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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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3 **How different are Baby-Led Weaning and conventional complementary feeding?**
4 **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 0.5 μ g, $p = 0.018$), 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 bodies⁹ and some healthcare professionals¹⁰ 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

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3 following BLW and those following traditional spoon-feeding; and, second, to
4 describe the ‘family meals’ offered to infants following BLW and traditional spoon-
5 feeding.
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8 9 **METHODS**

10 **Study design**

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12 This community-based, cross-sectional study of 6-8 month old infants combined data
13 from three sources: two small cross-sectional studies (the “Infant Feeding Study” and
14 the “How to Measure Infant Feeding” study), and the control group of a randomised
15 controlled trial (the “Baby-Led Introduction to Solids” (BLISS) study).¹² All
16 participants completed a pretested demographic questionnaire and a feeding
17 questionnaire, and a 3-day or 1-day Weighed Diet Record (WDR) depending on the
18 study. Ethical approval for the studies was obtained from the University of Otago
19 Human Ethics Committee (Reference 13/270), and from the Lower South Regional
20 Ethics Committee (Reference LRS/11/09/037). All adult participants provided written
21 informed consent.
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31 **Participants**

32 As many eligible participants as possible were recruited from the following three
33 studies (with BLW and TSF infants being recruited from each study):
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- 35 1) “Infant Feeding Study” (December 2013 to June 2014), Dunedin and Auckland
36 (New Zealand) – Advertisements in local newspapers and on social media sites,
37 posters placed in a range of community areas, word of mouth in local parent
38 support networks (29 mother-child pairs expressed interest of whom 19 were
39 eligible for this study);
- 40 2) “How to Measure Infant Feeding” study (April 2013), Dunedin (New Zealand) -
41 Advertisements on social media sites, posters placed in a range of community
42 areas, word of mouth in local parent support networks (11 participants were
43 recruited of whom 7 were eligible for this study);
- 44 3) BLISS Study (September 2013 to June 2014) Dunedin (New Zealand)¹² – All
45 women booking into the only birthing facility in Dunedin, the Queen Mary
46 Maternity Unit, Dunedin Hospital, were invited to participate in the BLISS study.
47 All those who were eligible for, and had consented to participate in, the BLISS
48 study; had been randomised to the control group; and had completed the WDR
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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 questions¹³), birth weight, and gestational age at birth; and maternal date of birth, and parity. The Feeding Questionnaire collected data on: duration of exclusive breastfeeding², 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

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3 All three studies used the same WDR which was collected on three random non-
4 consecutive days including two weekdays and one weekend day over a month (the
5 “Infant Feeding Study”, and the BLISS study: n=44) or on one day (the “How to
6 Measure Infant Feeding” Study: n=7). The diet record had three key components: (a)
7 a record of the foods eaten - time of day, type and brand of food or drink, preparation
8 method, weight of food or drink, consistency of food or drink (puréed, mashed, diced,
9 whole), who fed the child (parent, child, both), and total weight and estimated
10 proportions of any leftover food or drink; (b) a description of any recipes used - raw
11 amounts of ingredients, cooking method, and proportion of the total recipe fed to the
12 child; and (c) an “end of day questionnaire” which determined, for each meal and
13 snack, whether the child ate with at least one adult, and whether the meal ingredients
14 and preparation were the same or different to the family meal. Resources were also
15 provided to assist with estimating food portions when outside the home or in early
16 childhood education.
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28 Parents were given detailed oral and written instructions on how to complete the
29 WDR, and were provided with a set of electronic scales (Salter Electronic Model
30 1017, Kent, United Kingdom), accurate to within \pm one gram.
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34 All diet records were entered into the dietary analysis software programme ‘Kai-
35 culator’ version 1.11v (University of Otago, Dunedin, New Zealand). Kai-culator uses
36 the New Zealand food composition database, FOODfiles;¹⁴ nutrient data for
37 commonly consumed recipes collated in the 2008/09 New Zealand Adult Nutrition
38 Survey;¹⁵ and nutrient data for commercial infant foods calculated by the research
39 team.¹⁶ Breast milk intake was assumed to be 750g/day based on a quadratic curve
40 fitted to the breast milk volumes reported by Dewey and colleagues¹⁷ with the amount
41 of infant formula consumed subtracted from this total if infants were mixed fed. After
42 the diet records had been entered in Kai-culator, a Registered Dietitian blinded to the
43 BLW or TSF status of the infant checked each diet record, and made corrections when
44 required.
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54 Diet record data were used to determine nutrient intake, the percentage of foods
55 currently adult or self-fed, the percentage of foods currently fed as purées or finger
56 foods, and whether any of the following foods were offered: foods posing a choking
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3 risk (described below), iron-fortified infant cereal, red meat (defined as beef or lamb),
4 foods with sugar added (i.e. more than 4g/100g of added sugar or honey¹⁸), foods that
5 were high in sodium (i.e. more than 350mg sodium/100g¹⁸), fruits, vegetables, and
6 commercial baby food. Foods posing a choking risk were identified using lists from
7 the literature^{19 20} and public health organisations,^{21 22} and advice from a paediatric
8 Speech-Language Therapist. Each weighed diet record day was reviewed against this
9 list to determine which foods posing a choking risk were offered to infants.
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15 16 17 **Statistical Analysis**

18 The data were analysed using Stata version 13.1 (StataCorp, College Station, TX,
19 USA). A two-sided $p < 0.05$ was considered to indicate statistical significance.
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23 Participant characteristics were examined for differences between the two groups.
24 Continuous variables (infant age, birth weight, gestational age, and maternal age at
25 birth) were compared using unpaired, two-tailed t-tests. Categorical variables (infant
26 sex, ethnicity, maternal parity, feeding practices, and when solids were introduced)
27 were compared using chi-squared tests.
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33 As data for current feeding practices were skewed, medians and interquartile ranges
34 for each group were calculated and a Wilcoxon-Mann-Whitney test was used to
35 determine if the groups differed in these behaviours.
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40 For descriptive purposes, the number of infants in each group who consumed a food
41 type of interest (e.g., foods posing a choking risk), a type of milk (e.g., breast milk),
42 or shared meals with their family (e.g., breakfast) was summed using the first day of
43 the diet record (this was because participants in all three studies had provided at least
44 one day of diet record). To compare consumption patterns between groups over all
45 three days of diet record, population-averaged generalised estimating equations for
46 binary data were used with an exchangeable working correlation. Coefficients were
47 back transformed to give odds ratios and 95% confidence intervals. This same
48 technique was used to compare the number of infants who had the same or nearly the
49 same meal ingredients and preparation as the family at mealtimes. An unstructured
50 working correlation was used for these analyses.
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3 Mean nutrient intake was calculated using the first day of the diet record (as
4 participants in the “How to Measure Baby-Led Weaning” study only completed one
5 day of diet record). As the data were mostly right-skewed, geometric means and 95%
6 confidence intervals are presented. To determine the mean difference between groups
7 in nutrient intake, all days of the diet record were used in a mixed effects model with
8 group as a fixed effect and participant identification number as a random effect. Log-
9 transformed nutrient amounts were used as the outcome variable and regression
10 coefficients back-transformed and presented as mean percent difference between the
11 groups along with 95% confidence intervals and p Values. The prevalence of
12 inadequate zinc intakes was determined using the EAR cutpoint method.²³ Whether
13 the group was likely to have adequate intakes of the other nutrients was determined
14 by comparing the group mean intake to the Adequate Intake (AI). The AI cannot be
15 used to calculate the prevalence of inadequate nutrient intake, however when groups
16 have a mean intake at or above the AI it can generally be assumed that there is a low
17 prevalence of inadequate nutrient intake for that population group.²³
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29 RESULTS

30 Participant characteristics

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32 Of the 80 families who were identified as potentially eligible to participate in the
33 study, 13 were excluded because: their child was born before 34 weeks gestation (n =
34 2), their child was not aged between 6 and 8 months (n = 8), or the participant could
35 not be contacted (n = 3); and 16 declined or were not required for age- and sex-
36 matching. The final sample consisted of 26 infants reported to be following TSF and
37 25 reported to be following BLW either in part (n=7) or fully (n=18) at the time the
38 diet record was collected. Mean (SD) maternal age was 33.8 (3.9) years and most
39 mothers (86%) were multiparous. The infants were 6.0 to 8.8 months of age and more
40 than half were New Zealand European (74%). There were no significant differences
41 between the groups in any of the demographic variables collected (**Table 1**).
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Table 1 Demographic and early feeding characteristics of participants according to method of complementary feeding¹ (mean (SD) unless stated otherwise)

	Traditional Spoon-Feeding (n = 26)	Baby-Led Weaning (n = 25)	p Value²
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

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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).

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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 themselves) 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 themselves 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 <i>when 'solids' first introduced</i> , 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 <i>when 'solids' first introduced</i> , 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 <i>currently</i> , 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 <i>currently</i> , 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
<i>Foods posing a choking risk:</i>					
Number consuming foods posing a choking risk ^{3,4}	10 (38%)	13 (52%)	1.89 (0.85, 4.23)	-	0.120
<i>Foods high in iron:</i>					
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
<i>Foods with sugar added:</i>					
Number consuming foods with sugar added ^{3,8}	9 (35)	10 (40)	1.80 (0.67, 4.83)	-	0.244
<i>Foods high in sodium:</i>					
Number consuming foods high in sodium ^{3,9}	14 (54)	17 (68)	1.60 (0.61, 4.17)	-	0.338
<i>Other foods:</i>					
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
<i>Breast milk and infant formula:</i>					
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 than 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 feeding¹ (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

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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 Value³
<i>Number of infants eating their meal with the family:</i>				
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
<i>Number of infants with ingredients the same as family meal:⁴</i>				
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
<i>Number of infants with meal preparation the same as family meal:⁴</i>				
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 themselves, and the form the food was in, for each food item in the diet record allowed us to determine the true extent of baby-led feeding in families who consider themselves to be following BLW or TSF. The results are consistent with our earlier survey in New Zealand parents²⁵ 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

