



Baby knows best? The impact of weaning style on food preferences and Body Mass Index in early childhood in a case-controlled sample

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2011-000298
Article Type:	Research
Date Submitted by the Author:	11-Aug-2011
Complete List of Authors:	Townsend, Ellen; University of Nottingham, School of Psychology Pitchford, Nicola; University of Nottingham, Psychology
Primary Subject Heading:	Nutrition & metabolism
Secondary Subject Heading:	
Keywords:	NUTRITION & DIETETICS, GENERAL MEDICINE (see Internal Medicine), Community child health < PAEDIATRICS

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3 **Baby knows best? The impact of weaning style on food preferences and Body Mass**
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5 **Index in early childhood in a case-controlled sample**
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54 Main text word count 1466
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57 Keywords: food preferences, weaning, children, baby-led weaning.
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Abstract

Objective: The impact of different weaning methods on food preferences and Body Mass Index in early childhood is not known. Here we examine if weaning method – Baby-Led Weaning versus Traditional Spoon Feeding – influences food preferences and health-related outcomes.

Design, setting and participants: From November 2008 to January 2009, 155 parents recruited via the XXXX Toddler Lab and relevant internet sites completed a questionnaire concerning (a) infant feeding and weaning style (Baby-Led=92, Spoon-Fed=63, age range 20-78 months), (b) their child's preference for 151 foods (analysed by common food categories e.g. carbohydrates, proteins, dairy) and (c) exposure (frequency of consumption).

Main outcome measures: Food preferences, exposure, weaning style, Body Mass Index, picky eating.

Results: Compared to the Spoon-Fed group the Baby-Led group demonstrated: i) significantly increased liking for carbohydrates (no other differences in preference were found), ii) carbohydrates to be their most preferred foods (compared to sweet foods for the Spoon-Fed group), and iii) significantly lower Body Mass Index scores (despite no differences in birth weight or parental Body Mass Index). No difference in picky eating was found between the two weaning groups. Preference and exposure ratings were not influenced by socially desirable responding or Socio-Economic Status, although an increased liking of vegetables was associated with higher social class.

Conclusions: Weaning style impacts on food preferences and health in early childhood. Our results suggest that infants weaned through the Baby-Led approach learn to regulate their food intake in a manner which leads to a healthy Body Mass Index and a preference for

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3 healthy foods like carbohydrates. This has implications for combating the well-documented
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5 rise of obesity in contemporary societies.
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8 **Article summary**

9 **Article focus**

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15 - Although numerous studies have focused on when to introduce solid foods into an
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17 infant's diet there is a dearth of evidence concerning the impact of different weaning
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19 methods on food preferences and health.
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24 - Baby-Led Weaning is suitable for most infants and is associated with reduced
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26 maternal anxiety about weaning and feeding, and a maternal feeding style which is
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28 low in control.
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31 **Key messages**

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34 - Our study suggests that Baby-Led Weaning has a positive impact on the liking of
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36 foods that form the building blocks of healthy nutrition such as carbohydrates.
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40 - Baby-Led Weaning was associated with lower Body Mass Index that could not be
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42 accounted for by differences in birth weight, parental Body Mass Index or Socio-
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44 Economic Status.
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48 **Strengths and limitations of this study**

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50 One limitation of the present study is that we relied on self-report. However, using a self-
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52 report questionnaire is a standard approach when dealing with food preferences and we
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54 controlled for self-presentation effects (none were uncovered). A second criticism that may
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56 be levied here is our reliance on a small sample size. However, we used a matched-sample
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58 and report robust effect sizes.
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Introduction

How should solid foods be introduced to infants? Do different weaning methods impact on food preferences and health-related outcomes? These questions are currently unanswered. To date, the focus on weaning has been on when, rather than how, to wean¹. Recently much media attention has centred on Baby-Led Weaning^{2,3} which emphasises infant self-feeding with solid foods from the outset rather than spoon feeding with purees. Baby-Led Weaning is suitable for most infants⁴, is associated with (i) reduced maternal anxiety about weaning and feeding⁵ and (ii) a maternal feeding style which is low in control⁶. However, the impact of this weaning method on food preferences and health-related outcomes is not known. Thus, we examined the influence of different weaning styles on food preference, Body Mass Index and picky eating in early childhood.

Method

Parents of 155 children (aged 20-78 months) were recruited to the study between November 2008 and January 2009. The Baby-Led group ($n=92$) was recruited via an advert posted on relevant internet sites; the Spoon-Fed group ($n=63$) was recruited from our toddler lab database.

Participants completed a questionnaire (a standard research tool for examining food preferences⁷) concerning the following. (i) Infant feeding and weaning style. (ii) Child's preference (rated from 1 "loves it" to 5 "hates it") for 151 foods (adapted from Wardle *et al.*, 2001⁸), which was analysed by standard food categories e.g. carbohydrates, proteins, dairy⁹, and included a category called 'meals' for whole meals like lasagne⁸. See eTable 1 for details. (iii) Exposure (frequency of consumption) rated from 1 "more than once a day" to 7

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3 “less than once per month”, as this is closely related to food preferences^{10, 11}. (iv) Picky
4 eating (a single item requiring a ‘yes/no’ response to ‘Would you classify your child as a
5 picky eater?’). (v) Child height and weight for Body Mass Index calculation (for children
6 aged 24 months and over) using the Centers for Disease Control and Prevention Child and
7 Teen Body Mass Index Calculator¹² – in the Spoon-Fed group these measurements were
8 made using standardized procedures when assessed in our lab. (vi) Socio-Economic Status
9 (via postcode using the Income Deprivation Affecting Children Index (IDACI) score and
10 rank for 2007 and National Statistics 2001 Area Classification of Super Output Areas and
11 Data Zones (SOA¹³)). These measures are frequently used in social and health related
12 research with children and by government departments¹⁴. Socio-Economic Status has been
13 shown to influence eating practices and behaviours¹⁵⁻¹⁷. (vii) Marlowe-Crowne Social
14 Desirability Scale (short form)¹⁸. Parents who returned a completed questionnaire were
15 entered into a prize draw for £50. Ethical approval was granted by the University of XXXX,
16 School of Psychology Ethics Committee. Parents completed a consent form prior to
17 participation in the study.
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43 Results

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46 Data were analyzed using PASW Statistics 18.0¹⁹. Pearson’s correlations and t-tests were
47 used to examine relationships between outcome measures and groups respectively. Non-
48 parametric tests (Spearman’s rank correlations, Mann-Whitney *U*) were used when there was
49 significant skew or problems with homogeneity (Bonferroni-corrected for multiple
50 comparisons). Missing food preference data was accounted for in the calculation of averages
51 across categories. Cases with other missing data (e.g. Body Mass Index) were excluded from
52 analyses. Preliminary analyses showed that exposure and preference ratings were not
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contaminated by socially desirable responding and only liking of vegetables was significantly related to Socio-Economic Status (IDACI score), ($r_s = -.25, p=.005$) (higher social class associated with increased liking of vegetables).

