference LRS/11/09/037). 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)[12] – 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 the current study were invited to contribute their data (40 participants were approached, of whom 25 consented to contribute their data and met the age- and sex-matching criteria (see below)).

Inclusion criteria for the current study were: infant 6 to 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 plus or minus one 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 the current study.

Definition of Baby-Led Weaning and traditional spoon-feeding

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 Traditional Spoon-Feeding (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[13]), birth weight, and gestational age at birth; and maternal date of birth, and parity. The Feeding Questionnaire collected data on: duration of exclusive breastfeeding[2], age when complementary foods were introduced, extent of infant self-feeding *vs.* 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 one day (the "How to Measure Infant Feeding" Study: n=7). The diet record had three key components: (a) 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; (b) a description of any recipes used - raw amounts of ingredients, cooking method, and proportion of the total recipe fed to the child; and (c) 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 or different to 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, United Kingdom), accurate to within ± one gram.

All diet records were entered into the dietary analysis software programme 'Kai-culator' version 1.11v (University of Otago, Dunedin, New Zealand). Kai-culator uses the New Zealand food composition database, FOODfiles;[14] nutrient data for commonly consumed recipes collated in the 2008/09 New Zealand Adult Nutrition Survey;[15] and nutrient data for commercial infant foods calculated by the research team.[16] Breast milk intake was assumed to be 750g/day based on a quadratic curve fitted to the breast milk volumes reported by Dewey and colleagues[17] 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 posing a choking risk (described below), iron-fortified infant cereal, red meat (defined as beef or lamb), foods with sugar added (i.e. more than 4g/100g of added sugar or honey[18]), foods that were high in sodium (i.e. more than 350mg sodium/100g[18]), fruits, vegetables, and commercial baby food. Foods posing a choking risk were identified using lists from the literature[19 20] and public health organisations,[21 22] and advice from a paediatric Speech-Language Therapist. Each weighed diet record day was reviewed against this list to determine which foods posing a choking risk were offered to infants.

Statistical Analysis

The data were analysed using Stata version 13.1 (StataCorp, College Station, TX, 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 sex, ethnicity, maternal parity, feeding practices, and when solids were introduced) were compared using chi-squared tests and Fisher's exact test 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-squared test for proportions (Table 2). As current feeding practices were skewed, medians and interquartile ranges 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 (e.g., foods posing a choking risk) or a type of milk (e.g., breast milk) on any day of the diet record was recorded and odds ratios with a chi-squared 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). As the data were mostly right-skewed, geometric means and 95% confidence intervals 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 percent difference between the groups along with 95% confidence intervals and p Values

The prevalence of inadequate zinc intakes was determined using the EAR cutpoint method.[23] 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.[23]

In Table 5, for descriptive purposes, the number of infants in each group who shared meals with their family (e.g., breakfast) was summed using the first day of the diet record. To compare consumption patterns between groups over all three days of diet record, population-averaged generalised estimating equations for binary data were used with an exchangeable working correlation. Coefficients were back transformed to give odds ratios and 95% confidence intervals. 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 age was 33.8 (3.9) years and most mothers (86%) were multiparous. The infants were 6.0 to 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**).

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

	Traditional Spoon-Feeding (n = 26)	Baby-Led Weaning		p Value[2]
		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 (%)[3]				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)[3]	39.8 (1.4)	40.4 (1.2)	39.2 (1.1)	0.156
Maternal age at birth (years)[3]	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 breastfeeding (weeks)	14.4 (8.6)	17.1 (7.3)	22.2 (7.6)	**0.003**

Number exclusively breastfed to 6 months, n (%)[4]	0	1 (14%)	8 (44%)	**<0.001**
Age when complementary foods were introduced (weeks)	21.3 (2.8)	19.5 (3.5)	24.6 (2.0)	**<0.001**
Number introduced to complementary foods before 6 months, n (%)[4]	25 (96%)	6 (86%)	9 (50)%	**0.001**

267 [1] Method of complementary feeding parents reported using at the time the weighed diet record was completed.

268 [2] p Values were calculated for differences between the full BLW group and the TSF group using unpaired t-test for continuous variables and chi-

269 squared test for categorical variables.

270 [3] Missing values: Ethnicity = 1 participant (full BLW); Gestational age = 2 participants (1 partial BLW, 1 full BLW).

271 [4] 6 months defined as 180 days (26 weeks).

Feeding behaviours

Women from the full BLW group exclusively breastfed their infants for approximately 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 breastfed their infant to 6 months, compared with none in the TSF group.

When complementary foods were first introduced, the TSF group were 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 were 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 themself) when 'solids' were introduced. As would be expected, the partial BLW group were intermediate between the TSF and full BLW groups.

The diet record data suggest that when infants were 6 to 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 to 12% of those in the TSF group ($p = 0.015$). Interestingly, 62% of parents following TSF reported that their infant was feeding themself some solids at least once a day (compared to 78% of those following full BLW; $p = 0.290$).