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3 parents' categorisation enabled us to determine the dietary characteristics of infants
4 whose parents would describe them as following BLW.
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8 Three major concerns have been raised regarding the use of a baby-led approach to
9 complementary feeding, namely whether the infant will consume sufficient energy
10 and iron, and whether they will be at increased risk of choking.¹⁰ It has been proposed
11 that infants may not have the motor skills or motivation to feed themselves enough
12 food to meet their energy needs for growth if they are following BLW.¹⁰ This may be
13 particularly relevant if low energy finger foods such as fruit and vegetables
14 predominate in the diet.²⁶ While the current study did not measure infant body mass
15 index, so growth faltering could not be identified, the reported energy intakes were
16 similar for the two feeding styles, were comparable to those reported for New Zealand
17 infants,²⁷ and met recommendations.²⁴
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26 In contrast, iron intakes were very different. Achieving adequate iron intake is
27 problematic for infants worldwide because by 6 months of age substantial amounts of
28 iron are needed from complementary foods.^{1 28 29} Iron fortified infant cereals are
29 recommended as a suitable first food to help address this.^{2 30} It has been proposed that
30 the BLW infant may be at particular risk of iron deficiency because the texture of
31 infant cereal makes it difficult for infants to self-feed, and because foods that are
32 easier to grasp tend to be naturally low in iron (e.g., fruits and vegetables).¹⁰ Our
33 results would suggest that these concerns may have some value given that infants
34 following BLW had approximately half the daily dietary iron intake of infants
35 following TSF. The BLW group introduced fortified infant cereal 3 weeks later and
36 were considerably less likely to consume fortified infant cereal during the weighed
37 diet record. Although the adequacy of intakes below the AI cannot be determined,²³
38 the iron intakes of both groups were considerably lower than the AI of 7mg²⁴ (3.6mg
39 and 1.9mg for TSF and BLW respectively). Half of the infants (51%) consumed no
40 fortified infant cereal over the three days of WDR, 45% consumed no red meat, and
41 22% consumed neither fortified cereal or red meat, suggesting the need for health care
42 professionals to emphasise the importance of including iron rich food sources in
43 infants' diets in the complementary feeding period. This applies particularly to those
44 following BLW, but also to those following traditional spoon-feeding. It is possible
45 that the choice of infant milk may also have contributed to these differences in iron
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3 intake - the infants in the BLW group were less likely to be having infant formula
4 (n=3; 12%) than those in the TSF group (n=11; 42%), and infant formulas have a
5 higher iron concentration than breast milk.
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10 It has been suggested that infants following BLW may be at increased risk of choking
11 because they are feeding themselves whole foods during the early stages of
12 complementary feeding, while they are still learning to chew and swallow.^{10 31 32}

13 Although our sample size was too small to investigate actual choking incidents, we
14 observed that a worryingly high number of parents in both groups were offering foods
15 posing a choking risk. Further education for parents on how to minimize the risk of
16 choking is therefore warranted - no matter what approach to complementary feeding
17 is used. This advice needs to refer not just to types of food that are commonly
18 considered to pose a choking risk (e.g., one parent offered their infant whole nuts), but
19 also to foods that do not pose a risk to older children and adults so may form part of
20 the family meal (e.g., corn), and to ways in which foods posing a choking risk can be
21 modified to make them safer (e.g., chicken is safer if it is offered in pieces that can be
22 chewed on but not put in the mouth whole, or if it is chopped finely).
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33 Concern has been expressed that infant self-feeding of family meals is only of benefit
34 if the family meals themselves are nutritionally adequate.¹⁰ While previous studies
35 have reported that infants following BLW are more likely to eat with their family,^{26 31}
36 we extend these findings to show that the foods eaten also tend to more closely
37 resemble those eaten by the family. Thus, it appears that BLW infants do follow a
38 more 'adult' food pattern. This may be an issue given that exposure to a variety of
39 'unhealthy' family foods might lead to negative impacts on eating behaviours later in
40 life.³³ Certainly, in our study, total and saturated fat intakes were significantly higher
41 for those following BLW. It is recommended that total fat intakes should be 30 to
42 45% of energy,¹ and the mean intake of those following BLW was slightly above this
43 (46% of energy). It is not clear, however, whether the saturated fat intakes are of
44 concern. Both the TSF (18% energy) and BLW (21% energy) saturated fat intakes are
45 lower than mature breast milk which has 25% energy from saturated fat.¹⁴ It is also
46 possible that family meals do not provide sufficient zinc and vitamin B12 to meet the
47 relatively high requirements of infants. There is considerable controversy about the
48 Estimated Average Requirement (EAR) for zinc for infants,³⁴ and although 20% of
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3 the infants in the BLW group in this study had a zinc intake less than the EAR of
4 2.5mg for Australian and New Zealand infants,²⁴ 56% had an intake less than the
5 EAR set by IZiNCG of 3.0mg/day.³⁵ A prevalence of 25% or higher is considered to
6 indicate an elevated risk of zinc deficiency.³⁵ It is not possible to state that the mean
7 vitamin B12 intake in the BLW group of 0.3µg/day is inadequate even though it is
8 below the AI,²³ however, intakes would need to more than double by the age of 12
9 months to meet the EAR for that age (0.7µg/day²⁴). As our study was cross-sectional
10 we cannot determine whether these differences would still be apparent at older ages,
11 given that by 12 months of age, all children should be eating predominantly family
12 foods.² However, we suggest that advice on BLW should stress the importance of the
13 family adopting healthy eating behaviours with a variety of nutrient dense foods that
14 both the family and the infant can enjoy.
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25 In conclusion, while BLW appears to be associated with a number of health-related
26 behaviours that would be expected to be beneficial: exclusive breastfeeding to 6
27 months, waiting until 6 months to introduce solids, and greater involvement in family
28 meals, further research is required to determine whether BLW infants may be at
29 higher risk of iron and vitamin B12 deficiencies. The extent to which differences in
30 total and saturated fat intake remain at 12 months also needs to be determined.
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33 Although BLW children did not appear to be offered more foods posing a choking
34 risk, it is of concern that 45% of the infants had been offered a food posing a choking
35 risk on the first day of the diet record. Given the widespread interest and debate
36 regarding the suitability of BLW as an alternative infant feeding method, further
37 research in a larger, ideally representative, sample of children, preferably with
38 measurements of growth, biochemical nutrient status, and rate of choking, is required
39 to confirm these findings. In the meantime, it is important that families of infants
40 following BLW are encouraged to include a variety of nutrient dense foods in family
41 meals, and to offer their infants iron rich foods (such as iron-fortified infant cereal and
42 red meat); and that all parents, no matter what approach they take to complementary
43 feeding, are given advice on how to minimise their infant's exposure to foods that
44 pose a choking risk.
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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 (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	5-6 5-6 -
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest	9, Table 1 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 (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Tables 3-5 Tables 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.

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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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3 1 **How different are Baby-Led Weaning and conventional complementary feeding?**

4 2 **A cross-sectional study of 6 to 8 month old infants**

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8 4 Brittany J Morison¹, Rachael W Taylor², Jillian J Haszard¹, Claire J Schramm¹, Liz
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24 ABSTRACT

25 **Objectives:** To compare the food, nutrient, and ‘family meal’ intakes of infants
26 following Baby-Led Weaning (BLW) with those of infants following a more
27 Traditional Spoon-Feeding (TSF) approach to complementary feeding.

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

31 **Methods:** Parents completed a questionnaire, and Weighed Diet Records (WDR) on
32 1-3 non-consecutive days, to investigate food and nutrient intakes, the extent to which
33 infants were self- or parent-fed, and infant involvement in ‘family meals’.

34 **Results:** BLW infants were more likely than TSF infants to have fed themselves all or
35 most of their food when starting complementary feeding (67% vs 8%, $p<0.001$).

36 Although there was no statistically significant difference in the large number of
37 infants consuming foods posing a choking risk during the WDR (78% vs 58%,
38 $p=0.172$), the confidence interval was wide so we cannot rule out increased odds with
39 BLW (odds ratio, 95% CI: 2.57, 0.63-10.44). No difference was observed in energy
40 intake, but BLW infants consumed more total (48% vs 42% energy, $p<0.001$) and
41 saturated (22% vs 18% energy, $p<0.001$) fat, and less iron (1.6 vs 3.6mg, $p<0.001$),
42 zinc (3.0 vs 3.7mg, $p=0.001$) and vitamin B12 (0.2 vs 0.5 μ g, $p<0.001$), than TSF
43 infants. BLW infants were more likely to eat with their family at lunch and evening
44 meal (both $p\leq 0.020$).

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

51 **ARTICLE SUMMARY**52 **Strengths and limitations of this study:**

- 53 • First study to compare the dietary intake of children following Baby-Led Weaning
54 (BLW) with that of infants following a more Traditional Spoon-Feeding (TSF)
55 approach to complementary feeding.
- 56 • Weighed diet records with careful recording of foods offered and foods eaten.
- 57 • Age- and sex-matching of children following BLW and those following TSF.
- 58 • Small sample size.
- 59 • Participants defined themselves as following BLW or TSF.

60 INTRODUCTION

61 Traditionally, parents have been advised to spoon-feed their infant puréed foods from
62 ‘around’ 6 months of age, progressing to mashed, then chopped foods so that they are
63 eating family foods by 12 months of age.^{1,2} However, anecdotal reports suggest that
64 an alternative method of complementary feeding, known as Baby-Led Weaning
65 (BLW), is becoming popular in New Zealand, the UK and Canada. In BLW, infants
66 are not spoon-fed at all, but instead feed themselves whole pieces of food, preferably
67 from the family meal, from the onset of complementary feeding.^{3,4}

68
69 Proponents of this baby-led approach suggest that it allows the infant to be in control
70 of how much food they eat; as they are in the first few months of life if they are
71 breastfed. It is proposed that this control over their own feeding may allow the infant
72 who is following BLW to respond better to hunger and satiety cues than a baby who is
73 spoon-fed by someone else. It has also been pointed out that although the age at which
74 it is recommended that parents start feeding their infant ‘solids’ has increased from 4
75 months to 6 months of age,^{2,5,6} most countries have not changed their advice on *how*
76 to introduce foods.^{3,7} The exception to this is the UK, where recent NHS advice is that
77 first foods can include soft vegetables and fruit offered as finger food or mashed.⁸

78
79 Despite increasing enthusiasm about BLW on the internet (8,960,000 hits in May
80 2015) and in the social media, health governing bodies⁹ and some healthcare
81 professionals¹⁰ have expressed considerable concern that infants following a baby-led
82 approach to infant feeding may be at an increased risk of choking and inadequate iron
83 and energy intakes. Therefore, it is important to determine what infants following
84 BLW are actually eating. The only study to date that has collected dietary information
85 about BLW was a pilot study in just 11 families that focused on parental diet.
86 Although some of the foods eaten by infants were reported, infant nutrient intakes
87 were not analysed, and there was no comparison group of families following
88 traditional spoon-feeding.¹¹

89
90 Therefore, the aims of the current study were: first, to determine whether there are
91 differences in nutrient intakes and food intakes (particularly foods posing a choking
92 risk, foods high in iron, and foods containing added sugars or salt) between infants
93 following BLW and those following traditional spoon-feeding; and, second, to