As no formal definition of Baby-Led Weaning exists⁶ parental self-report of weaning style was used to generate weaning groups. To verify the veracity of self-reported weaning style responses to items concerning weaning methods were interrogated. This confirmed that the Baby-Led children were more likely to have handled food from the introduction of solid foods, were given finger foods earlier and fewer had been spoon-fed with puréed foods at all (Table 1). Thus, the two groups differed significantly on criteria typically used to characterise Baby-Led Weaning⁶.

Insert Table 1 here

The Baby-Led group was significantly younger than the Spoon-Fed group (Table 1) and overall age and preference were significantly correlated (collapsed across food categories, $r_s = .28, p=.001$; and for the individual food categories of dairy, $r_s = .35, p<.0001$; snacks, $r_s = .21, p<.009$ and meals, $r_s = .26, p=.001$). To control for this effect of age a case-controlled aged-matched sample of 74 participants (37 pairs) was generated to analyze the food preference data (see Table 2 for details).

Between the two weaning groups, significant differences in preference were found for only one food category – the Baby-Led group liked carbohydrates more than the Spoon-Fed group, $t(72) = -3.11, p=.003, d = -.53$. Indeed, carbohydrates was the most liked food category for the Baby-Led group whereas sweet foods was most liked by the Spoon-Fed group (Table 2). The Baby-Led group also liked proteins ($t(72) = -2.71, p=.008, d = -.63$) and whole meals ($U = 448.00, p=.02, d = -.40$) more than the Spoon-Fed group but these differences did not survive Bonferroni adjustment.

Insert Table 2 here

Next we investigated the effects of exposure on food preferences in the matched sample^{10,11} (Table 3). Exposure was significantly associated with liking of dairy foods ($r_s = .58, p < .0001$), snacks ($r_s = .1, p < .001$), vegetables ($r_s = .47, p < .0001$) and proteins ($r_s = .44, p < .0001$). No association was found for carbohydrates ($r_s = 0.19, p = .11$), sweet foods ($r_s = .19, p = .11$), fruits ($r_s = .10, p = .39$) and meals ($r_s = .17, p = .14$). This suggests that, for carbohydrates, the only food category with significant group differences, weaning style was more influential than exposure on preference ratings. Across group comparisons revealed increased exposure to vegetables, fruit, carbohydrates, protein, meals and sweets in the Spoon-Fed group.

Insert Table 3 here

Finally we investigated the influence of weaning method on health-related outcomes. Body Mass Index scores (percentile rank) differed significantly between groups (Table 1) – lower Body Mass Index scores were associated with Baby-Led Weaning. Body Mass Index was not correlated with socially desirable responding in the Baby-Led group (where self-report of height and weight measurements was used, $r_s = -.09, p = .55$). Also Body Mass Index did not correlate with Socio-Economic Status (IDACI score) in the whole sample ($r_s = -.10, p = .32$). No difference between the two weaning groups was found in the prevalence of picky eaters (Table 1).

Discussion

Understanding the factors which contribute to healthy nutrition in early childhood is crucial as this could be the optimal time to modify food preferences so as to foster healthy diets in

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obesigenic food environments¹⁰. Our findings show that Baby-Led Weaning has a positive impact on the liking of carbohydrates - foods that form the building blocks of healthy nutrition (ie. those found at the bottom of the food pyramid)⁹. This is a significant finding since, to date, the factors thought to be most influential on early food preferences are sweetness and familiarity (exposure)¹⁰. Consistent with previous research the Spoon-Fed group preferred sweet foods most, whereas the Baby-Led group most preferred carbohydrates (even though significantly higher exposure to carbohydrates was reported in the Spoon-Fed group).

Children weaned using the Baby-Led method are more likely to encounter carbohydrates in their whole food format earlier than Spoon-Fed children as these foods are ideal early finger foods (e.g. toast and pitta breads). However, our data show that exposure *per se* did not influence preference for carbohydrates, so another factor must be driving preference here. Presenting carbohydrates to infants in their whole food format, such as toast, rather than a puréed form may highlight awareness of perceptual features (such as texture) that is masked when food is puréed. Previous research has shown that food presentation significantly influences food preferences²⁰, so it is possible that differences in the presentation of foods across the two weaning groups impacted on preferences. Interestingly, the Baby-Led group showed increased preference for all food categories except sweets compared to the Spoon-Fed group (although this was only significant for carbohydrates).

Importantly, Baby-Led Weaning was associated with lower Body Mass Index that could not be accounted for by differences in birth weight, parental Body Mass Index or Socio-Economic Status. No difference in the prevalence in picky eating was found across groups. Seemingly, weaning style is associated with important health outcomes in early life. Moreover, 93.5% of the Baby-Led group reported that their child had never experienced a choking incident (a serious concern for parents and practitioners)². Given that Baby-Led