301 **Table 2 Baby-Led Weaning associated behaviours of infants when complementary foods were first introduced, and currently,**
302 **according to method of complementary feeding**
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	Traditional Spoon-Feeding (n=26)	**Baby-Led Weaning: Partial (n=7)**	**Baby-Led Weaning: Full (n=18)**	**p Value[1]**
Number of infants fed by an adult or self-fed *when 'solids' first introduced*, n (%)[2]				**<0.001**
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 (%)[2]				**<0.001**
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 (25^{th}, 75^{th} percentile)[3]				
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)	**0.001**
Percentage of foods fed by infant	18 (12, 47)	48 (42, 65)	77 (39, 98)	**0.001**
Percentage of foods fed as purées or finger foods *currently*, median (25^{th}, 75^{th} percentile)[3]				
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)	**0.002**
Percentage of foods as finger foods	33 (14, 53)	65 (27, 74)	77 (58, 100)	**<0.001**

304 [1] p Values were calculated for differences between the full BLW group and the TSF group using chi-squared test for proportions, and Wilcoxon-
305 Mann-Whitney test for median percentage of foods.
306 [2] Data from the Feeding Questionnaire.
307 [3] Data from the weighed diet record collected when participants were between 6 and 8 months of age.

Foods

In total, two-thirds (69%) of participants offered foods posing 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 the TSF groups in the number of infants consuming foods posing a choking risk (78% *vs* 58%, p=0.172), the confidence interval for the odds ratio was wide and included values consistent with an important potential increase in the odds of offering these foods (odds ratio, 95% CI: 2.57, 0.63-10.44).

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 breastfeeding (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 posing 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 posing 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).

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

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	Traditional Spoon-Feeding (n = 26)	Baby-Led Weaning: Partial (n=7)	Baby-Led Weaning: Full (n = 18)	Odds ratio (95% CI)[1]	Mean difference (95% CI)	p Value[2]
Foods posing a choking risk:						
Number that consumed foods posing a choking risk[3,4]	15 (58%)	6 (86%)	14 (78%)	2.57 (0.63, 10.44)	-	0.172
Foods high in iron:						
Age iron-fortified infant cereal[5] introduced (weeks), mean (SD)[6]	21.7 (3.3)	22.3 (4.9)	26.8 (2.2)	-	5.1 (2.6, 7.5)	**<0.001**
Number not yet introduced to iron-fortified infant cereal[5,6]	3 (12%)	0 (0%)	8 (44%)	6.13 (1.17, 32.20)	-	**0.014**
Number that consumed iron-fortified infant cereal[3,5]	16 (62%)	5 (71%)	4 (22%)	0.18 (0.04, 0.80)	-	**0.011**
Age red meat[7] introduced (weeks), mean (SD)[6]	26.2 (3.5)	24.1 (2.3)	27.5 (2.4)	-	1.2 (-1.3, 3.8)	0.332
Number not yet introduced to red meat[6,7]	9 (35%)	1 (14%)	8 (44%)	1.51 (0.43, 5.29)[7]	-	0.515
Number that consumed red meat[3,7]	15 (58%)	6 (86%)	7 (39%)	0.47 (0.13, 1.64)[7]	-	0.225
Foods with sugar added:						
Number that consumed foods with sugar added[3,8]	11 (42%)	5 (71%)	7 (39%)	0.86 (0.25, 3.00)	-	0.823
Foods high in sodium:						
Number that consumed foods high in sodium[3,9]	20 (77%)	5 (71%)	14 (78%)	1.05 (0.25, 4.50)	-	0.948
Other foods:						
Number that consumed fruit[3]	25 (96%)	7 (100%)	17 (94%)	0.68 (0.04, 12.05)	-	0.791
Number that consumed vegetables[3]	25 (96%)	7 (100%)	16 (89%)	0.32 (0.03, 4.04)	-	0.353
Number that consumed commercial infant food[3,10]	15 (58%)	7 (100%)	8 (44%)	0.59 (0.17, 2.02)	-	0.393
Breast milk and infant formula:						
Number currently having breast milk (not infant formula)[6,11]	11 (42%)	4 (57%)	18 (100%)	-	-	**<0.001**
Number currently having infant formula (not breast milk)[6,11]	3 (12%)	0	0	-	-	0.258

Number currently having breast milk and infant formula[6,11]	12 (46%)	3 (43%)	0	-	-	**<0.001**

[1] Odds ratios compare those following full BLW with those following TSF.
[2] p Values were calculated for (a) odds ratios using population-averaged generalised estimating equations for binary data from the 3-day diet records and for questionnaire data, and (b) for mean differences using unpaired t-tests for continuous variables, unless stated otherwise.
[3] The number that consumed a food was determined using all three days of diet record (except for 7 participants who completed a one day diet record: 4 full BLW, 3 TSF).
[4] Foods posing a choking risk were identified using lists from the literature[19 20] and from public health organisations.[21 22]
[5] 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).
[6] Data from the Feeding Questionnaire.
[7] Red meat was defined as beef and lamb.
[8] Foods that contained more that 4g/100g of added sugar or honey.
[9] Foods that contained more than 350mg sodium/100g.
[10] Commercial infant foods excluded iron-fortified infant cereals.
[11] Fisher's exact test used to calculate p Values.

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 B12, 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% confidence interval 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 (e.g., 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 had adequate intakes of protein, fat, vitamin C, and calcium because the mean intakes of these nutrients were higher than the AI. However, carbohydrate, iron, and vitamin B12 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.