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3 94 describe the ‘family meals’ offered to infants following BLW and traditional spoon-
4 95 feeding.
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8 97 **METHODS**

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10 98 **Study design**

11 99 This community-based, cross-sectional study of 6-8 month old infants combined data
12 from three sources: two small cross-sectional studies (the “Infant Feeding Study” and
13 100 the “How to Measure Infant Feeding” study), and the control group of a randomised
14 101 controlled trial (the “Baby-Led Introduction to Solids” (BLISS) study).¹² All
15 102 participants completed a pretested demographic questionnaire and a feeding
16 103 questionnaire, and a 3-day or 1-day Weighed Diet Record (WDR) depending on the
17 104 study. Ethical approval for the studies was obtained from the University of Otago
18 105 Human Ethics Committee (Reference 13/270), and from the Lower South Regional
19 106 Ethics Committee (Reference LRS/11/09/037). All adult participants provided written
20 107 informed consent.
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25 110 **Participants**

26 111 As many eligible participants as possible were recruited from the following three
27 112 studies (with BLW and TSF infants being recruited from each study):

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31 113 1) “Infant Feeding Study” (December 2013 to June 2014), Dunedin and Auckland
32 114 (New Zealand) – Advertisements in local newspapers and on social media sites,
33 115 posters placed in a range of community areas, word of mouth in local parent
34 116 support networks (29 mother-child pairs expressed interest of whom 19 were
35 117 eligible for this study);
36 118 2) “How to Measure Infant Feeding” study (April 2013), Dunedin (New Zealand) -
37 119 Advertisements on social media sites, posters placed in a range of community
38 120 areas, word of mouth in local parent support networks (11 participants were
39 121 recruited of whom 7 were eligible for this study);
40 122 3) BLISS Study (September 2013 to June 2014) Dunedin (New Zealand)¹² – All
41 123 women booking into the only birthing facility in Dunedin, the Queen Mary
42 124 Maternity Unit, Dunedin Hospital, were invited to participate in the BLISS study
43 125 (23% of those eligible volunteered). All those who were eligible for, and had
44 126 consented to participate in, the BLISS study; had been randomised to the control
45 127 group; and had completed the WDR administered at 7 months of age at the time
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3 128 we were recruiting for the current study were invited to contribute their data (40
4 129 participants were approached, of whom 25 consented to contribute their data and
5
6 130 met the age- and sex-matching criteria (see below)).
7

8 131 Inclusion criteria for the current study were: infant 6 to 8 months of age when the
9
10 132 WDR was completed, mother able to communicate in English or Te Reo Māori (the
11 133 language of the indigenous people of New Zealand) and mother 16 years of age or
12
13 134 older. Exclusion criteria were: infant born before 37 weeks gestation; or presence of a
14 135 congenital abnormality, physical condition, or intellectual disability likely to affect
15
16 136 the infant's feeding or growth. Infant participants were matched to within plus or
17
18 137 minus one week of age, and wherever possible for sex. BLISS study participants were
19
20 138 used as a pool of prospective matches with the first match that was identified being
21
22 139 recruited into the current study.
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24 140

25 141 **Definition of Baby-Led Weaning and traditional spoon-feeding**

26 142 Mothers were asked to state "... what approach to infant feeding you were using
27
28 143 around the time you completed the food diary: "Spoon-feeding" or "Baby-Led
29
30 144 Weaning" or "Other"." Parents who reported following BLW were assigned to the
31
32 145 full BLW group, whereas those who reported following a mixture of spoon-feeding
33
34 146 and BLW were assigned to the partial BLW group. Parents who were spoon-feeding
35
36 147 their child (without reporting BLW) were assigned to the Traditional Spoon-Feeding
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38 148 (TSF) group.
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41 150 **Questionnaires**

42 151 The same questions were asked of all participants. The Demographic Questionnaire
43
44 152 collected information on: infant date of birth, sex, ethnicity (New Zealand Census
45
46 153 questions¹³), birth weight, and gestational age at birth; and maternal date of birth, and
47
48 154 parity. The Feeding Questionnaire collected data on: duration of exclusive
49
50 155 breastfeeding², age when complementary foods were introduced, extent of infant self-
51
52 156 feeding *vs.* parent-feeding (and puréed *vs.* finger foods) on the first complementary
53
54 157 feeding occasion, ages when iron-fortified infant cereal and red meat were first
55
56 158 introduced, and whether breast milk or infant formula was currently being consumed.
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59 160 **Dietary assessment**

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3 161 All three studies used the same WDR which was collected on three random non-
4 162 consecutive days including two weekdays and one weekend day over a month (the
5 163 “Infant Feeding Study”, and the BLISS study: n=44) or on one day (the “How to
6 164 Measure Infant Feeding” Study: n=7). The diet record had three key components: (a)
7 165 a record of the foods eaten - time of day, type and brand of food or drink, preparation
8 166 method, weight of food or drink, consistency of food or drink (puréed, mashed, diced,
9 167 whole), who fed the child (parent, child, both), and total weight and estimated
10 168 proportions of any leftover food or drink; (b) a description of any recipes used - raw
11 169 amounts of ingredients, cooking method, and proportion of the total recipe fed to the
12 170 child; and (c) an “end of day questionnaire” which determined, for each meal and
13 171 snack, whether the child ate with at least one adult, and whether the meal ingredients
14 172 and preparation were the same or different to the family meal. Resources were also
15 173 provided to assist with estimating food portions when outside the home or in early
16 174 childhood education.
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28 176 Parents were given detailed oral and written instructions on how to complete the
29 177 WDR, and were provided with a set of electronic scales (Salter Electronic Model
30 178 1017, Kent, United Kingdom), accurate to within \pm one gram.
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34 180 All diet records were entered into the dietary analysis software programme ‘Kai-
35 181 culator’ version 1.11v (University of Otago, Dunedin, New Zealand). Kai-culator uses
36 182 the New Zealand food composition database, FOODfiles;¹⁴ nutrient data for
37 183 commonly consumed recipes collated in the 2008/09 New Zealand Adult Nutrition
38 184 Survey;¹⁵ and nutrient data for commercial infant foods calculated by the research
39 185 team.¹⁶ Breast milk intake was assumed to be 750g/day based on a quadratic curve
40 186 fitted to the breast milk volumes reported by Dewey and colleagues¹⁷ with the amount
41 187 of infant formula consumed subtracted from this total if infants were mixed fed. After
42 188 the diet records had been entered in Kai-culator, a Registered Dietitian blinded to the
43 189 BLW or TSF status of the infant checked each diet record, and made corrections when
44 190 required.
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54 192 Diet record data were used to determine nutrient intake, the percentage of foods
55 193 currently adult or self-fed, the percentage of foods currently fed as purées or finger
56 194 foods, and whether any of the following foods were offered: foods posing a choking
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3 195 risk (described below), iron-fortified infant cereal, red meat (defined as beef or lamb),
4 196 foods with sugar added (i.e. more than 4g/100g of added sugar or honey¹⁸), foods that
5 197 were high in sodium (i.e. more than 350mg sodium/100g¹⁸), fruits, vegetables, and
6 198 commercial baby food. Foods posing a choking risk were identified using lists from
7 199 the literature^{19 20} and public health organisations,^{21 22} and advice from a paediatric
8 200 Speech-Language Therapist. Each weighed diet record day was reviewed against this
9 201 list to determine which foods posing a choking risk were offered to infants.
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16 203 **Statistical Analysis**

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18 204 The data were analysed using Stata version 13.1 (StataCorp, College Station, TX,
19 205 USA). A two-sided $p < 0.05$ was considered to indicate statistical significance.
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22

23 207 Participant characteristics were examined for differences between the full BLW and
24 208 TSF groups (Table 1). Continuous variables (infant age, birth weight, gestational age,
25 209 and maternal age at birth) were compared using unpaired, two-tailed t-tests.

26 210 Categorical variables (infant sex, ethnicity, maternal parity, feeding practices, and
27 211 when solids were introduced) were compared using chi-squared tests and Fisher's
28 212 exact test where cell numbers were low (<5).
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33 213
34 214 Differences in BLW associated behaviours between the full BLW and TSF groups
35 215 when "solids" were first introduced were determined using chi-squared test for
36 216 proportions (Table 2). As current feeding practices were skewed, medians and
37 217 interquartile ranges for each group were calculated and a Wilcoxon-Mann-Whitney
38 218 test was used to determine if the groups differed.
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45 220 The number of infants in each group who consumed a food type of interest (e.g.,
46 221 foods posing a choking risk) or a type of milk (e.g., breast milk) on any day of the diet
47 222 record was recorded and odds ratios with a chi-squared test comparing the two groups
48 223 were calculated (Table 3).
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51 224
52 225 Mean nutrient intake was calculated using the mean of all available days of the diet
53 226 record for each participant (Table 4). As the data were mostly right-skewed,
54 227 geometric means and 95% confidence intervals are presented. To determine the mean
55 228 difference between groups in nutrient intake, all days of the diet record were used in a
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229 mixed effects model with group as a fixed effect and participant identification number
230 as a random effect. Log-transformed nutrient amounts were used as the outcome
231 variable and regression coefficients back-transformed and presented as mean percent
232 difference between the groups along with 95% confidence intervals and p Values

233

234 The prevalence of inadequate zinc intakes was determined using the EAR cutpoint
235 method.²³ Whether the group was likely to have adequate intakes of the other
236 nutrients was determined by comparing the group mean intake to the Adequate Intake
237 (AI). The AI cannot be used to calculate the prevalence of inadequate nutrient intake,
238 however when groups have a mean intake at or above the AI it can generally be
239 assumed that there is a low prevalence of inadequate nutrient intake for that
240 population group.²³

241

242 In Table 5, for descriptive purposes, the number of infants in each group who shared
243 meals with their family (e.g., breakfast) was summed using the first day of the diet
244 record. To compare consumption patterns between groups over all three days of diet
245 record, population-averaged generalised estimating equations for binary data were
246 used with an exchangeable working correlation. Coefficients were back transformed
247 to give odds ratios and 95% confidence intervals. This same technique was used to
248 compare the number of infants who had the same or nearly the same meal ingredients
249 and preparation as the family at mealtimes. An unstructured working correlation was
250 used for these analyses.