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3 Weaning promotes healthy food preferences and Body Mass Index in early childhood the
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5 benefits appear to outweigh the concerns associated with this weaning style. These are
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7 findings of note given problems with childhood obesity being faced in many modern
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9 societies²¹.
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14 This is the first study to have examined the impact of weaning method on food
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16 preferences and health outcomes in early childhood. Future research should determine
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18 whether our findings hold for more specialist populations, such as babies born prematurely or
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20 with specific health difficulties.
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26 **Acknowledgments:** Dr Sarah Knowles BSc (Hons), MSc, PhD (now at School of
27
28 Community Based Medicine, University of Manchester, UK) assisted with data collection
29
30 and input. She was a paid researcher on the study funded by a School of Psychology
31
32 (University of XXXX) pump-priming grant. The researchers are independent of the funders.
33
34 Our funders had no role in the design and conduct of the study; collection, management,
35
36 analysis, and interpretation of the data; and preparation, review, or approval of the
37
38 manuscript. Joanne Pybis BSc (Hons), MSc (now at British Association for Counselling and
39
40 Psychotherapy) assisted with the data collection for the Spoon-Fed group as part of her PhD
41
42 research funded by the Economic and Social Research Council. We thank the parents who
43
44 took part in the study from the XXXX Toddler lab, the 'I Want My Mum forum' and the
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46 'Baby-Led Weaning forum'.
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53 **Author contributions.** ET and NP designed the study and secured the funding for it. ET
54
55 collected and analysed the data and wrote the paper. NP contributed to the analysis and write
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57 up of the paper. ET is the guarantor for the study and both authors had full access to all of the
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59 data in the study and take responsibility for the integrity of the data and the accuracy of the
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3 data analysis. All authors have completed the Unified Competing Interest form at
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5 www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and
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7 declare that ET and NP have no non-financial interests that may be relevant to the submitted
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9 work. With regards to data sharing consent was not obtained but the presented data are
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11 anonymous and risk of identification is low.
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Tables and figures

Table 1. Outcomes on weaning style and infant feeding, Socio-Economic Status scores, picky eating and Body Mass Index¹

Characteristics	Baby-Led (n=92)	Spoon-Fed (n=63)	P value
Child age at testing (months)	32.12 (10.30)	41.62 (13.58)	<.0001
Female [†]	57.6% [53/92]	39.7% [25/63]	.03
Handled food from introduction of solids	96.7% [89/92]	15.87% [10/63]	<.0001
Exposed to pureed food	32.6% [30/92]	100% [63/63]	.0001
First exposed to finger food (age in months)	6.49 (1.41)	7.10 (1.63)	.001
Child was breast fed	98.9% [91/92]	88.9% [56/63]	.008
Duration (months) of breast feeding	24.00 (11.51)	9.00 (9.32)	<.0001
Socio-Economic Status: IDACI score	.11 (.08)	.14 (.11)	.17
Socio-Economic Status: IDACI rank	19566.81 (8304.26)	21679.33 (7218.74)	.16
Birth weight (lbs/oz)	7.64 (2.70)	7.09 (1.31)	.09
Child Body Mass Index Percentile rank*	47.22 (26.72)	60.9 (27.33)	.006
Parent Body Mass Index	24.08 (5.46)	24.91 (1.31)	.91
Child is picky eater	18.5% [17/92]	23.8% [15/63]	.43

¹Means and standard deviations are shown in brackets for continuous variables. [†]In the matched sample (used to analyze weaning style preference data) there was no gender difference (Table 2). *Height and weight data were missing from 47% of the Baby-Led group (mostly because parents had not weighed or measured their child recently or the child was under 24-months). Within the Baby-Led group there was no difference in preference ratings between those children with Body Mass Index scores and those without (max $U = 151.5$, $p = .88$, for protein).

Table 2. Mean preference ratings by weaning group (presented in order of liking for each group)ⁱ

Baby-Led group (n=37; females=17)	Mean (SD)	Spoon-Fed group (n=37; females=15)	Mean (SD)
Carbohydrates	1.82 (.42)	Sweet foods	1.81 (.59)
Savoury snacks	1.83 (.59)	Savoury snacks	2.08 (.63)
Sweet foods	1.89 (.71)	Carbohydrates	2.12 (.41)
Fruit	1.97 (.58)	Fruit	2.15 (.46)
Protein	2.03 (.51)	Protein	2.38 (.60)
Dairy	2.25 (.89)	Dairy	2.44 (.97)
Meals	2.33 (.82)	Meals	2.62 (.62)
Vegetables	2.74 (.66)	Vegetables	2.87 (.62)

ⁱ Lower scores indicate greater liking. Case-controlled, chronological aged-matched pairs were formed according to the following criteria: age alone ($n=11$), age and Socio-Economic Status ($n=20$), age, Socio-Economic Status and gender ($n=1$) and age and gender ($n=5$) (as no information on Socio-Economic Status was available). There was no effect of gender in this matched sample ($\chi^2 = .22, p = .82$).

Table 3. Mean exposure ratings by weaning group - means and standard deviations presentedⁱ.

Food category	Baby-Led group (n=37; females=17)	Spoon-Fed group (n=37; females=15)	P value	Effect size (d)
Carbohydrates	4.59 (.52)	4.07 (.69)	.001 ⁱ	.85
Savoury snacks	1.83 (.59)	2.08 (.63)	.13	-.41
Sweet foods	5.96 (.72)	4.64 (.79)	<.0001 ⁱ	1.78
Fruit	5.02 (.69)	4.31(.45)	<.0001 ⁱ	1.22
Protein	4.97 (.70)	4.48 (.66)	.003 ⁱ	.72
Dairy	4.37 (1.41)	4.10 (1.00)	.30	.22
Meals	5.69 (.65)	5.02 (.75)	<.0001 ⁱ	.95
Vegetables	4.89 (.83)	4.42 (.67)	.005 ⁱ	.62

ⁱ Difference remains significant after Bonferroni adjustment for multiple comparisons (*. $.05/8 = .006$). Lower exposure scores indicate more frequent consumption.