Table 4 Mean nutrient intake from weighed diet records of infants according to method of complementary feeding[1] (geometric mean (95%CI))

Nutrients	Nutrient Reference Value[2]	Traditional Spoon-Feeding (n = 26)[3]	Baby-Led Weaning		Mean % difference between groups[4] (95% CI)	p Value[5]
			Partial (n=7)	Full (n = 18)[3]		
Energy (kJ)	Boys: 2800[6] Girls: 2500[6]	2897 (2718, 3088)	3073 (2682, 3521)	2800 (2518, 3115)	-3.7 (-13.5, 7.3)	0.500
Protein (g)	14g	17 (15, 19)	18 (14, 23)	15 (12, 17)	-14.4 (-28.3, 2.3)	0.087
Protein (% energy)	-	10 (9, 11)	10 (9, 11)	9 (8, 10)	-11.3 (-20.6, -1.0)	**0.033**
Total fat (g)	30g	33 (31, 35)	36 (33, 38)	36 (33, 39)	10.6 (0.4, 21.9)	**0.042**
Total fat (% energy)	-	42 (39, 44)	43 (39, 47)	48 (46, 50)	15.1 (6.9, 23.9)	**<0.001**
Saturated fat (g)	-	14 (13, 16)	16 (15, 17)	17 (15, 18)	15.6 (3.7, 28.8)	**0.009**
Saturated fat (% energy)	-	18 (17, 20)	19 (17, 22)	22 (21, 23)	20.0 (8.9, 32.2)	**<0.001**
Total carbohydrate (g)	95g	82 (75, 90)	86 (70, 105)	72 (64, 82)	-12.1 (23.8, 1.4)	0.076
Total carbohydrate (% energy)	-	48 (46, 50)	47 (44, 51)	44 (42, 46)	-8.9 (-14.0, -3.5)	**0.001**
Sugars (g)	-	46 (35, 61)	54 (36, 81)	62 (57, 68)	42.3 (-2.4, 107.3)	0.067
Dietary fibre (g)	-	3.6 (2.2, 5.8)	3.7 (2.1, 6.3)	2.0 (1.2, 3.4)	-50.7 (-73.3, -9.1)	**0.023**
Iron (mg)	7mg	3.6 (2.7, 4.9)	3.3 (1.3, 8.0)	1.6 (1.2, 2.1)	-59.0 (-72.5, -38.9)	**<0.001**
Zinc (mg)	2.5mg[7]	3.7 (3.3, 4.1)	4.0 (2.9, 5.4)	3.0 (2.6, 3.3)	-20.5 (-31.1, -7.4)	**0.001**
Vitamin C (mg)	30mg	66 (57, 76)	67 (53, 86)	46 (38, 55)	-29.6 (-40.0, -12.9)	**0.001**
Vitamin B12 (µg)	0.5µg	0.5 (0.3, 0.8)	0.6 (0.3, 1.1)	0.2 (0.1, 0.3)	-60.2 (-76.2, -33.5)	**<0.001**
Calcium (mg)	270mg	382 (352, 436)	437 (311, 616)	318 (290, 349)	-19.1 (-29.4, -7.3)	**0.002**

Sodium (mg)	170mg	235 (200, 275)	235 (171, 323)	232 (178, 302)	-1.5 (-24.3, 28.2)	0.911

[1] Method of complementary feeding parents reported using at the time the weighed diet record was completed.

[2] Nutrient Reference Values are the Adequate Intake (AI) from food and breast milk (or infant formula) for infants 7-12 months of age (unless stated otherwise).[24]

[3] Geometric mean and 95% confidence interval calculated using the mean of all available days of the diet record (7 participants completed a one day diet record: 4 full BLW, 3 TSF).

[4] Mean % difference between the BLW group and the TSF group calculated using the mean of all available days of the diet record (7 participants completed a one day diet record: 4 full BLW, 3 TSF).

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

[6] Estimated Energy Requirement (EER) for infants 7 months of age.

[7] Estimated Average Requirement (EAR).

Family meals

The relationship between the foods consumed at the three main meals (breakfast, lunch, evening meal) by the infant and those consumed by the family is reported in **Table 5**. Baby-Led Weaning 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 meal times. However, breakfast eaters in all three groups were likely to share breakfast with the family (83% of the infants consuming the meal). Compared to those following TSF, mothers following a full BLW approach were more likely to offer foods that were similar or the same (both ingredients and preparation) to those eaten by the rest of the family at lunch and the evening meal.

Table 5 Relationship between the foods eaten by the infant and the meals eaten by their family (i.e. 'family meals') according to method of complementary feeding (n (%))[1,2]

	Traditional Spoon-Feeding (n = 26)	Baby-Led Weaning: Partial (n = 7)	Baby-Led Weaning: Full (n = 18)	Odds ratio (95% CI)[3]	p Value[4]
Number of infants eating their meal with the family:					
Breakfast	16/20 (80%)	6/6 (100%)	12/15 (80%)	1.99 (0.48, 8.31)	0.344
Lunch	13/21 (50%)	1/4 (25%)	12/14 (86%)	10.29 (2.67, 39.65)	**0.001**
Evening meal	12/23 (52%)	5/6 (83%)	12/15 (80%)	4.75 (1.27, 17.75)	**0.020**
Number of infants with ingredients the same as family meal:[5]					
Breakfast	5/19 (19%)	0/6 (0%)	5/14 (36%)	1.60 (0.44, 5.78)	0.473
Lunch	1/20 (4%)	0/6 (0%)	6/14 (43%)	10.56 (2.51, 44.39)	**0.001**
Evening meal	4/22 (15%)	0/6 (0%)	9/15 (60%)	9.00 (2.64, 30.62)	**<0.001**
Number of infants with meal preparation the same as family meal:[5]					
Breakfast	2/19 (8%)	2/6 (33%)	6/13 (46%)	2.27 (0.59, 8.70)	0.232
Lunch	1/20 (4%)	0/3 (0%)	7/13 (54%)	10.31 (2.87, 37.09)	**<0.001**
Evening meal	3/22 (12%)	1/6 (17%)	8/14 (57%)	8.18 (2.66, 25.14)	**<0.001**

[1] Summary numbers presented are from first day of diet record.