251

252 RESULTS

253 Participant characteristics

254 Of the 80 families who were identified as potentially eligible to participate in the
255 study, 13 were excluded because: their child was born before 34 weeks gestation (n =
256 2), their child was not aged between 6 and 8 months (n = 8), or the participant could
257 not be contacted (n = 3); and 16 declined or were not required for age- and sex-
258 matching. The final sample consisted of 26 infants reported to be following TSF and
259 25 reported to be following BLW either in part (n=7) or fully (n=18) at the time the
260 diet record was collected. Mean (SD) maternal age was 33.8 (3.9) years and most
261 mothers (86%) were multiparous. The infants were 6.0 to 8.8 months of age and more

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3 262 than half were New Zealand European (74%). There were no significant differences
4
5 263 between the groups in any of the demographic variables collected (**Table 1**).
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For peer review only

264 **Table 1** Demographic and early feeding characteristics of participants according to method of complementary feeding¹ (mean (SD))
 265 unless stated otherwise)
 266

	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

12

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

268 ²p 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.

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

271 ⁴6 months defined as 180 days (26 weeks).

272 Feeding behaviours

273 Women from the full BLW group exclusively breastfed their infants for
274 approximately 8 weeks longer ($p = 0.003$), and introduced solid foods 3 weeks later (p
275 < 0.001), than women following TSF (Table 1). In fact, 44% of the full BLW group
276 exclusively breastfed their infant to 6 months, compared with none in the TSF group.

277

278 When complementary foods were first introduced, the TSF group were more likely (p
279 < 0.001) to have puréed or mashed food (92% vs. 22%) and to be fed by an adult
280 (88% vs. 17%) than the full BLW group (Table 2). Although the full BLW group
281 were more likely to have finger foods as first foods (72% vs. 4%) which the infant
282 self-fed (67% vs. 8%) than the TSF group, almost a third of participants in the full
283 BLW group gave their infant puréed or mashed food (28%) and a third fed their infant
284 (rather than the infant feeding themselves) when 'solids' were introduced. As would be
285 expected, the partial BLW group were intermediate between the TSF and full BLW
286 groups.

287

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

292 Considerable differences were observed in the form in which foods were offered to
293 the infants: while TSF babies consumed many finger foods (a median of 33% of their
294 food intake was finger foods), this proportion was considerably lower than that
295 observed in the full BLW group (77%; $p < 0.001$). At the time the study was
296 conducted, parents reported that 50% of the full BLW infants were feeding
297 themselves all their food, compared to 12% of those in the TSF group ($p = 0.015$).
298 Interestingly, 62% of parents following TSF reported that their infant was feeding
299 themselves some solids at least once a day (compared to 78% of those following full
300 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**
 303

	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 <i>when 'solids' first introduced</i> , 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 <i>when 'solids' first introduced</i> , 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 <i>currently</i> , 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 <i>currently</i> , 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.

308 Foods

309 In total, two-thirds (69%) of participants offered foods posing a choking risk to their
310 child, almost half (45%) offered sweetened foods, and three-quarters (76%) offered
311 foods high in sodium on at least one occasion during the WDR; this did not differ
312 between groups (**Table 3**). However, although there was no statistically significant
313 difference between the full BLW and the TSF groups in the number of infants
314 consuming foods posing a choking risk (78% vs 58%, $p=0.172$), the confidence
315 interval for the odds ratio was wide and included values consistent with an important
316 potential increase in the odds of offering these foods (odds ratio, 95% CI: 2.57, 0.63-
317 10.44).

318
319 There were no differences in the number consuming fruit (96%), vegetables (94%),
320 and, interestingly, the number using commercial baby foods (59%). However, infants
321 in the full BLW group were introduced to iron-fortified infant cereal on average 5.1
322 weeks later than those following TSF, and had only one fifth the odds of consuming
323 iron-fortified infant cereal during the WDR. There were no differences in the age
324 when red meat was introduced, the number not yet introduced to red meat (35%
325 overall), or the number who consumed it during the diet record.

326
327 Considerable differences were observed in breast milk and infant formula
328 consumption between the full BLW and TSF groups, with significantly more
329 participants in the full BLW group currently breastfeeding (and not offering infant
330 formula), than in the TSF group (100% vs. 42%; $p < 0.001$). More participants in the
331 TSF group than in the full BLW group were having both breast milk and infant
332 formula (12% vs. 0%, $p < 0.001$).

333
334 For those following full BLW, the most commonly consumed food types posing a
335 choking risk were: raw vegetables, raw apple, and dried fruit (which were offered on
336 10, 3, and 3 days respectively of the 46 days recorded by participants in their WDRs);
337 whereas for those following TSF, the most commonly consumed foods posing a risk
338 were: rusks, small pieces of meat (other than sausages and similar processed meats, or
339 battered fish), crackers, and corn kernels (which were offered on 10, 5, 4, and 4 days
340 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		Odds ratio (95% CI) ¹	Mean difference (95% CI)	p Value ²
		Partial (n=7)	Full (n = 18)			
<i>Foods posing a choking risk:</i>						
Number that consumed foods posing a choking risk ^{3,4}	15 (58%)	6 (86%)	14 (78%)	2.57 (0.63, 10.44)	-	0.172
<i>Foods high in iron:</i>						
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
<i>Foods with sugar added:</i>						
Number that consumed foods with sugar added ^{3,8}	11 (42%)	5 (71%)	7 (39%)	0.86 (0.25, 3.00)	-	0.823
<i>Foods high in sodium:</i>						
Number that consumed foods high in sodium ^{3,9}	20 (77%)	5 (71%)	14 (78%)	1.05 (0.25, 4.50)	-	0.948
<i>Other foods:</i>						
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
<i>Breast milk and infant formula:</i>						
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
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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 than 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.

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3 357 **Nutrients**

4 358 **Table 4** shows significantly higher mean intakes of total fat, saturated fat, and
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6 359 percentage energy from fat and saturated fat in the full BLW group. In contrast, mean
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8 360 intakes of iron, zinc, vitamin B12, vitamin C, dietary fibre, and calcium were lower in
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10 361 the full BLW group than in the TSF group. No differences in mean dietary intake of
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12 362 energy, sugar, or sodium were detected between the two groups. The 95% confidence
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14 363 interval for energy suggests that, at most, the energy intake of infants following full
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16 364 BLW is likely to be 13% lower to 7% higher than that in those following TSF. For
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18 365 most nutrients, the intake of the partial BLW group appeared to be similar to that of
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20 366 the TSF group.

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22 368 In the absence of anthropometric data (e.g., body mass index) it is not possible to
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24 369 determine whether energy intake was adequate, although the mean intakes for both
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26 370 groups were higher than the Estimated Energy Requirement (EER). Overall, 13.7% of
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28 371 participants had inadequate intakes of zinc (5 from the full BLW group, 2 from the
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30 372 TSF group, and 0 from the partial BLW group). Study participants are likely to have
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32 373 had adequate intakes of protein, fat, vitamin C, and calcium because the mean intakes
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34 374 of these nutrients were higher than the AI. However, carbohydrate, iron, and vitamin
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36 375 B12 adequacy cannot be determined because the group mean intakes were below the
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38 376 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 feeding¹ (geometric mean**
 378 **(95%CI))**
 379

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

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

391 **Family meals**

392 The relationship between the foods consumed at the three main meals (breakfast,
393 lunch, evening meal) by the infant and those consumed by the family is reported in
394 **Table 5**. Baby-Led Weaning was associated with greater infant involvement in family
395 meal times, with full BLW infants significantly more likely to sit with the family
396 during lunch and evening meal times. However, breakfast eaters in all three groups
397 were likely to share breakfast with the family (83% of the infants consuming the
398 meal). Compared to those following TSF, mothers following a full BLW approach
399 were more likely to offer foods that were similar or the same (both ingredients and
400 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)		
<i>Number of infants eating their meal with the family:</i>					
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
<i>Number of infants with ingredients the same as family meal:⁵</i>					
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
<i>Number of infants with meal preparation the same as family meal:⁵</i>					
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.

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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).

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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 themselves, and the form the food was in, for each food item in the diet record allowed us to determine the true extent of baby-led feeding in families who consider themselves to be following BLW or TSF.

The major limitation of our study was its small sample size that may not be representative of the wider population, and that decreased our ability to detect differences between the feeding styles. However, a number of statistically significant differences were detected between the two complementary feeding styles, and 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

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3 447 breastfeeding to 6 months.²⁷ Although there were some differences, therefore,
4 448 between the study participants and the general public, the groups were closely
5 449 matched for age, sex and the demographic variables measured so differences in the
6 450 diets of the infants studied are not likely to be due to differences in demography.
7
8 451 Another limitation was the use of estimated breast milk volume. It was not feasible to
9 452 use test weighing or stable isotopes to measure intake in each individual, and
10 453 estimated volumes are commonly used in dietary studies in infants.²⁸⁻³⁰ It is also
11 454 somewhat reassuring that the energy intakes in the full BLW and TSF groups were
12 455 not statistically significantly different, and were also very similar (a difference of just
13 456 3.7%.) If the breast milk value we used underestimated breast milk volume, then
14 457 overall energy intake would be higher in BLW – this is unlikely as studies to date
15 458 have suggested lower rather than higher BMI in infants following BLW.^{31 32} If the
16 459 breast milk value we used overestimated breast milk volume, then the differences in
17 460 nutrient intakes would be even greater than we have reported. Finally, families were
18 461 assigned to the full BLW, partial BLW, and TSF groups based on parental report of
19 462 the complementary feeding approach used, rather than on an objective definition.
20 463 Although this means that many in the full BLW group were not following the
21 464 approach fully, the differences in feeding behaviours were substantial, and the use of
22 465 the parents' categorisation enabled us to determine the dietary characteristics of
23 466 infants whose parents would describe them as following BLW.
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29 468 Three major concerns have been raised regarding the use of a baby-led approach to
30 469 complementary feeding, namely whether the infant will consume sufficient energy
31 470 and iron, and whether they will be at increased risk of choking.¹⁰ It has been proposed
32 471 that infants may not have the motor skills or motivation to feed themselves enough
33 472 food to meet their energy needs for growth if they are following BLW.¹⁰ This may be
34 473 particularly relevant if low energy finger foods such as fruit and vegetables
35 474 predominate in the diet.³³ While the current study did not measure infant body mass
36 475 index, so growth faltering could not be identified, the reported energy intakes were
37 476 similar for the two feeding styles, were comparable to those reported for New Zealand
38 477 infants,³⁴ and met recommendations.²⁴
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56 479 In contrast, iron intakes were very different. Achieving adequate iron intake is
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58 480 problematic for infants worldwide because by 6 months of age substantial amounts of
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3 481 iron are needed from complementary foods.^{1 35 36} Iron fortified infant cereals are
4 482 recommended as a suitable first food to help address this.^{2 37} It has been proposed that
5 483 the BLW infant may be at particular risk of iron deficiency because the texture of
6 484 infant cereal makes it difficult for infants to self-feed, and because foods that are
7 485 easier to grasp tend to be naturally low in iron (e.g., fruits and vegetables).¹⁰ Our
8 486 results would suggest that these concerns may have some value given that, on
9 487 average, infants following full BLW had less than half the daily dietary iron intake of
10 488 infants following TSF. The full BLW group introduced fortified infant cereal 5 weeks
11 489 later and were considerably less likely to consume fortified infant cereal during the
12 490 weighed diet record. Although the adequacy of intakes below the AI cannot be
13 491 determined,²³ the iron intakes of all three groups were considerably lower than the AI
14 492 of 7mg²⁴ (3.6mg, 3.3mg and 1.6mg for TSF, partial BLW and full BLW respectively).
15 493 Half of the infants (51%) consumed no fortified infant cereal over the three days of
16 494 WDR, 45% consumed no red meat, and 22% consumed neither fortified cereal or red
17 495 meat. It is important that these results are confirmed in other studies, particularly
18 496 studies determining iron status as well as intake so that it can be determined whether
19 497 infants following BLW have poorer iron status. In the meantime, health care
20 498 professionals should emphasise the importance of including iron rich food sources in
21 499 infants' diets in the complementary feeding period because of the well-accepted
22 500 challenges of achieving adequate iron intake at this age, whether BLW or TSF is
23 501 being followed. It is important to note that it is possible that the choice of infant milk
24 502 may have contributed to these differences in total iron intake – none of the infants in
25 503 the full BLW group were having infant formula whereas more than half were
26 504 consuming formula in the TSF group (n=15; 58%), and infant formulas have a higher
27 505 iron concentration than breast milk.