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eTable 1. Food items and food categories

Fruits	Vegetables	Carbohydrates	Protein	Dairy	Sweet foods	Savoury snacks	Meals
Blueberry	Aubergine	Baked potato	Scrambled egg	White cheese	Danish pastry	Ritz	Vegetable soup
Cherry	Celery	Rice	Boiled egg	Red cheese	Fairy cake - plain	Samosa	Chicken soup
Mango	Avocado	Mashed potato	Mackerel	Blue cheese	Fairy cake - chocolate	Onion bajee	Lasagne
Pineapple	Tomatoes	Roast potato	Salmon	Babybel	Fruitcake	Pork pie	Macaroni cheese
Raspberry	Onion	Boiled potato	Kidney beans	Dairylea	Cream Slice	Tuc cracker	Sweet/sour chicken
Apple	Yellow pepper	Weetabix	Chicken		Banana Angel Delight	Sausage roll	Curry
Banana	Sweet corn	Rice crispies	Beef		Chocolate Angel Delight	Spring roll	Pie
Pear	Carrot	Cornflakes	Lamb		Strawberry Angel Delight	Crisps	Tomato soup
Peach	Red cabbage	Cocopops	Pork		Ice cream –strawberry	Wotsits	Oxtail soup
Strawberry	Green cabbage	Shreddies	Ham		Ice cream –vanilla	Doritos	Mushroom soup
Watermelon	Cucumber	Cheerios	Cod		Ice cream – chocolate	Hoolahoops	Pizza
Melon	Butternut squash	Museli	Crabstick		Digestive	Cream cracker	Spagetti bolognaise
Blackberry	Babycorn	Sugar Puffs	Bacon		Chocolate digestive	Ryvita	Cottage pie
Red grape	Corn on cob	White bread	Burger		Bourbon	Quavers	
Green grape	Courgette	Brown bread	Sausage		Custard cream		
Orange	Red pepper	White roll	Tuna		Cookie		
Tangerine	Green pepper	Brown roll	Tuna mayo		Chocolate éclair		
Plum	Orange pepper	Pitta bread	Salami		Cheesecake		
Kiwi	Mushroom	Naan bread	Baked beans		Milk chocolate		
Grapefruit	Broccoli	Crumpet	Fried egg		Dark chocolate		
	Cauliflower	Chips	Fish finger		White chocolate		
	Mangetout	Croissants			Jelly sweet		
	Sprouts	Pancakes			Boiled sweet		
	Peas	Pasta			Jam doughnut		
	Parsnip	Baguette					
	Spinach	Potato waffle					
		Yorkshire pudding					
		Bagel					

For peer review only

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of case-control 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
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Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
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Participants	6	(a) Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	4-5
		(b) For matched studies, give matching criteria and the number of controls per case	6, 14
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	4-7
Bias	9	Describe any efforts to address potential sources of bias	6, 14
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	5, 6
		(b) Describe any methods used to examine subgroups and interactions	6
		(c) Explain how missing data were addressed	5
		(d) If applicable, explain how matching of cases and controls was addressed	6, 14
		(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	4, 14
		(b) Give reasons for non-participation at each stage	4, 14
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	13
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Outcome data	15*	Report numbers in each exposure category, or summary measures of exposure	13-15
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		(b) Report category boundaries when continuous variables were categorized	N/A
		(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	5, 14
Discussion			
Key results	18	Summarise key results with reference to study objectives	6-8
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	3
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8-9
Generalisability	21	Discuss the generalisability (external validity) of the study results	8-9
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	9

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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.



Baby knows best? The impact of weaning style on food preferences and Body Mass Index in early childhood in a case-controlled sample

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2011-000298.R1
Article Type:	Research
Date Submitted by the Author:	30-Sep-2011
Complete List of Authors:	Townsend, Ellen; University of Nottingham, School of Psychology Pitchford, Nicola; University of Nottingham, Psychology
Primary Subject Heading:	Nutrition & metabolism
Keywords:	NUTRITION & DIETETICS, GENERAL MEDICINE (see Internal Medicine), Community child health < PAEDIATRICS

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Manuscripts

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3 **Baby knows best? The impact of weaning style on food preferences and Body Mass**
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5 **Index in early childhood in a case-controlled sample**
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11 Ellen Townsend* and Nicola Pitchford†

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53 Main text word count 1826
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57 Keywords: food preferences, weaning, children, baby-led weaning.
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Abstract

Objective: The impact of different weaning methods on food preferences and Body Mass Index in early childhood is not known. Here we examine if weaning method – Baby-Led Weaning versus Traditional Spoon Feeding – influences food preferences and health-related outcomes.

Design, setting and participants: From November 2008 to January 2009, 155 parents recruited via the Nottingham Toddler Lab and relevant internet sites completed a questionnaire concerning (a) infant feeding and weaning style (Baby-Led=92, Spoon-Fed=63, age range 20-78 months), (b) their child's preference for 151 foods (analysed by common food categories e.g. carbohydrates, proteins, dairy) and (c) exposure (frequency of consumption).

Main outcome measures: Food preferences, exposure, weaning style, Body Mass Index, picky eating.

Results: Compared to the Spoon-Fed group the Baby-Led group demonstrated: i) significantly increased liking for carbohydrates (no other differences in preference were found), ii) carbohydrates to be their most preferred foods (compared to sweet foods for the Spoon-Fed group), and iii) significantly lower Body Mass Index scores (despite no differences in birth weight or parental Body Mass Index). No difference in picky eating was found between the two weaning groups. Preference and exposure ratings were not influenced by socially desirable responding or Socio-Economic Status, although an increased liking of vegetables was associated with higher social class.

Conclusions: Weaning style impacts on food preferences and health in early childhood. Our results suggest that infants weaned through the Baby-Led approach learn to regulate their

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3 food intake in a manner which leads to a healthy Body Mass Index and a preference for
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5 healthy foods like carbohydrates. This has implications for combating the well-documented
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7 rise of obesity in contemporary societies.
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10 **Article summary**

11 **Article focus**

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18 - Although numerous studies have focused on when to introduce solid foods into an
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20 infant's diet there is a dearth of evidence concerning the impact of different weaning
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22 methods on food preferences and health.
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26 - Baby-Led Weaning is suitable for most infants and is associated with reduced
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28 maternal anxiety about weaning and feeding, and a maternal feeding style which is
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30 low in control.
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33 **Key messages**

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37 - Our study suggests that Baby-Led Weaning has a positive impact on the liking of
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39 foods that form the building blocks of healthy nutrition such as carbohydrates.
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43 - Baby-Led Weaning was associated with lower Body Mass Index that could not be
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45 accounted for by differences in birth weight, parental Body Mass Index or Socio-
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47 Economic Status.
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50 **Strengths and limitations of this study**

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52 One limitation of the present study is that we relied on self-report. However, using a self-
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54 report questionnaire is a standard approach when dealing with food preferences and we
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56 controlled for self-presentation effects (none were uncovered). A second criticism that may
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be levied here is our reliance on a small sample size. However, we used a matched-sample and report robust effect sizes.