[2] 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.

[3] Odds ratios compare those following full BLW with those following TSF and are calculated using all three days of diet record (except for 7 participants who completed a one day diet record: 4 full BLW, 3 TSF). They may not, therefore, reflect exactly the differences on the first day of diet record

[4] p Values were calculated for odds ratios using population-averaged generalized estimating equations for binary data.

411 [5] The "same as" was defined as the participant answering 1=exactly the same, or 2=almost the same, on a 4-point scale (other values were
412 3=similar, 4=mostly different).

DISCUSSION

Our findings suggest that there may be several differences in foods, nutrients, and eating behaviours between children following Baby-Led Weaning and those following a more traditional spoon-feeding approach. In this small study, Baby-Led Weaning was associated with a number of health-related behaviours that would be expected to be beneficial: longer duration of exclusive breastfeeding, later introduction of complementary foods, and greater participation in family meals. However, the iron intakes of full BLW infants were even lower than those of infants following TSF, and intakes of zinc and vitamin B12 may also be marginal. Although total energy intakes were similar, the sources of that energy differed with full BLW infants consuming more saturated and total fat than TSF infants. It is clear that a high proportion of all three groups were consuming foods posing 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 (a) the recruitment of groups of infants following BLW and TSF who were closely matched for age and sex and other demographic variables, and (b) 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 themself, 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 confidence intervals 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,[25] and more likely to be multiparous,[26] than typical New Zealand mothers. However, they were just as likely as New Zealand mothers to be of non-European ethnicity,[27] and the participants in the TSF group had a similar very low rate of exclusive breastfeeding to 6 months.[27] 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.[28-30] 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.[31 32] If the breast milk value we used overestimated breast milk volume, then the differences in nutrient intakes would be even greater than we have reported. 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.[10] 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.[10] This may be particularly relevant if low energy finger foods such as fruit and vegetables predominate in the diet.[33] While the current study did not measure infant body mass index, so growth faltering could not be identified, the reported energy intakes were similar for the two feeding styles, were comparable to those reported for New Zealand infants,[34] and met recommendations.[24]

In contrast, iron intakes were 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.[1 35 36] Iron fortified infant cereals are recommended as a suitable first food to help address this.[2 37] 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 (e.g., fruits and vegetables).[10] Our results would suggest that these concerns may have some value given that, on average, infants following full BLW had 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 weighed diet record. Although the adequacy of intakes below the AI cannot be determined,[23] the iron intakes of all three groups were considerably lower than the AI of 7mg[24] (3.6mg, 3.3mg and 1.6mg for TSF, partial BLW and full BLW respectively). Half of the infants (51%) consumed no fortified infant cereal over the three days of WDR, 45% consumed no red meat, and 22% consumed neither fortified cereal or 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, health care 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.[10 38 39] 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 posing a choking risk. These results suggest that further education for parents on how to minimize the risk of choking may be needed - no matter what approach to complementary feeding was being used. This advice would need to refer not just to types of food that are commonly considered to pose a choking risk (e.g., 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 (e.g., corn), and to ways in which foods posing a choking risk can be modified to make them safer (e.g., 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 are more likely to be exposed to foods posing a choking risk. Although there was no statistically significant difference between the groups, the upper limit of the wide confidence interval for the odds ratio suggests that a substantially higher odds of exposure is possible. It is, therefore, extremely important that exposure to foods posing 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.[10] While previous studies have reported that infants following BLW are more likely to eat with their family,[33 38 40] 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.[41] 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 to 45% of energy,[1] and the mean intake of those in the full BLW group was 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.[14] It is also possible that family meals do not provide sufficient zinc and vitamin B12 to meet the relatively high requirements of infants, particularly given the small portion sizes consumed by infants. There is considerable controversy about the Estimated Average Requirement (EAR) for zinc for infants,[42] but 28% of the infants in the full BLW group in this study had a zinc intake less than the EAR of 2.5mg for Australian and New Zealand infants.[24] It is not possible to state that the mean vitamin B12 intake in the BLW group of 0.2µg/day is inadequate even though it is below the AI,[23] however, intakes would need to more than triple by the age of 12 months to meet the

EAR for that age (0.7µg/day[24]). 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 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".[43] 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.[2] If confirmed, these results suggest that the current complementary feeding guidelines for infants, that 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 Baby-Led Weaning. Modifications would 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 B12.

In conclusion, the current study suggests that BLW may be associated with a number of health-related behaviours that would be expected to be beneficial: exclusive breastfeeding 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 B12 deficiencies. 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 posing a choking risk, it is of concern that two-thirds of the infants were offered at least one food posing 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 B12; 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 that pose a choking risk.

STATEMENTS

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Author contributions:

ALMH 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 posing 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. ALMH is the guarantor.

Data sharing statement: Data are not available for sharing.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	5, 6, 7
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	5-6
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Tables
Outcome data	15*	Report numbers of outcome events or summary measures	Tables
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 3-5
		(*b*) Report category boundaries when continuous variables were categorized	Tables
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	24
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	24-25
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	24-29
Generalisability	21	Discuss the generalisability (external validity) of the study results	24-25
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	30

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

How different are Baby-Led Weaning and conventional complementary feeding? A cross-sectional study of 6 to 8 month old infants

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How different are Baby-Led Weaning and conventional complementary feeding? A cross-sectional study of 6 to 8 month old infants

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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- and sex-matched infants (n = 25 BLW, 26 TSF) 6-8 months of age.