28 506
29 507 It has been suggested that infants following BLW may be at increased risk of choking
30 508 because they are feeding themselves whole foods during the early stages of
31 509 complementary feeding, while they are still learning to chew and swallow.^{10 38 39}
32 510 Although our sample size was too small to investigate actual choking incidents, we
33 511 observed that a worryingly high number of parents in all three groups were offering
34 512 foods posing a choking risk. These results suggest that further education for parents
35 513 on how to minimize the risk of choking may be needed - no matter what approach to
36 514 complementary feeding was being used. This advice would need to refer not just to

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3 515 types of food that are commonly considered to pose a choking risk (e.g., one parent
4 516 offered their infant whole nuts), but also to foods that do not pose a risk to older
5 517 children and adults so may form part of the family meal (e.g., corn), and to ways in
6 518 which foods posing a choking risk can be modified to make them safer (e.g., chicken
7 519 is safer if it is offered in pieces that can be chewed on but not put in the mouth whole,
8 520 or if it is chopped finely). It is not clear from our study sample whether the population
9 521 of infants following BLW are more likely to be exposed to foods posing a choking
10 522 risk. Although there was no statistically significant difference between the groups, the
11 523 upper limit of the wide confidence interval for the odds ratio suggests that a
12 524 substantially higher odds of exposure is possible. It is, therefore, extremely important
13 525 that exposure to foods posing a choking risk, and choking prevalence, are investigated
14 526 in future, larger, studies of BLW.
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25 528 Concern has been expressed that infant self-feeding of family meals is only of benefit
26 529 if the family meals themselves are nutritionally adequate.¹⁰ While previous studies
27 530 have reported that infants following BLW are more likely to eat with their family,^{33 38}
28 531 ⁴⁰ we extend these findings to show that the foods eaten also tend to more closely
29 532 resemble those eaten by the family. Thus, it appears that BLW infants do follow a
30 533 more 'adult' food pattern. This may be an issue given that exposure to a variety of
31 534 'unhealthy' family foods might lead to negative impacts on eating behaviours later in
32 535 life.⁴¹ Certainly, in our study, total and saturated fat intakes were significantly higher
33 536 for those following full BLW. It is recommended that total fat intakes should be 30 to
34 537 45% of energy,¹ and the mean intake of those in the full BLW group was slightly
35 538 above this (48% of energy). It is not clear, however, whether the saturated fat intakes
36 539 are of concern. Both the TSF (18% energy) and BLW (22% energy) saturated fat
37 540 intakes are lower than mature breast milk which has 25% energy from saturated fat.¹⁴
38 541 It is also possible that family meals do not provide sufficient zinc and vitamin B12 to
39 542 meet the relatively high requirements of infants, particularly given the small portion
40 543 sizes consumed by infants. There is considerable controversy about the Estimated
41 544 Average Requirement (EAR) for zinc for infants,⁴² but 28% of the infants in the full
42 545 BLW group in this study had a zinc intake less than the EAR of 2.5mg for Australian
43 546 and New Zealand infants.²⁴ It is not possible to state that the mean vitamin B12 intake
44 547 in the BLW group of 0.2µg/day is inadequate even though it is below the AI,²³
45 548 however, intakes would need to more than triple by the age of 12 months to meet the
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3 549 EAR for that age ($0.7\mu\text{g}/\text{day}^{24}$). There were a number of other differences in nutrient
4 550 intakes between the full BLW infants and those using TSF, but these are of less
5 551 concern. Although percentage energy from protein and carbohydrate was lower in the
6 552 full BLW group, the gram amounts eaten were not significantly different, and
7 553 although vitamin C and calcium intakes were lower, they were still well above the AI.
8 554 Dietary fibre intake was also significantly lower in the full BLW group, but no
9 555 recommended intake has been set for this age group because breast milk does not
10 556 contain dietary fibre, and there are “no functional criteria for dietary fibre in
11 557 infants”.⁴³ It is important to note when interpreting these dietary data that our study
12 558 was small, cross-sectional, and not from a random sample of families, and that we
13 559 cannot determine whether these differences would still be apparent at older ages,
14 560 given that by 12 months of age, all children should be eating predominantly family
15 561 foods.² If confirmed, these results suggest that the current complementary feeding
16 562 guidelines for infants, that were after all developed to meet the needs of traditionally
17 563 spoon-fed infants, may need to be modified to account for parents who choose to
18 564 follow Baby-Led Weaning. Modifications would likely include an emphasis on the
19 565 importance of the family adopting healthy eating behaviours with a variety of nutrient
20 566 dense foods that both the family and the infant can enjoy, and the inclusion of foods
21 567 that are rich sources of iron, zinc and vitamin B12.

22 568
23 569 In conclusion, the current study suggests that BLW may be associated with a number
24 570 of health-related behaviours that would be expected to be beneficial: exclusive
25 571 breastfeeding to 6 months, waiting until 6 months to introduce solids, and greater
26 572 involvement in family meals, however, further research is required to determine
27 573 whether BLW infants may be at higher risk of iron, zinc and vitamin B12
28 574 deficiencies. The extent to which differences in total and saturated fat intake remain at
29 575 12 months also needs to be determined. Although BLW children did not appear to be
30 576 offered more foods posing a choking risk, it is of concern that two-thirds of the infants
31 577 were offered at least one food posing a choking risk during the diet record, and we
32 578 cannot rule out the possibility that those following BLW may be more likely to offer
33 579 such foods. Given the widespread interest and debate regarding the suitability of
34 580 BLW as an alternative infant feeding method, further research in a larger, ideally
35 581 representative, sample of children, preferably with measurements of growth,
36 582 biochemical nutrient status, and rate of choking, is required to confirm these findings.

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3 583 In the meantime, our findings suggest that families of infants following BLW should
4 584 be encouraged to include a variety of nutrient dense foods in family meals, and to
5 585 offer their infants foods rich in iron, zinc and vitamin B12; and that all parents, no
6 586 matter what approach they take to complementary feeding, should be given advice on
7 587 how to minimise their infant's exposure to foods that pose a choking risk.
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For peer review only

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594

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604

605 **Author contributions:**

606 ALMH and RWT conceived the idea for the study and designed the research. BJM,
607 CJS, AL, LWE and EAF collected the data and analysed the diet records. LJF
608 designed the approach used to determine the consumption of foods posing a choking
609 risk. JJH completed all statistical analyses. BJM wrote the first draft of the manuscript.
610 All authors contributed to the interpretation of the results and revision of the
611 manuscript, and approved the final manuscript. ALMH is the guarantor.

612

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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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Primary Subject Heading:	Nutrition and metabolism
Secondary Subject Heading:	Paediatrics
Keywords:	complementary feeding, baby-led weaning, nutrient intake, food intake

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3 **1 How different are Baby-Led Weaning and conventional complementary feeding?**

4 **2 A cross-sectional study of 6 to 8 month old infants**

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21 **Keywords:** complementary feeding, Baby-Led Weaning, nutrient intake, food intake

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24 ABSTRACT

25 **Objectives:** To compare the food, nutrient, and ‘family meal’ intakes of infants
26 following Baby-Led Weaning (BLW) with those of infants following a more
27 Traditional Spoon-Feeding (TSF) approach to complementary feeding.

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

31 **Methods:** Parents completed a questionnaire, and Weighed Diet Records (WDR) on
32 1-3 non-consecutive days, to investigate food and nutrient intakes, the extent to which
33 infants were self- or parent-fed, and infant involvement in ‘family meals’.

34 **Results:** BLW infants were more likely than TSF infants to have fed themselves all or
35 most of their food when starting complementary feeding (67% vs 8%, $p<0.001$).

36 Although there was no statistically significant difference in the large number of
37 infants consuming foods thought to pose a choking risk during the WDR (78% vs
38 58%, $p=0.172$), the confidence interval was wide so we cannot rule out increased
39 odds with BLW (odds ratio, 95% CI: 2.57, 0.63-10.44). No difference was observed
40 in energy intake, but BLW infants appeared to consume more total (48% vs 42%
41 energy, $p<0.001$) and saturated (22% vs 18% energy, $p<0.001$) fat, and less iron (1.6
42 vs 3.6mg, $p<0.001$), zinc (3.0 vs 3.7mg, $p=0.001$) and vitamin B12 (0.2 vs 0.5 μ g,
43 $p<0.001$), than TSF infants. BLW infants were more likely to eat with their family at
44 lunch and evening meal (both $p\leq 0.020$).

45 **Conclusions:** Infants following BLW had similar energy intakes to those following
46 TSF and were eating family meals more regularly, but appeared to have higher intakes
47 of fat and saturated fat, and lower intakes of iron, zinc and vitamin B12. A high
48 proportion of both groups were offered foods thought to pose a choking risk.