Introduction

How should solid foods be introduced to infants? Do different weaning methods impact on food preferences and health-related outcomes? These questions are currently unanswered. To date, the focus on weaning has been on when, rather than how, to wean¹. Recently much media attention has centred on Baby-Led Weaning^{2,3} which emphasises infant self-feeding with solid foods from the outset rather than spoon feeding with purees. Baby-Led Weaning is suitable for most infants⁴, is associated with (i) reduced maternal anxiety about weaning and feeding⁵ and (ii) a maternal feeding style which is low in control⁶. However, the impact of this weaning method on food preferences and health-related outcomes is not known. Thus, we examined the influence of different weaning styles on food preference, Body Mass Index and picky eating in early childhood.

Method

Parents of 155 children (aged 20-78 months) were recruited to the study between November 2008 and January 2009. The Baby-Led group ($n=92$) was recruited via an advert posted on relevant internet sites; the Spoon-Fed group ($n=63$) was recruited from our toddler lab database.

Participants completed a questionnaire (a standard research tool for examining food preferences⁷) concerning the following. (i) Infant feeding and weaning style. (ii) Child's preference (rated from 1 "loves it" to 5 "hates it") for 151 foods (adapted from Wardle *et al.*, 2001⁸), which was analysed by standard food categories e.g. carbohydrates, proteins, dairy⁹,

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3 and included a category called ‘meals’ for whole meals like lasagne⁸. See eTable 1 for
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5 details. (iii) Exposure (frequency of consumption) rated from 1 “more than once a day” to 7
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7 “less than once per month”, as this is closely related to food preferences^{10,11}. (iv) Picky
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9 eating (a single item requiring a ‘yes/no’ response to ‘Would you classify your child as a
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11 picky eater?’). (v) Child height and weight for Body Mass Index calculation (for children
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13 aged 24 months and over) using the Centers for Disease Control and Prevention Child and
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15 Teen Body Mass Index Calculator¹² – in the Spoon-Fed group these measurements were
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17 made using standardized procedures when assessed in our lab. (vi) Socio-Economic Status
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19 (via postcode using the Income Deprivation Affecting Children Index (IDACI) score and
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21 rank for 2007 and National Statistics 2001 Area Classification of Super Output Areas and
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23 Data Zones (SOA¹³)). These measures are frequently used in social and health related
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25 research with children and by government departments¹⁴. Socio-Economic Status has been
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27 shown to influence eating practices and behaviours¹⁵⁻¹⁷. (vii) Marlowe-Crowne Social
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29 Desirability Scale (short form)¹⁸. Parents who returned a completed questionnaire were
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31 entered into a prize draw for £50. Ethical approval was granted by the University of
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33 **Nottingham**, School of Psychology Ethics Committee. Parents completed a consent form
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35 prior to participation in the study.
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Results

Data were analyzed using PASW Statistics 18.0¹⁹. Pearson’s correlations and t-tests were used to examine relationships between outcome measures and groups respectively. Non-parametric tests (Spearman’s rank correlations, Mann-Whitney *U*) were used when there was significant skew or problems with homogeneity (Bonferroni-corrected for multiple comparisons). Missing food preference data was accounted for in the calculation of averages

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3 across categories. Cases with other missing data (e.g. Body Mass Index) were excluded from
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5 analyses. Preliminary analyses showed that exposure and preference ratings were not
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7 contaminated by socially desirable responding and only liking of vegetables was significantly
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9 related to Socio-Economic Status (IDACI score), ($r_s = -.25, p=.005$) (higher social class
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11 associated with increased liking of vegetables).
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16 As no formal definition of Baby-Led Weaning exists⁶ parental self-report of weaning
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18 style was used to generate weaning groups. To verify the veracity of self-reported weaning
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20 style responses to items concerning weaning methods were interrogated. This confirmed that
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22 the Baby-Led children were more likely to have handled food from the introduction of solid
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24 foods, were given finger foods earlier and fewer had been spoon-fed with puréed foods at all
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26 (Table 1). Thus, the two groups differed significantly on criteria typically used to characterise
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28 Baby-Led Weaning⁶.
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33 **Insert Table 1 here**

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36 The Baby-Led group was significantly younger than the Spoon-Fed group (Table 1)
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38 and overall age and preference were significantly correlated (collapsed across food
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40 categories, $r_s = .28, p=.001$; and for the individual food categories of dairy, $r_s = .35, p<.0001$;
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42 snacks, $r_s = .21, p<.009$ and meals, $r_s = .26, p=.001$). To control for this effect of age a case-
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44 controlled aged-matched sample of 74 participants (37 pairs) was generated to analyze the
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46 food preference data (see Table 2 for details).
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51 Between the two weaning groups, significant differences in preference were found for
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53 only one food category – the Baby-Led group liked carbohydrates more than the Spoon-Fed
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55 group, $t(72) = -3.11, p=.003, d = -.53$. Indeed, carbohydrates was the most liked food category
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57 for the Baby-Led group whereas sweet foods was most liked by the Spoon-Fed group (Table
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59 2). The Baby-Led group also liked proteins ($t(72) = -2.71, p=.008, d = -.63$) and whole meals
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($U=448.00$, $p=.02$, $d=-.40$) more than the Spoon-Fed group but these differences did not survive Bonferroni adjustment.

Insert Table 2 here

Next we investigated the effects of exposure on food preferences in the matched sample^{10,11} (Table 3). Exposure was significantly associated with liking of dairy foods ($r_s = .58$, $p<.0001$), snacks ($r_s = .1$, $p<.001$), vegetables ($r_s = .47$, $p<.0001$) and proteins ($r_s = .44$, $p<.0001$). No association was found for carbohydrates ($r_s = 0.19$, $p=.11$), sweet foods ($r_s = .19$, $p=.11$), fruits ($r_s = .10$, $p=.39$) and meals ($r_s = .17$, $p=.14$). This suggests that, for carbohydrates, the only food category with significant group differences, weaning style was more influential than exposure on preference ratings. Across group comparisons revealed increased exposure to vegetables, fruit, carbohydrates, protein, meals and sweets in the Spoon-Fed group.