Methods: Parents completed a questionnaire, and Weighed Diet Records (WDR) on 1-3 non-consecutive days, to investigate food and nutrient intakes, the extent to which infants were self- 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 confidence interval was wide so we cannot rule out increased odds with BLW (odds ratio, 95% CI: 2.57, 0.63-10.44). 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* 3.6mg, p<0.001), zinc (3.0 *vs* 3.7mg, p=0.001) and vitamin B12 (0.2 *vs* 0.5µg, p<0.001), than TSF infants. BLW infants were more likely to eat with their family at lunch and evening meal (both p≤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 B12. A high proportion of both groups were offered foods thought to pose a choking risk.

ARTICLE SUMMARY

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.

INTRODUCTION

Traditionally, parents have been advised to spoon-feed their infant puréed foods from ‘around’ 6 months of age, progressing to mashed, then chopped foods so that they are eating family foods by 12 months of age.[1 2] 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.[3 4]

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 breastfed. 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 months to 6 months of age,[2 5 6] most countries have not changed their advice on *how* to introduce foods.[3 7] The exception to this is the UK, where recent NHS advice is that first foods can include soft vegetables and fruit offered as finger food or mashed.[8]

Despite increasing enthusiasm about BLW on the internet (8,960,000 hits in May 2015) and in the social media, health governing bodies[9] and some healthcare professionals[10] 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.[11]

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 traditional spoon-feeding; and, second, to describe the 'family meals' offered to infants following BLW and traditional spoon-feeding.

METHODS

Study design

This community-based, cross-sectional study of 6-8 month old infants 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).[12] 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. Ethical approval for the studies was obtained from the University of Otago Human Ethics Committee (Reference 13/270), and from the Lower South Regional Ethics Committee (Reference LRS/11/09/037). 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)[12] – 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 the current study were invited to contribute their data (40 participants were approached, of whom 25 consented to contribute their data and met the age- and sex-matching criteria (see below)).

Inclusion criteria for the current study were: infant 6 to 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 plus or minus one 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 the current study.

Definition of Baby-Led Weaning and traditional spoon-feeding

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 Traditional Spoon-Feeding (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[13]), birth weight, and gestational age at birth; and maternal date of birth, and parity. The Feeding Questionnaire collected data on: duration of exclusive breastfeeding[2], age when complementary foods were introduced, extent of infant self-feeding *vs.* 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 one day (the "How to Measure Infant Feeding" Study: n=7). The diet record had three key components: (a) 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; (b) a description of any recipes used - raw amounts of ingredients, cooking method, and proportion of the total recipe fed to the child; and (c) 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 or different to 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, United Kingdom), accurate to within ± one gram.

All diet records were entered into the dietary analysis software programme 'Kai-culator' version 1.11v (University of Otago, Dunedin, New Zealand). Kai-culator uses the New Zealand food composition database, FOODfiles;[14] nutrient data for commonly consumed recipes collated in the 2008/09 New Zealand Adult Nutrition Survey;[15] and nutrient data for commercial infant foods calculated by the research team.[16] Breast milk intake was assumed to be 750g/day based on a quadratic curve fitted to the breast milk volumes reported by Dewey and colleagues[17] 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 (i.e. more than 4g/100g of added sugar or honey[18]), foods that were high in sodium (i.e. more than 350mg sodium/100g[18]), fruits, vegetables, and commercial baby food. Foods thought to pose a choking risk were identified using lists from the literature[19 20] and public health organisations,[21 22] and advice from a paediatric Speech-Language Therapist. Each weighed diet record 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 version 13.1 (StataCorp, College Station, TX, 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 sex, ethnicity, maternal parity, feeding practices, and when solids were introduced) were compared using chi-squared tests and Fisher's exact test 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-squared test for proportions (Table 2). As current feeding practices were skewed, medians and interquartile ranges 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 (e.g., foods thought to pose a choking risk) or a type of milk (e.g., breast milk) on any day of the diet record was recorded and odds ratios with a chi-squared 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). As the data were mostly right-skewed, geometric means and 95% confidence intervals 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 percent difference between the groups along with 95% confidence intervals and p Values

The prevalence of inadequate zinc intakes was determined using the EAR cutpoint method.[23] 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.[23]

In Table 5, for descriptive purposes, the number of infants in each group who shared meals with their family (e.g., breakfast) was summed using the first day of the diet record. To compare consumption patterns between groups over all three days of diet record, population-averaged generalised estimating equations for binary data were used with an exchangeable working correlation. Coefficients were back transformed to give odds ratios and 95% confidence intervals. 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 age was 33.8 (3.9) years and most mothers (86%) were multiparous. The infants were 6.0 to 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**).

264 265 266 **Table 1 Demographic and early feeding characteristics of participants according to method of complementary feeding[1] (mean (SD) unless stated otherwise)**

	Traditional Spoon-Feeding (n = 26)	Baby-Led Weaning Partial (n=7)	Baby-Led Weaning Full (n = 18)	p Value[2]
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 (%)[3]				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)[3]	39.8 (1.4)	40.4 (1.2)	39.2 (1.1)	0.156
Maternal age at birth (years)[3]	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 breastfeeding (weeks)	14.4 (8.6)	17.1 (7.3)	22.2 (7.6)	**0.003**

Number exclusively breastfed to 6 months, n (%)[4]	0	1 (14%)	8 (44%)	**<0.001**
Age when complementary foods were introduced (weeks)	21.3 (2.8)	19.5 (3.5)	24.6 (2.0)	**<0.001**
Number introduced to complementary foods before 6 months, n (%)[4]	25 (96%)	6 (86%)	9 (50)%	**0.001**

[1] Method of complementary feeding parents reported using at the time the weighed diet record was completed.
[2] p Values were calculated for differences between the full BLW group and the TSF group using unpaired t-test for continuous variables and chi-squared test for categorical variables.
[3] Missing values: Ethnicity = 1 participant (full BLW); Gestational age = 2 participants (1 partial BLW, 1 full BLW).
[4] 6 months defined as 180 days (26 weeks).