50 **ARTICLE SUMMARY**51 **Strengths and limitations of this study:**

- 52 • First study to compare the dietary intake of children following Baby-Led Weaning
53 (BLW) with that of infants following a more Traditional Spoon-Feeding (TSF)
54 approach to complementary feeding.
- 55 • Weighed diet records with careful recording of foods offered and foods eaten.
- 56 • Age- and sex-matching of children following BLW and those following TSF.
- 57 • Small sample size.
- 58 • Participants defined themselves as following BLW or TSF.

59 INTRODUCTION

60 Traditionally, parents have been advised to spoon-feed their infant puréed foods from
61 ‘around’ 6 months of age, progressing to mashed, then chopped foods so that they are
62 eating family foods by 12 months of age.^{1,2} However, anecdotal reports suggest that
63 an alternative method of complementary feeding, known as Baby-Led Weaning
64 (BLW), is becoming popular in New Zealand, the UK and Canada. In BLW, infants
65 are not spoon-fed at all, but instead feed themselves whole pieces of food, preferably
66 from the family meal, from the onset of complementary feeding.^{3,4}

67
68 Proponents of this baby-led approach suggest that it allows the infant to be in control
69 of how much food they eat; as they are in the first few months of life if they are
70 breastfed. It is proposed that this control over their own feeding may allow the infant
71 who is following BLW to respond better to hunger and satiety cues than a baby who is
72 spoon-fed by someone else. It has also been pointed out that although the age at which
73 it is recommended that parents start feeding their infant ‘solids’ has increased from 4
74 months to 6 months of age,^{2,5,6} most countries have not changed their advice on *how*
75 to introduce foods.^{3,7} The exception to this is the UK, where recent NHS advice is that
76 first foods can include soft vegetables and fruit offered as finger food or mashed.⁸

77
78 Despite increasing enthusiasm about BLW on the internet (8,960,000 hits in May
79 2015) and in the social media, health governing bodies⁹ and some healthcare
80 professionals¹⁰ have expressed considerable concern that infants following a baby-led
81 approach to infant feeding may be at an increased risk of choking and inadequate iron
82 and energy intakes. Therefore, it is important to determine what infants following
83 BLW are actually eating. The only study to date that has collected dietary information
84 about BLW was a pilot study in just 11 families that focused on parental diet.
85 Although some of the foods eaten by infants were reported, infant nutrient intakes
86 were not analysed, and there was no comparison group of families following
87 traditional spoon-feeding.¹¹

88
89 Therefore, the aims of the current study were: first, to determine whether there are
90 differences in nutrient intakes and food intakes (particularly foods thought to pose a
91 choking risk, foods high in iron, and foods containing added sugars or salt) between
92 infants following BLW and those following traditional spoon-feeding; and, second, to

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3 93 describe the ‘family meals’ offered to infants following BLW and traditional spoon-
4 94 feeding.
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8 96 **METHODS**

9 97 **Study design**

10 98 This community-based, cross-sectional study of 6-8 month old infants combined data
11 99 from three sources: two small cross-sectional studies (the “Infant Feeding Study” and
12 100 the “How to Measure Infant Feeding” study), and the control group of a randomised
13 101 controlled trial (the “Baby-Led Introduction to Solids” (BLISS) study).¹² All
14 102 participants completed a pretested demographic questionnaire and a feeding
15 103 questionnaire, and a 3-day or 1-day Weighed Diet Record (WDR) depending on the
16 104 study. Ethical approval for the studies was obtained from the University of Otago
17 105 Human Ethics Committee (Reference 13/270), and from the Lower South Regional
18 106 Ethics Committee (Reference LRS/11/09/037). All adult participants provided written
19 107 informed consent.
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28 108 29 109 **Participants**

30 110 As many eligible participants as possible were recruited from the following three
31 111 studies (with BLW and TSF infants being recruited from each study):

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34 112 1) “Infant Feeding Study” (December 2013 to June 2014), Dunedin and Auckland
35 113 (New Zealand) – Advertisements in local newspapers and on social media sites,
36 114 posters placed in a range of community areas, word of mouth in local parent
37 115 support networks (29 mother-child pairs expressed interest of whom 19 were
38 116 eligible for this study);
39 117 2) “How to Measure Infant Feeding” study (April 2013), Dunedin (New Zealand) -
40 118 Advertisements on social media sites, posters placed in a range of community
41 119 areas, word of mouth in local parent support networks (11 participants were
42 120 recruited of whom 7 were eligible for this study);
43 121 3) BLISS Study (September 2013 to June 2014) Dunedin (New Zealand)¹² – All
44 122 women booking into the only birthing facility in Dunedin, the Queen Mary
45 123 Maternity Unit, Dunedin Hospital, were invited to participate in the BLISS study
46 124 (23% of those eligible volunteered). All those who were eligible for, and had
47 125 consented to participate in, the BLISS study; had been randomised to the control
48 126 group; and had completed the WDR administered at 7 months of age at the time
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3 127 we were recruiting for the current study were invited to contribute their data (40
4 128 participants were approached, of whom 25 consented to contribute their data and
5
6 129 met the age- and sex-matching criteria (see below)).
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8 130 Inclusion criteria for the current study were: infant 6 to 8 months of age when the
9 131 WDR was completed, mother able to communicate in English or Te Reo Māori (the
10 132 language of the indigenous people of New Zealand) and mother 16 years of age or
11 133 older. Exclusion criteria were: infant born before 37 weeks gestation; or presence of a
12 134 congenital abnormality, physical condition, or intellectual disability likely to affect
13 135 the infant's feeding or growth. Infant participants were matched to within plus or
14 136 minus one week of age, and wherever possible for sex. BLISS study participants were
15 137 used as a pool of prospective matches with the first match that was identified being
16 138 recruited into the current study.
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24 140 **Definition of Baby-Led Weaning and traditional spoon-feeding**

25 141 Mothers were asked to state "... what approach to infant feeding you were using
26 142 around the time you completed the food diary: "Spoon-feeding" or "Baby-Led
27 143 Weaning" or "Other"." Parents who reported following BLW were assigned to the
28 144 full BLW group, whereas those who reported following a mixture of spoon-feeding
29 145 and BLW were assigned to the partial BLW group. Parents who were spoon-feeding
30 146 their child (without reporting BLW) were assigned to the Traditional Spoon-Feeding
31 147 (TSF) group.
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39 149 **Questionnaires**

40 150 The same questions were asked of all participants. The Demographic Questionnaire
41 151 collected information on: infant date of birth, sex, ethnicity (New Zealand Census
42 152 questions¹³), birth weight, and gestational age at birth; and maternal date of birth, and
43 153 parity. The Feeding Questionnaire collected data on: duration of exclusive
44 154 breastfeeding², age when complementary foods were introduced, extent of infant self-
45 155 feeding *vs.* parent-feeding (and puréed *vs.* finger foods) on the first complementary
46 156 feeding occasion, ages when iron-fortified infant cereal and red meat were first
47 157 introduced, and whether breast milk or infant formula was currently being consumed.
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56 159 **Dietary assessment**

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3 160 All three studies used the same WDR which was collected on three random non-
4 161 consecutive days including two weekdays and one weekend day over a month (the
5 162 “Infant Feeding Study”, and the BLISS study: n=44) or on one day (the “How to
6 163 Measure Infant Feeding” Study: n=7). The diet record had three key components: (a)
7 164 a record of the foods eaten - time of day, type and brand of food or drink, preparation
8 165 method, weight of food or drink, consistency of food or drink (puréed, mashed, diced,
9 166 whole), who fed the child (parent, child, both), and total weight and estimated
10 167 proportions of any leftover food or drink; (b) a description of any recipes used - raw
11 168 amounts of ingredients, cooking method, and proportion of the total recipe fed to the
12 169 child; and (c) an “end of day questionnaire” which determined, for each meal and
13 170 snack, whether the child ate with at least one adult, and whether the meal ingredients
14 171 and preparation were the same or different to the family meal. Resources were also
15 172 provided to assist with estimating food portions when outside the home or in early
16 173 childhood education.
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28 175 Parents were given detailed oral and written instructions on how to complete the
29 176 WDR, and were provided with a set of electronic scales (Salter Electronic Model
30 177 1017, Kent, United Kingdom), accurate to within \pm one gram.
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34 179 All diet records were entered into the dietary analysis software programme ‘Kai-
35 180 culator’ version 1.11v (University of Otago, Dunedin, New Zealand). Kai-culator uses
36 181 the New Zealand food composition database, FOODfiles;¹⁴ nutrient data for
37 182 commonly consumed recipes collated in the 2008/09 New Zealand Adult Nutrition
38 183 Survey;¹⁵ and nutrient data for commercial infant foods calculated by the research
39 184 team.¹⁶ Breast milk intake was assumed to be 750g/day based on a quadratic curve
40 185 fitted to the breast milk volumes reported by Dewey and colleagues¹⁷ with the amount
41 186 of infant formula consumed subtracted from this total if infants were mixed fed. After
42 187 the diet records had been entered in Kai-culator, a Registered Dietitian blinded to the
43 188 BLW or TSF status of the infant checked each diet record, and made corrections when
44 189 required.
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54 191 Diet record data were used to determine nutrient intake, the percentage of foods
55 192 currently adult or self-fed, the percentage of foods currently fed as purées or finger
56 193 foods, and whether any of the following foods were offered: foods thought to pose a
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3 194 choking risk (described below), iron-fortified infant cereal, red meat (defined as beef
4 195 or lamb), foods with sugar added (i.e. more than 4g/100g of added sugar or honey¹⁸),
5 196 foods that were high in sodium (i.e. more than 350mg sodium/100g¹⁸), fruits,
6 197 vegetables, and commercial baby food. Foods thought to pose a choking risk were
7 198 identified using lists from the literature^{19 20} and public health organisations,^{21 22} and
8 199 advice from a paediatric Speech-Language Therapist. Each weighed diet record day
9 200 was reviewed against this list to determine which foods thought to pose a choking risk
10 201 were offered to infants.
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203 **Statistical Analysis**

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

206

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

210 Categorical variables (infant sex, ethnicity, maternal parity, feeding practices, and
211 when solids were introduced) were compared using chi-squared tests and Fisher's
212 exact test where cell numbers were low (<5).

213

214 Differences in BLW associated behaviours between the full BLW and TSF groups
215 when "solids" were first introduced were determined using chi-squared test for
216 proportions (Table 2). As current feeding practices were skewed, medians and
217 interquartile ranges for each group were calculated and a Wilcoxon-Mann-Whitney
218 test was used to determine if the groups differed.