Insert Table 3 here

Finally we investigated the influence of weaning method on health-related outcomes. Body Mass Index scores (percentile rank) differed significantly between groups (Table 1) – lower Body Mass Index scores were associated with Baby-Led Weaning. Body Mass Index was not correlated with socially desirable responding in the Baby-Led group (where self-report of height and weight measurements was used, $r_s = -.09$, $p=.55$). Also Body Mass Index (percentile rank) did not correlate with Socio-Economic Status (IDACI score) ($r_s = -.10$, $p=.32$), or breastfeeding duration ($r_s = -.20$, $p=.07$) in the whole sample. (There was also no correlation between Body Mass Index scores and breastfeeding duration in the matched sample ($r_s = -.21$, $p=.12$)). (No difference between the two weaning groups was found in the prevalence of picky eaters (Table 1).

Discussion

Understanding the factors which contribute to healthy nutrition in early childhood is crucial as this could be the optimal time to modify food preferences so as to foster healthy diets in obesigenic food environments¹⁰. Our findings show that Baby-Led Weaning has a positive impact on the liking of carbohydrates - foods that form the building blocks of healthy nutrition (ie. those found at the bottom of the food pyramid)⁹. This is a significant finding since, to date, the factors thought to be most influential on early food preferences are sweetness and familiarity (exposure)¹⁰. Consistent with previous research the Spoon-Fed group preferred sweet foods most, whereas the Baby-Led group most preferred carbohydrates (even though significantly higher exposure to carbohydrates was reported in the Spoon-Fed group).

Children weaned using the Baby-Led method are more likely to encounter carbohydrates in their whole food format earlier than Spoon-Fed children as these foods are ideal early finger foods (e.g. toast and pitta breads). However, our data show that exposure *per se* did not influence preference for carbohydrates, so another factor must be driving preference here. Presenting carbohydrates to infants in their whole food format, such as toast, rather than a puréed form may highlight awareness of perceptual features (such as texture) that is masked when food is puréed. Previous research has shown that food presentation significantly influences food preferences²⁰, so it is possible that differences in the presentation of foods across the two weaning groups impacted on preferences. It is also possible that carbohydrates are easier to masticate compared to some other foods such as meat (which may be easier to eat when puréed and spoon-fed). Interestingly, the Baby-Led group showed increased preference for all food categories except sweets compared to the Spoon-Fed group (although this was only significant for carbohydrates).

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Importantly, Baby-Led Weaning was associated with lower Body Mass Index that could not be accounted for by differences in birth weight, parental Body Mass Index or Socio-Economic Status. There was a trend towards a significant, yet weak, negative correlation between breastfeeding duration and Body Mass Index in the whole sample (which is in keeping with the literature)²¹. Interestingly, although not significant in the smaller matched sample the strength of correlation was comparable across samples (r_s - .21 for the matched sample, r_s - .20 for the whole sample). So duration of breastfeeding may have a mediating effect which requires investigation in relation to the impact that weaning style has on Body Mass Index. No difference in the prevalence in picky eating was found across groups. Seemingly, weaning style is associated with important health outcomes in early life. Moreover, 93.5% of the Baby-Led group reported that their child had never experienced a choking incident (a serious concern for parents and practitioners)². Given that Baby-Led Weaning promotes healthy food preferences and Body Mass Index in early childhood the benefits appear to outweigh the concerns associated with this weaning style. These are findings of note given problems with childhood obesity being faced in many modern societies²².

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This is the first study to have examined the impact of weaning method on food preferences and health outcomes in early childhood. Future research should determine whether our findings hold for more specialist populations, such as babies born prematurely or with specific health difficulties. Moreover, careful consideration should be given to the classification of weaning method. In the present study we relied on parents identifying themselves as having used Baby-Led Weaning (and we checked the reliability of this self-report by asking some specific questions about their weaning practices). This gave rise to a dichotomous variable – either the parents used Baby-Led Weaning or they did not. However, it may be more sensitive to consider weaning methods as a continuum where parents rate the

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3 percentage use of pureed foods in their child's diet over time⁵. In addition, previous studies
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5 have shown that parents who used the Baby-Led approach to weaning are less controlling and
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7 more willing to hand control over to the child when introducing solid foods⁶. Future research
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9 needs to address the contribution of this factor into any effect of weaning method on food
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11 preferences.
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16 A large, controlled prospective study is now required which examines weaning
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18 practices in tandem with the other key factors including Body Mass Index, milk feeding
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20 practices (breast vs. bottle/formula fed), Socio-Economic Status, locus of control, and picky
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22 eating. In particular, a study is needed that includes a greater proportion of children who have
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24 been formula/bottle fed in order to compare the relative impacts of weaning method and milk
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26 feeding practices on food preferences and health outcomes in early childhood.
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33 **Acknowledgments:** Dr Sarah Knowles BSc (Hons), MSc, PhD (now at School of
34
35 Community Based Medicine, University of Manchester, UK) assisted with data collection
36
37 and input. Joanne Pybis BSc (Hons), MSc (now at British Association for Counselling and
38
39 Psychotherapy) assisted with the data collection for the Spoon-Fed group as part of her PhD
40
41 research funded by the Economic and Social Research Council (ESRC). We thank the parents
42
43 who took part in the study from the Nottingham Toddler lab, the 'I Want My Mum forum'
44
45 and the 'Baby-Led Weaning forum'.
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50 **Competing interests:** Within the last five years ET and NJP have received co-funding from
51
52 Nutricia/Danone to support an ESRC CASE PhD Studentship.
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55
56 **Funding:** The study was funded by a School of Psychology (University of Nottingham)
57
58 pump-priming grant. The researchers are independent of the funders. Our funders had no role
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3 in the design and conduct of the study; collection, management, analysis, and interpretation
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5 of the data; and preparation, review, or approval of the manuscript.
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9 **Author contributions.** ET and NP designed the study and secured the funding for it. ET
10 collected and analysed the data and wrote the paper. NP contributed to the analysis and write
11 up of the paper. ET is the guarantor for the study and both authors had full access to all of the
12 data in the study and take responsibility for the integrity of the data and the accuracy of the
13 data analysis. With regards to data sharing consent was not obtained but the presented data
14 are anonymous and risk of identification is low.
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Tables and figures