Feeding behaviours

Women from the full BLW group exclusively breastfed their infants for approximately 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 breastfed their infant to 6 months, compared with none in the TSF group.

When complementary foods were first introduced, the TSF group were 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 were 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 themself) when 'solids' were introduced. As would be expected, the partial BLW group were intermediate between the TSF and full BLW groups.

The diet record data suggest that when infants were 6 to 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 to 12% of those in the TSF group ($p = 0.015$). Interestingly, 62% of parents following TSF reported that their infant was feeding themself some solids at least once a day (compared to 78% of those following full BLW; $p = 0.290$).

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

	Traditional Spoon-Feeding (n=26)	Baby-Led Weaning		p Value[1]
		Partial (n=7)	Full (n=18)	
Number of infants fed by an adult or self-fed *when 'solids' first introduced*, n (%)[2]				**<0.001**
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 (%)[2]				**<0.001**
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 (25^{th}, 75^{th} percentile)[3]				
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)	**0.001**
Percentage of foods fed by infant	18 (12, 47)	48 (42, 65)	77 (39, 98)	**0.001**
Percentage of foods fed as purées or finger foods *currently*, median (25^{th}, 75^{th} percentile)[3]				
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)	**0.002**
Percentage of foods as finger foods	33 (14, 53)	65 (27, 74)	77 (58, 100)	**<0.001**

[1] p Values were calculated for differences between the full BLW group and the TSF group using chi-squared test for proportions, and Wilcoxon-Mann-Whitney test for median percentage of foods.
[2] Data from the Feeding Questionnaire.
[3] Data from the weighed diet record collected when participants were between 6 and 8 months of age.

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 the TSF groups in the number of infants consuming foods thought to pose a choking risk (78% *vs* 58%, p=0.172), the confidence interval for the odds ratio was wide so we cannot rule out higher odds of offering these foods in the full BLW group (odds ratio, 95% CI: 2.57, 0.63-10.44).

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 breastfeeding (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).

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

	Traditional Spoon-Feeding (n = 26)	Baby-Led Weaning Partial (n=7)	Baby-Led Weaning Full (n = 18)	Odds ratio (95% CI)[1]	Mean difference (95% CI)	p Value[2]
Foods thought to pose a choking risk:						
Number that consumed foods thought to pose a choking risk[3,4]	15 (58%)	6 (86%)	14 (78%)	2.57 (0.63, 10.44)	-	0.172
Foods high in iron:						
Age iron-fortified infant cereal[5] introduced (weeks), mean (SD)[6]	21.7 (3.3)	22.3 (4.9)	26.8 (2.2)	-	5.1 (2.6, 7.5)	**<0.001**
Number not yet introduced to iron-fortified infant cereal[5,6]	3 (12%)	0 (0%)	8 (44%)	6.13 (1.17, 32.20)	-	**0.014**
Number that consumed iron-fortified infant cereal[3,5]	16 (62%)	5 (71%)	4 (22%)	0.18 (0.04, 0.80)	-	**0.011**
Age red meat[7] introduced (weeks), mean (SD)[6]	26.2 (3.5)	24.1 (2.3)	27.5 (2.4)	-	1.2 (-1.3, 3.8)	0.332
Number not yet introduced to red meat[6,7]	9 (35%)	1 (14%)	8 (44%)	1.51 (0.43, 5.29)[7]	-	0.515
Number that consumed red meat[3,7]	15 (58%)	6 (86%)	7 (39%)	0.47 (0.13, 1.64)[7]	-	0.225
Foods with sugar added:						
Number that consumed foods with sugar added[3,8]	11 (42%)	5 (71%)	7 (39%)	0.86 (0.25, 3.00)	-	0.823
Foods high in sodium:						
Number that consumed foods high in sodium[3,9]	20 (77%)	5 (71%)	14 (78%)	1.05 (0.25, 4.50)	-	0.948
Other foods:						
Number that consumed fruit[3]	25 (96%)	7 (100%)	17 (94%)	0.68 (0.04, 12.05)	-	0.791
Number that consumed vegetables[3]	25 (96%)	7 (100%)	16 (89%)	0.32 (0.03, 4.04)	-	0.353
Number that consumed commercial infant food[3,10]	15 (58%)	7 (100%)	8 (44%)	0.59 (0.17, 2.02)	-	0.393
Breast milk and infant formula:						
Number currently having breast milk (not infant formula)[6,11]	11 (42%)	4 (57%)	18 (100%)	-	-	**<0.001**
Number currently having infant formula (not breast milk)[6,11]	3 (12%)	0	0	-	-	0.258

Number currently having breast milk and infant formula[6,11]	12 (46%)	3 (43%)	0	-	-	**<0.001**

[1] Odds ratios compare those following full BLW with those following TSF.

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

[3] The number that consumed a food was determined using all three days of diet record (except for 7 participants who completed a one day diet record: 4 full BLW, 3 TSF).

[4] Foods thought to pose a choking risk were identified using lists from the literature[19 20] and from public health organisations.[21 22]

[5] 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).

[6] Data from the Feeding Questionnaire.

[7] Red meat was defined as beef and lamb.