219

220 The number of infants in each group who consumed a food type of interest (e.g.,
221 foods thought to pose a choking risk) or a type of milk (e.g., breast milk) on any day
222 of the diet record was recorded and odds ratios with a chi-squared test comparing the
223 two groups were calculated (Table 3).

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225 Mean nutrient intake was calculated using the mean of all available days of the diet
226 record for each participant (Table 4). As the data were mostly right-skewed,
227 geometric means and 95% confidence intervals are presented. To determine the mean

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3 228 difference between groups in nutrient intake, all days of the diet record were used in a
4 229 mixed effects model with group as a fixed effect and participant identification number
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6 230 as a random effect. Log-transformed nutrient amounts were used as the outcome
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8 231 variable and regression coefficients back-transformed and presented as mean percent
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10 232 difference between the groups along with 95% confidence intervals and p Values
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13 234 The prevalence of inadequate zinc intakes was determined using the EAR cutpoint
14 235 method.²³ Whether the group was likely to have adequate intakes of the other
15 236 nutrients was determined by comparing the group mean intake to the Adequate Intake
16 237 (AI). The AI cannot be used to calculate the prevalence of inadequate nutrient intake,
17 238 however when groups have a mean intake at or above the AI it can generally be
18 239 assumed that there is a low prevalence of inadequate nutrient intake for that
19 240 population group.²³
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27 242 In Table 5, for descriptive purposes, the number of infants in each group who shared
28 243 meals with their family (e.g., breakfast) was summed using the first day of the diet
29 244 record. To compare consumption patterns between groups over all three days of diet
30 245 record, population-averaged generalised estimating equations for binary data were
31 246 used with an exchangeable working correlation. Coefficients were back transformed
32 247 to give odds ratios and 95% confidence intervals. This same technique was used to
33 248 compare the number of infants who had the same or nearly the same meal ingredients
34 249 and preparation as the family at mealtimes. An unstructured working correlation was
35 250 used for these analyses.
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43 252 **RESULTS**

44 253 **Participant characteristics**

45 254 Of the 80 families who were identified as potentially eligible to participate in the
46 255 study, 13 were excluded because: their child was born before 34 weeks gestation (n =
47 256 2), their child was not aged between 6 and 8 months (n = 8), or the participant could
48 257 not be contacted (n = 3); and 16 declined or were not required for age- and sex-
49 258 matching. The final sample consisted of 26 infants reported to be following TSF and
50 259 25 reported to be following BLW either in part (n=7) or fully (n=18) at the time the
51 260 diet record was collected. Mean (SD) maternal age was 33.8 (3.9) years and most
52 261 mothers (86%) were multiparous. The infants were 6.0 to 8.8 months of age and more
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3 262 than half were New Zealand European (74%). There were no significant differences
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5 263 between the groups in any of the demographic variables collected (**Table 1**).
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264 **Table 1** Demographic and early feeding characteristics of participants according to method of complementary feeding¹ (mean (SD))
 265 unless stated otherwise)
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	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 ¹Method of complementary feeding parents reported using at the time the weighed diet record was completed.

268 ²p 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.

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

271 ⁴6 months defined as 180 days (26 weeks).

272 Feeding behaviours

273 Women from the full BLW group exclusively breastfed their infants for
274 approximately 8 weeks longer ($p = 0.003$), and introduced solid foods 3 weeks later (p
275 < 0.001), than women following TSF (Table 1). In fact, 44% of the full BLW group
276 exclusively breastfed their infant to 6 months, compared with none in the TSF group.

277

278 When complementary foods were first introduced, the TSF group were more likely (p
279 < 0.001) to have puréed or mashed food (92% vs. 22%) and to be fed by an adult
280 (88% vs. 17%) than the full BLW group (Table 2). Although the full BLW group
281 were more likely to have finger foods as first foods (72% vs. 4%) which the infant
282 self-fed (67% vs. 8%) than the TSF group, almost a third of participants in the full
283 BLW group gave their infant puréed or mashed food (28%) and a third fed their infant
284 (rather than the infant feeding themselves) when ‘solids’ were introduced. As would be
285 expected, the partial BLW group were intermediate between the TSF and full BLW
286 groups.

287

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

292 Considerable differences were observed in the form in which foods were offered to
293 the infants: while TSF babies consumed many finger foods (a median of 33% of their
294 food intake was finger foods), this proportion was considerably lower than that
295 observed in the full BLW group (77%; $p < 0.001$). At the time the study was
296 conducted, parents reported that 50% of the full BLW infants were feeding
297 themselves all their food, compared to 12% of those in the TSF group ($p = 0.015$).
298 Interestingly, 62% of parents following TSF reported that their infant was feeding
299 themselves some solids at least once a day (compared to 78% of those following full
300 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		p Value ¹
		Partial (n=7)	Full (n=18)	
Number of infants fed by an adult or self-fed <i>when 'solids' first introduced</i> , 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 <i>when 'solids' first introduced</i> , 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 <i>currently</i> , 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 <i>currently</i> , 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.

308 Foods

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

317
318 There were no differences in the number consuming fruit (96%), vegetables (94%),
319 and, interestingly, the number using commercial baby foods (59%). However, infants
320 in the full BLW group were introduced to iron-fortified infant cereal on average 5.1
321 weeks later than those following TSF, and had only one fifth the odds of consuming
322 iron-fortified infant cereal during the WDR. There were no differences in the age
323 when red meat was introduced, the number not yet introduced to red meat (35%
324 overall), or the number who consumed it during the diet record.

325
326 Considerable differences were observed in breast milk and infant formula
327 consumption between the full BLW and TSF groups, with significantly more
328 participants in the full BLW group currently breastfeeding (and not offering infant
329 formula), than in the TSF group (100% vs. 42%; $p < 0.001$). More participants in the
330 TSF group than in the full BLW group were having both breast milk and infant
331 formula (12% vs. 0%, $p < 0.001$).

332
333 For those following full BLW, the most commonly consumed food types thought to
334 pose a choking risk were: raw vegetables, raw apple, and dried fruit (which were
335 offered on 10, 3, and 3 days respectively of the 46 days recorded by participants in
336 their WDRs); whereas for those following TSF, the most commonly consumed foods
337 thought to pose a risk were: rusks, small pieces of meat (other than sausages and
338 similar processed meats, or battered fish), crackers, and corn kernels (which were
339 offered on 10, 5, 4, and 4 days respectively of the 72 days recorded by participants in
340 their WDRs).

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

342

	Traditional Spoon-Feeding (n = 26)	Baby-Led Weaning		Odds ratio (95% CI) ¹	Mean difference (95% CI)	p Value ²
		Partial (n=7)	Full (n = 18)			
<i>Foods thought to pose a choking risk:</i>						
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
<i>Foods high in iron:</i>						
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
<i>Foods with sugar added:</i>						
Number that consumed foods with sugar added ^{3,8}	11 (42%)	5 (71%)	7 (39%)	0.86 (0.25, 3.00)	-	0.823
<i>Foods high in sodium:</i>						
Number that consumed foods high in sodium ^{3,9}	20 (77%)	5 (71%)	14 (78%)	1.05 (0.25, 4.50)	-	0.948
<i>Other foods:</i>						
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
<i>Breast milk and infant formula:</i>						
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
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343 ¹ Odds ratios compare those following full BLW with those following TSF.

344 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.

345 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).

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

347 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).

348 ⁶ Data from the Feeding Questionnaire.

349 ⁷ Red meat was defined as beef and lamb.

350 ⁸ Foods that contained more than 4g/100g of added sugar or honey.

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

352 ¹⁰ Commercial infant foods excluded iron-fortified infant cereals.

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

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3 357 **Nutrients**

4 358 **Table 4** shows significantly higher mean intakes of total fat, saturated fat, and
5
6 359 percentage energy from fat and saturated fat in the full BLW group. In contrast, mean
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8 360 intakes of iron, zinc, vitamin B12, vitamin C, dietary fibre, and calcium were lower in
9
10 361 the full BLW group than in the TSF group. No differences in mean dietary intake of
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12 362 energy, sugar, or sodium were detected between the two groups. The 95% confidence
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14 363 interval for energy suggests that, at most, the energy intake of infants following full
15
16 364 BLW is likely to be 13% lower to 7% higher than that in those following TSF. For
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18 365 most nutrients, the intake of the partial BLW group appeared to be similar to that of
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20 366 the TSF group.

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22 368 In the absence of anthropometric data (e.g., body mass index) it is not possible to
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24 369 determine whether energy intake was adequate, although the mean intakes for both
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26 370 groups were higher than the Estimated Energy Requirement (EER). Overall, 13.7% of
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28 371 participants had inadequate intakes of zinc (5 from the full BLW group, 2 from the
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30 372 TSF group, and 0 from the partial BLW group). Study participants are likely to have
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32 373 had adequate intakes of protein, fat, vitamin C, and calcium because the mean intakes
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34 374 of these nutrients were higher than the AI. However, carbohydrate, iron, and vitamin
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36 375 B12 adequacy cannot be determined because the group mean intakes were below the
37
38 376 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 feeding¹ (geometric mean**
 378 **(95%CI))**
 379

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

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

391 **Family meals**

392 The relationship between the foods consumed at the three main meals (breakfast,
393 lunch, evening meal) by the infant and those consumed by the family is reported in
394 **Table 5**. Baby-Led Weaning was associated with greater infant involvement in family
395 meal times, with full BLW infants significantly more likely to sit with the family
396 during lunch and evening meal times. However, breakfast eaters in all three groups
397 were likely to share breakfast with the family (83% of the infants consuming the
398 meal). Compared to those following TSF, mothers following a full BLW approach
399 were more likely to offer foods that were similar or the same (both ingredients and
400 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)		
<i>Number of infants eating their meal with the family:</i>					
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
<i>Number of infants with ingredients the same as family meal:⁵</i>					
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
<i>Number of infants with meal preparation the same as family meal:⁵</i>					
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.

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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).

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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 themselves, and the form the food was in, for each food item in the diet record allowed us to determine the true extent of baby-led feeding in families who consider themselves to be following BLW or TSF.