Table 1. Outcomes on weaning style and infant feeding, Socio-Economic Status scores, picky eating and Body Mass Index¹

Characteristics	Baby-Led (n=92)	Spoon-Fed (n=63)	P value
Child age at testing (months)	32.12 (10.30)	41.62 (13.58)	<.0001
Female [†]	57.6% [53/92]	39.7% [25/63]	.03
Handled food from introduction of solids	96.7% [89/92]	15.87% [10/63]	<.0001
Exposed to pureed food	32.6% [30/92]	100% [63/63]	.0001
First exposed to finger food (age in months)	6.49 (1.41)	7.10 (1.63)	.001
Child was breast fed*	98.9% [91/92]	88.9% [56/63]	.008
Duration (months) of breast feeding	24.00 (11.51)	9.00 (9.32)	<.0001
Socio-Economic Status: IDACI score	.11 (.08)	.14 (.11)	.17
Socio-Economic Status: IDACI rank	19566.81 (8304.26)	21679.33 (7218.74)	.16
Birth weight (lbs/oz)	7.64 (2.70)	7.09 (1.31)	.09
Child Body Mass Index Percentile rank**	47.22 (26.72)	60.9 (27.33)	.006
Parent Body Mass Index	24.08 (5.46)	24.91 (1.31)	.91
Child is picky eater	18.5% [17/92]	23.8% [15/63]	.43

¹Means and standard deviations are shown in brackets for continuous variables. [†]In the matched sample (used to analyze weaning style preference data) there was no gender difference (Table 2). * There was no difference in breast-feeding between the groups in the matched sample (92% were in the Spoon-Fed group compared to 97% in the Baby-Led group), ($\chi = .30$, $p = .62$). **Height and weight data were missing from 47% of the Baby-Led group (mostly because parents had not weighed or measured their child recently or the child was under 24-months). Within the Baby-Led group there was no difference in preference ratings between those children with Body Mass Index scores and those without (max $U = 151.5$, $p = .88$, for protein).

Table 2. Mean preference ratings by weaning group (presented in order of liking for each group)ⁱ

Baby-Led group (n=37; females=17)	Mean (SD)	Spoon-Fed group (n=37; females=15)	Mean (SD)
Carbohydrates	1.82 (.42)	Sweet foods	1.81 (.59)
Savoury snacks	1.83 (.59)	Savoury snacks	2.08 (.63)
Sweet foods	1.89 (.71)	Carbohydrates	2.12 (.41)
Fruit	1.97 (.58)	Fruit	2.15 (.46)
Protein	2.03 (.51)	Protein	2.38 (.60)
Dairy	2.25 (.89)	Dairy	2.44 (.97)
Meals	2.33 (.82)	Meals	2.62 (.62)
Vegetables	2.74 (.66)	Vegetables	2.87 (.62)

ⁱ Lower scores indicate greater liking. Case-controlled, chronological aged-matched pairs were formed according to the following criteria: age alone ($n=11$), age and Socio-Economic Status ($n=20$), age, Socio-Economic Status and gender ($n=1$) and age and gender ($n=5$) (as no information on Socio-Economic Status was available). There was no effect of gender in this matched sample ($\chi^2 = .22$, $p = .82$).

Table 3. Mean exposure ratings by weaning group - means and standard deviations presentedⁱ.

Food category	Baby-Led group (n=37; females=17)	Spoon-Fed group (n=37; females=15)	P value	Effect size (d)
Carbohydrates	4.59 (.52)	4.07 (.69)	.001 ¹	.85
Savoury snacks	1.83 (.59)	2.08 (.63)	.13	-.41
Sweet foods	5.96 (.72)	4.64 (.79)	<.0001 ¹	1.78
Fruit	5.02 (.69)	4.31(.45)	<.0001 ¹	1.22
Protein	4.97 (.70)	4.48 (.66)	.003 ¹	.72
Dairy	4.37 (1.41)	4.10 (1.00)	.30	.22
Meals	5.69 (.65)	5.02 (.75)	<.0001 ¹	.95
Vegetables	4.89 (.83)	4.42 (.67)	.005 ¹	.62

ⁱ Difference remains significant after Bonferroni adjustment for multiple comparisons (*. $05/8 = .006$). Lower exposure scores indicate more frequent consumption.

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eTable 1. Food items and food categories

Fruits	Vegetables	Carbohydrates	Protein	Dairy	Sweet foods	Savoury snacks	Meals
Blueberry	Aubergine	Baked potato	Scrambled egg	White cheese	Danish pastry	Ritz	Vegetable soup
Cherry	Celery	Rice	Boiled egg	Red cheese	Fairy cake - plain	Samosa	Chicken soup
Mango	Avocado	Mashed potato	Mackerel	Blue cheese	Fairy cake - chocolate	Onion bajee	Lasagne
Pineapple	Tomatoes	Roast potato	Salmon	Babybel	Fruitcake	Pork pie	Macaroni cheese
Raspberry	Onion	Boiled potato	Kidney beans	Dairyalea	Cream Slice	Tuc cracker	Sweet/sour chicken
Apple	Yellow pepper	Weetabix	Chicken		Banana Angel Delight	Sausage roll	Curry
Banana	Sweet corn	Rice crispies	Beef		Chocolate Angel Delight	Spring roll	Pie
Pear	Carrot	Cornflakes	Lamb		Strawberry Angel Delight	Crisps	Tomato soup
Peach	Red cabbage	Cocopops	Pork		Ice cream –strawberry	Wotsits	Oxtail soup
Strawberry	Green cabbage	Shreddies	Ham		Ice cream –vanilla	Doritos	Mushroom soup
Watermelon	Cucumber	Cheerios	Cod		Ice cream – chocolate	Hoolahoops	Pizza
Melon	Butternut squash	Museli	Crabstick		Digestive	Cream cracker	Spagetti bolognaise
Blackberry	Babycorn	Sugar Puffs	Bacon		Chocolate digestive	Ryvita	Cottage pie
Red grape	Corn on cob	White bread	Burger		Bourbon	Quavers	
Green grape	Courgette	Brown bread	Sausage		Custard cream		
Orange	Red pepper	White roll	Tuna		Cookie		
Tangerine	Green pepper	Brown roll	Tuna mayo		Chocolate éclair		
Plum	Orange pepper	Pitta bread	Salami		Cheesecake		
Kiwi	Mushroom	Naan bread	Baked beans		Milk chocolate		
Grapefruit	Broccoli	Crumpet	Fried egg		Dark chocolate		
	Cauliflower	Chips	Fish finger		White chocolate		
	Mangetout	Croissants			Jelly sweet		
	Sprouts	Pancakes			Boiled sweet		
	Peas	Pasta			Jam doughnut		
	Parsnip	Baguette					
	Spinach	Potato waffle					
		Yorkshire pudding					
		Bagel					