[8] Foods that contained more that 4g/100g of added sugar or honey.

[9] Foods that contained more than 350mg sodium/100g.

[10] Commercial infant foods excluded iron-fortified infant cereals.

[11] Fisher's exact test used to calculate p Values.

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 B12, 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% confidence interval 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 (e.g., 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 had adequate intakes of protein, fat, vitamin C, and calcium because the mean intakes of these nutrients were higher than the AI. However, carbohydrate, iron, and vitamin B12 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.

377 **Table 4** **Mean nutrient intake from weighed diet records of infants according to method of complementary feeding[1] (geometric mean
378 (95%CI))**
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Nutrients	Nutrient Reference Value[2]	Traditional Spoon-Feeding (n = 26)[3]	Baby-Led Weaning Partial (n=7)	Baby-Led Weaning Full (n = 18)[3]	Mean % difference between groups[4] (95% CI)	p Value[5]
Energy (kJ)	Boys: 2800[6] Girls: 2500[6]	2897 (2718, 3088)	3073 (2682, 3521)	2800 (2518, 3115)	-3.7 (-13.5, 7.3)	0.500
Protein (g)	14g	17 (15, 19)	18 (14, 23)	15 (12, 17)	-14.4 (-28.3, 2.3)	0.087
Protein (% energy)	-	10 (9, 11)	10 (9, 11)	9 (8, 10)	-11.3 (-20.6, -1.0)	**0.033**
Total fat (g)	30g	33 (31, 35)	36 (33, 38)	36 (33, 39)	10.6 (0.4, 21.9)	**0.042**
Total fat (% energy)	-	42 (39, 44)	43 (39, 47)	48 (46, 50)	15.1 (6.9, 23.9)	**<0.001**
Saturated fat (g)	-	14 (13, 16)	16 (15, 17)	17 (15, 18)	15.6 (3.7, 28.8)	**0.009**
Saturated fat (% energy)	-	18 (17, 20)	19 (17, 22)	22 (21, 23)	20.0 (8.9, 32.2)	**<0.001**
Total carbohydrate (g)	95g	82 (75, 90)	86 (70, 105)	72 (64, 82)	-12.1 (23.8, 1.4)	0.076
Total carbohydrate (% energy)	-	48 (46, 50)	47 (44, 51)	44 (42, 46)	-8.9 (-14.0, -3.5)	**0.001**
Sugars (g)	-	46 (35, 61)	54 (36, 81)	62 (57, 68)	42.3 (-2.4, 107.3)	0.067
Dietary fibre (g)	-	3.6 (2.2, 5.8)	3.7 (2.1, 6.3)	2.0 (1.2, 3.4)	-50.7 (-73.3, -9.1)	**0.023**
Iron (mg)	7mg	3.6 (2.7, 4.9)	3.3 (1.3, 8.0)	1.6 (1.2, 2.1)	-59.0 (-72.5, -38.9)	**<0.001**
Zinc (mg)	2.5mg[7]	3.7 (3.3, 4.1)	4.0 (2.9, 5.4)	3.0 (2.6, 3.3)	-20.5 (-31.1, -7.4)	**0.001**
Vitamin C (mg)	30mg	66 (57, 76)	67 (53, 86)	46 (38, 55)	-29.6 (-40.0, -12.9)	**0.001**
Vitamin B12 (µg)	0.5µg	0.5 (0.3, 0.8)	0.6 (0.3, 1.1)	0.2 (0.1, 0.3)	-60.2 (-76.2, -33.5)	**<0.001**
Calcium (mg)	270mg	382 (352, 436)	437 (311, 616)	318 (290, 349)	-19.1 (-29.4, -7.3)	**0.002**

Sodium (mg)	170mg	235 (200, 275)	235 (171, 323)	232 (178, 302)	-1.5 (-24.3, 28.2)	0.911

[1] Method of complementary feeding parents reported using at the time the weighed diet record was completed.

[2] Nutrient Reference Values are the Adequate Intake (AI) from food and breast milk (or infant formula) for infants 7-12 months of age (unless stated otherwise).[24]

[3] Geometric mean and 95% confidence interval calculated using the mean of all available days of the diet record (7 participants completed a one day diet record: 4 full BLW, 3 TSF).

[4] Mean % difference between the BLW group and the TSF group calculated using the mean of all available days of the diet record (7 participants completed a one day diet record: 4 full BLW, 3 TSF).

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

[6] Estimated Energy Requirement (EER) for infants 7 months of age.

[7] Estimated Average Requirement (EAR).

Family meals

The relationship between the foods consumed at the three main meals (breakfast, lunch, evening meal) by the infant and those consumed by the family is reported in **Table 5**. Baby-Led Weaning 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 meal times. However, breakfast eaters in all three groups were likely to share breakfast with the family (83% of the infants consuming the meal). Compared to those following TSF, mothers following a full BLW approach were more likely to offer foods that were similar or the same (both ingredients and preparation) to those eaten by the rest of the family at lunch and the evening meal.