The major limitation of our study was its small sample size that may not be representative of the wider population, and that decreased our ability to detect differences between the feeding styles. However, a number of statistically significant differences were detected between the two complementary feeding styles, and 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

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3 447 breastfeeding to 6 months.²⁷ Although there were some differences, therefore,
4 448 between the study participants and the general public, the groups were closely
5 449 matched for age, sex and the demographic variables measured so differences in the
6 450 diets of the infants studied are not likely to be due to differences in demography.
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8 451 Another limitation was the use of estimated breast milk volume. It was not feasible to
9 452 use test weighing or stable isotopes to measure intake in each individual, and
10 453 estimated volumes are commonly used in dietary studies in infants.²⁸⁻³⁰ It is also
11 454 somewhat reassuring that the energy intakes in the full BLW and TSF groups were
12 455 not statistically significantly different, and were also very similar (a difference of just
13 456 3.7%.) If the breast milk value we used underestimated breast milk volume, then
14 457 overall energy intake would be higher in BLW – this is unlikely as studies to date
15 458 have suggested lower rather than higher BMI in infants following BLW.^{31 32} If the
16 459 breast milk value we used overestimated breast milk volume, then the differences in
17 460 nutrient intakes would be even greater than we have reported. However, it must be
18 461 borne in mind that breast milk provided the majority of the energy intake in the BLW
19 462 group (approximately 77% of energy), and that breast milk intake was not
20 463 individually measured. Finally, families were assigned to the full BLW, partial BLW,
21 464 and TSF groups based on parental report of the complementary feeding approach used,
22 465 rather than on an objective definition. Although this means that many in the full BLW
23 466 group were not following the approach fully, the differences in feeding behaviours
24 467 were substantial, and the use of the parents' categorisation enabled us to determine the
25 468 dietary characteristics of infants whose parents would describe them as following
26 469 BLW.
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29 471 Three major concerns have been raised regarding the use of a baby-led approach to
30 472 complementary feeding, namely whether the infant will consume sufficient energy
31 473 and iron, and whether they will be at increased risk of choking.¹⁰ It has been proposed
32 474 that infants may not have the motor skills or motivation to feed themselves enough
33 475 food to meet their energy needs for growth if they are following BLW.¹⁰ This may be
34 476 particularly relevant if low energy finger foods such as fruit and vegetables
35 477 predominate in the diet.³³ While the current study did not measure infant body mass
36 478 index, so growth faltering could not be identified, the reported energy intakes were
37 479 similar for the two feeding styles, were comparable to those reported for New Zealand
38 480 infants,³⁴ and met recommendations.²⁴

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4 482 In contrast, iron intakes appeared to be very different. Achieving adequate iron intake
5 483 is problematic for infants worldwide because by 6 months of age substantial amounts
6 484 of iron are needed from complementary foods.^{1 35 36} Iron fortified infant cereals are
7 485 recommended as a suitable first food to help address this.^{2 37} It has been proposed that
8 486 the BLW infant may be at particular risk of iron deficiency because the texture of
9 487 infant cereal makes it difficult for infants to self-feed, and because foods that are
10 488 easier to grasp tend to be naturally low in iron (e.g., fruits and vegetables).¹⁰ Our
11 489 results would suggest that these concerns may have some value given that, on
12 490 average, infants following full BLW appeared to have less than half the daily dietary
13 491 iron intake of infants following TSF. The full BLW group introduced fortified infant
14 492 cereal 5 weeks later and were considerably less likely to consume fortified infant
15 493 cereal during the weighed diet record. Although the adequacy of intakes below the AI
16 494 cannot be determined,²³ the iron intakes of all three groups were considerably lower
17 495 than the AI of 7mg²⁴ (3.6mg, 3.3mg and 1.6mg for TSF, partial BLW and full BLW
18 496 respectively). Half of the infants (51%) consumed no fortified infant cereal over the
19 497 three days of WDR, 45% consumed no red meat, and 22% consumed neither fortified
20 498 cereal or red meat. It is important that these results are confirmed in other studies,
21 499 particularly studies determining iron status as well as intake, so that it can be
22 500 determined whether infants following BLW have poorer iron status. In the meantime,
23 501 health care professionals should emphasise the importance of including iron rich food
24 502 sources in infants' diets in the complementary feeding period because of the well-
25 503 accepted challenges of achieving adequate iron intake at this age, whether BLW or
26 504 TSF is being followed. It is important to note that it is possible that the choice of
27 505 infant milk may have contributed to these differences in total iron intake – none of the
28 506 infants in the full BLW group were having infant formula whereas more than half
29 507 were consuming formula in the TSF group (n=15; 58%), and infant formulas have a
30 508 higher iron concentration than breast milk.

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41 510 It has been suggested that infants following BLW may be at increased risk of choking
42 511 because they are feeding themselves whole foods during the early stages of
43 512 complementary feeding, while they are still learning to chew and swallow.^{10 38 39}
44 513 Although our sample size was too small to investigate actual choking incidents, we
45 514 observed that a worryingly high number of parents in all three groups were offering

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3 515 foods thought to pose a choking risk. These results suggest that further education for
4 516 parents on how to minimize the risk of choking may be needed - no matter what
5 517 approach to complementary feeding is being used. This advice would need to refer not
6 518 just to types of food that are commonly considered to pose a choking risk (e.g., one
7 519 parent offered their infant whole nuts), but also to foods that do not pose a risk to
8 520 older children and adults so may form part of the family meal (e.g., corn), and to ways
9 521 in which foods thought to pose a choking risk can be modified to make them safer
10 522 (e.g., chicken is safer if it is offered in pieces that can be chewed on but not put in the
11 523 mouth whole, or if it is chopped finely). It is not clear from our study sample whether
12 524 the population of infants following BLW are more likely to be exposed to foods
13 525 thought to pose a choking risk. Although there was no statistically significant
14 526 difference between the groups, the confidence interval for the odds ratio was wide so
15 527 we cannot rule out higher odds of exposure in the full BLW group. It is, therefore,
16 528 extremely important that exposure to foods thought to pose a choking risk, and
17 529 choking prevalence, are investigated in future, larger, studies of BLW.

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19 531 Concern has been expressed that infant self-feeding of family meals is only of benefit
20 532 if the family meals themselves are nutritionally adequate.¹⁰ While previous studies
21 533 have reported that infants following BLW are more likely to eat with their family,^{33 38}
22 534 ⁴⁰ we extend these findings to show that the foods eaten also tend to more closely
23 535 resemble those eaten by the family. Thus, it appears that BLW infants do follow a
24 536 more 'adult' food pattern. This may be an issue given that exposure to a variety of
25 537 'unhealthy' family foods might lead to negative impacts on eating behaviours later in
26 538 life.⁴¹ Certainly, in our study, total and saturated fat intakes were significantly higher
27 539 for those following full BLW. It is recommended that total fat intakes should be 30 to
28 540 45% of energy,¹ and the mean intake of those in the full BLW group appeared to be
29 541 slightly above this (48% of energy). It is not clear, however, whether the saturated fat
30 542 intakes are of concern. Both the TSF (18% energy) and BLW (22% energy) saturated
31 543 fat intakes are lower than mature breast milk which has 25% energy from saturated
32 544 fat.¹⁴ It is also possible that family meals do not provide sufficient zinc and vitamin
33 545 B12 to meet the relatively high requirements of infants, particularly given the small
34 546 portion sizes consumed by infants. There is considerable controversy about the
35 547 Estimated Average Requirement (EAR) for zinc for infants,⁴² but 28% of the infants
36 548 in the full BLW group in this study appeared to have a zinc intake less than the EAR

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3 549 of 2.5mg for Australian and New Zealand infants.²⁴ It is not possible to state that the
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5 550 mean vitamin B12 intake in the BLW group of 0.2µg/day is inadequate even though it
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7 551 is below the AI,²³ however, intakes would need to more than triple by the age of 12
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9 552 months to meet the EAR for that age (0.7µg/day²⁴). There were a number of other
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11 553 differences in nutrient intakes between the full BLW infants and those using TSF, but
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13 554 these are of less concern. Although percentage energy from protein and carbohydrate
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15 555 was lower in the full BLW group, the gram amounts eaten were not significantly
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17 556 different, and although vitamin C and calcium intakes were lower, they were still well
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19 557 above the AI. Dietary fibre intake was also significantly lower in the full BLW group,
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21 558 but no recommended intake has been set for this age group because breast milk does
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23 559 not contain dietary fibre, and there are “no functional criteria for dietary fibre in
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25 560 infants”.⁴³ It is important to note when interpreting these dietary data that our study
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27 561 was small, cross-sectional, and not from a random sample of families, and that we
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29 562 cannot determine whether these differences would still be apparent at older ages,
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31 563 given that by 12 months of age, all children should be eating predominantly family
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33 564 foods.² If confirmed, these results suggest that the current complementary feeding
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35 565 guidelines for infants, that were after all developed to meet the needs of traditionally
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37 566 spoon-fed infants, may need to be modified to account for parents who choose to
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39 567 follow Baby-Led Weaning. Modifications would likely include an emphasis on the
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41 568 importance of the family adopting healthy eating behaviours with a variety of nutrient
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43 569 dense foods that both the family and the infant can enjoy, and the inclusion of foods
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45 570 that are rich sources of iron, zinc and vitamin B12.

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48 572 In conclusion, the current study suggests that BLW may be associated with a number
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50 573 of health-related behaviours that would be expected to be beneficial: exclusive
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52 574 breastfeeding to 6 months, waiting until 6 months to introduce solids, and greater
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54 575 involvement in family meals, however, further research is required to determine
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56 576 whether BLW infants may be at higher risk of iron, zinc and vitamin B12
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58 577 deficiencies. It would also be useful to determine the relative importance of the
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60 578 delayed introduction of solids and the high breastfeeding rates seen in infants
579 following BLW, compared to BLW itself, in determining nutrient intakes in 6 to 8
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62 580 month olds. The extent to which differences in total and saturated fat intake remain at
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64 581 12 months also needs to be determined. Although BLW children did not appear to be
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66 582 offered more foods thought to pose a choking risk, it is of concern that two-thirds of

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3 583 the infants were offered at least one food thought to pose a choking risk during the
4 584 diet record, and we cannot rule out the possibility that those following BLW may be
5 585 more likely to offer such foods. Given the widespread interest and debate regarding
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7 586 the suitability of BLW as an alternative infant feeding method, further research in a
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9 587 larger, ideally representative, sample of children, preferably with measurements of
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11 588 growth, biochemical nutrient status, and rate of choking, is required to confirm these
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13 589 findings. In the meantime, our findings suggest that families of infants following
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15 590 BLW should be encouraged to include a variety of nutrient dense foods in family
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17 591 meals, and to offer their infants foods rich in iron, zinc and vitamin B12; and that all
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19 592 parents, no matter what approach they take to complementary feeding, should be
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21 593 given advice on how to minimise their infant's exposure to foods thought to pose a
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23 594 choking risk - ideally by changing methods of food preparation rather than by
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25 595 excluding foods, many of which make an important contribution to the diet if offered
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603

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613

614 **Author contributions:**

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

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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			

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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.