401 **Table 5** **Relationship between the foods eaten by the infant and the meals eaten by their family (i.e. 'family meals') according to**
402 **method of complementary feeding (n (%))[1,2]**
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	Traditional Spoon-Feeding (n = 26)	**Baby-Led Weaning**		**Odds ratio (95% CI)[3]**	**p Value[4]**
		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, 8.31)	0.344
Lunch	13/21 (50%)	1/4 (25%)	12/14 (86%)	10.29 (2.67, 39.65)	**0.001**
Evening meal	12/23 (52%)	5/6 (83%)	12/15 (80%)	4.75 (1.27, 17.75)	**0.020**
Number of infants with ingredients the same as family meal:[5]					
Breakfast	5/19 (19%)	0/6 (0%)	5/14 (36%)	1.60 (0.44, 5.78)	0.473
Lunch	1/20 (4%)	0/6 (0%)	6/14 (43%)	10.56 (2.51, 44.39)	**0.001**
Evening meal	4/22 (15%)	0/6 (0%)	9/15 (60%)	9.00 (2.64, 30.62)	**<0.001**
Number of infants with meal preparation the same as family meal:[5]					
Breakfast	2/19 (8%)	2/6 (33%)	6/13 (46%)	2.27 (0.59, 8.70)	0.232
Lunch	1/20 (4%)	0/3 (0%)	7/13 (54%)	10.31 (2.87, 37.09)	**<0.001**
Evening meal	3/22 (12%)	1/6 (17%)	8/14 (57%)	8.18 (2.66, 25.14)	**<0.001**

404 [1] Summary numbers presented are from first day of diet record.
405 [2] 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
406 infant milk was consumed at the meal, or the infant was not with the parent for the meal.
407 [3] Odds ratios compare those following full BLW with those following TSF and are calculated using all three days of diet record (except for 7
408 participants who completed a one day diet record: 4 full BLW, 3 TSF). They may not, therefore, reflect exactly the differences on the first day of
409 diet record
410 [4] p Values were calculated for odds ratios using population-averaged generalized estimating equations for binary data.

[5] The “same as” was defined as the participant answering 1=exactly the same, or 2=almost the same, on a 4-point scale (other values were 3=similar, 4=mostly different).

DISCUSSION

Our findings suggest that there may be several differences in foods, nutrients, and eating behaviours between children following Baby-Led Weaning and those following a more traditional spoon-feeding approach. In this small study, Baby-Led Weaning was associated with a number of health-related behaviours that would be expected to be beneficial: longer duration of exclusive breastfeeding, 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 B12 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 (a) the recruitment of groups of infants following BLW and TSF who were closely matched for age and sex and other demographic variables, and (b) 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 themself, 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 confidence intervals 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,[25] and more likely to be multiparous,[26] than typical New Zealand mothers. However, they were just as likely as New Zealand mothers to be of non-European ethnicity,[27] and the participants in the TSF group had a similar very low rate of exclusive breastfeeding to 6 months.[27] 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.[28-30] 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.[31 32] If the breast milk value we used overestimated breast milk volume, then the differences in nutrient intakes would be even greater than we have reported. However, it must be borne in mind that breast milk provided the majority of the energy intake in the BLW group (approximately 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.[10] 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.[10] This may be particularly relevant if low energy finger foods such as fruit and vegetables predominate in the diet.[33] While the current study did not measure infant body mass index, so growth faltering could not be identified, the reported energy intakes were similar for the two feeding styles, were comparable to those reported for New Zealand infants,[34] and met recommendations.[24]

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.[1 35 36] Iron fortified infant cereals are recommended as a suitable first food to help address this.[2 37] 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 (e.g., fruits and vegetables).[10] 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 weighed diet record. Although the adequacy of intakes below the AI cannot be determined,[23] the iron intakes of all three groups were considerably lower than the AI of 7mg[24] (3.6mg, 3.3mg and 1.6mg for TSF, partial BLW and full BLW respectively). Half of the infants (51%) consumed no fortified infant cereal over the three days of WDR, 45% consumed no red meat, and 22% consumed neither fortified cereal or 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, health care 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.[10 38 39] 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 minimize 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 (e.g., 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 (e.g., corn), and to ways in which foods thought to pose a choking risk can be modified to make them safer (e.g., 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 are more likely to be exposed to foods thought to pose a choking risk. Although there was no statistically significant difference between the groups, the confidence interval for the odds ratio 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.[10] While previous studies have reported that infants following BLW are more likely to eat with their family,[33 38 40] 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.[41] 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 to 45% of energy,[1] 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.[14] It is also possible that family meals do not provide sufficient zinc and vitamin B12 to meet the relatively high requirements of infants, particularly given the small portion sizes consumed by infants. There is considerable controversy about the Estimated Average Requirement (EAR) for zinc for infants,[42] but 28% of the infants in the full BLW group in this study appeared to have a zinc intake less than the EAR of 2.5mg for Australian and New Zealand infants.[24] It is not possible to state that the mean vitamin B12 intake in the BLW group of 0.2µg/day is inadequate even though it is below the AI,[23] however, intakes would need to more than triple by the age of 12 months to meet the EAR for that age (0.7µg/day[24]). 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 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”.[43] 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.[2] If confirmed, these results suggest that the current complementary feeding guidelines for infants, that 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 Baby-Led Weaning. Modifications would 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 B12.

In conclusion, the current study suggests that BLW may be associated with a number of health-related behaviours that would be expected to be beneficial: exclusive breastfeeding 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 B12 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 to BLW itself, in determining nutrient intakes in 6 to 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 B12; 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.

STATEMENTS

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Author contributions:

ALMH 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. ALMH is the guarantor.

Data sharing statement: Data are not available for sharing.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1, 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	5, 6, 7
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	N/A
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5-6
		(b) Give reasons for non-participation at each stage	5-6
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9, Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Tables
Outcome data	15*	Report numbers of outcome events or summary measures	Tables
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Tables 3-5
		(*b*) Report category boundaries when continuous variables were categorized	Tables
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	24
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	24-25
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	24-29
Generalisability	21	Discuss the generalisability (external validity) of the study results	24-25
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	30

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.