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Baby knows best? The impact of weaning style on food preferences and Body Mass Index in early childhood in a case-controlled sample

Journal:	<i>BMJ Open</i>
Manuscript ID:	bmjopen-2011-000298.R2
Article Type:	Research
Date Submitted by the Author:	30-Nov-2011
Complete List of Authors:	Townsend, Ellen; University of Nottingham, School of Psychology Pitchford, Nicola; University of Nottingham, Psychology
Primary Subject Heading:	Nutrition & metabolism
Secondary Subject Heading:	Paediatrics
Keywords:	NUTRITION & DIETETICS, GENERAL MEDICINE (see Internal Medicine), Community child health < PAEDIATRICS

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Baby knows best? The impact of weaning style on food preferences and Body Mass**Index in early childhood in a case-controlled sample**

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Main text word count 2,156

Keywords: food preferences, weaning, children, baby-led weaning, Body Mass Index.

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Abstract

Objective: The impact of different weaning methods on food preferences and BMI (BMI) in early childhood is not known. Here we examine if weaning method – Baby-Led Weaning versus Traditional Spoon Feeding – influences food preferences and health-related outcomes.

Design, setting and participants: Parents ($n=155$) recruited via the Nottingham Toddler Lab and relevant internet sites completed a questionnaire concerning (a) infant feeding and weaning style (Baby-Led=92, Spoon-Fed=63, age range 20-78 months), (b) their child's preference for 151 foods (analysed by common food categories e.g. carbohydrates, proteins, dairy) and (c) exposure (frequency of consumption). Food preference and exposure data were analysed using a case-controlled matched sample to account for the effect of age on food preference. All other analyses were conducted with the whole sample.

Main outcome measures: **Primary:** Food preferences, exposure, weaning style. **Secondary:** BMI, picky eating.

Results: Compared to the Spoon-Fed group the Baby-Led group demonstrated: i) significantly increased liking for carbohydrates (no other differences in preference were found), and ii) carbohydrates to be their most preferred foods (compared to sweet foods for the Spoon-Fed group). Preference and exposure ratings were not influenced by socially desirable responding or Socio-Economic Status, although an increased liking of vegetables was associated with higher social class. There was an increased incidence of (a) underweight in the Baby-Led group and (b) obesity in the Spoon-Fed group. No difference in picky eating was found between the two weaning groups.

Conclusions: Weaning style impacts on food preferences and health in early childhood. Our results suggest that infants weaned through the Baby-Led approach learn to regulate their

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3 food intake in a manner which leads to a lower BMI and a preference for healthy foods like
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5 carbohydrates. This has implications for combating the well-documented rise of obesity in
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7 contemporary societies.
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10 Article summary

11 Article focus

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17 - Although numerous studies have focused on when to introduce solid foods into an
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19 infant's diet there is a dearth of evidence concerning the impact of different weaning
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21 methods on food preferences and health.
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25 - Baby-Led Weaning is suitable for most infants and is associated with reduced
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27 maternal anxiety about weaning and feeding, and a maternal feeding style which is
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29 low in control.
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31 Key messages

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34 - Our study suggests that Baby-Led Weaning has a positive impact on the liking of
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36 foods that form the building blocks of healthy nutrition such as carbohydrates.
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40 - Baby-Led Weaning promotes healthy food preferences in early childhood which may
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42 protect against obesity.
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45 Strengths and limitations of this study

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47 One limitation of the present study is that we relied on self-report. However, using a self-
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49 report questionnaire is a standard approach when dealing with food preferences and we
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51 controlled for self-presentation effects (none were uncovered). A second criticism that may
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53 be levied here is our reliance on a small sample size. However, we used a matched-sample
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55 and report robust effect sizes.
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Introduction

How should solid foods be introduced to infants? Do different weaning methods impact on food preferences and health-related outcomes? These questions are currently unanswered. To date, the focus on weaning has been on when, rather than how, to wean¹. Recently much media attention has centred on Baby-Led Weaning^{2,3} which emphasises infant self-feeding with solid finger foods from the outset rather than parental spoon feeding with purees. Baby-Led Weaning is suitable for most infants⁴, is associated with (i) reduced maternal anxiety about weaning and feeding⁵ and (ii) a maternal feeding style which is low in control⁶. However, the impact of this weaning method on food preferences and health-related outcomes is not known. Thus, we examined the influence of different weaning styles on food preference, BMI and picky eating in early childhood.

Method

Parents of 155 children (aged 20-78 months) were recruited to the study between June 2006 and January 2009. The Baby-Led group ($n=92$) was recruited via an advert posted on relevant internet sites; the Spoon-Fed group ($n=63$) was recruited from our toddler lab database.

Participants completed a questionnaire (a standard research tool for examining food preferences⁷) concerning the following. (i) Infant feeding and weaning style. (ii) Child's preference (rated from 1 "loves it" to 5 "hates it") for 151 foods (adapted from Wardle *et al.*, 2001⁸), which was analysed by standard food categories e.g. carbohydrates, proteins, dairy⁹, and included a category called 'meals' for whole meals like lasagne⁸. See supplementary information in eTable 1 for details. (iii) Exposure (frequency of consumption) rated from 1

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3 “more than once a day” to 7 “less than once per month”, as this is closely related to food
4 preferences^{10,11}. (iv) Picky eating (a single item requiring a ‘yes/no’ response to ‘Would you
5 classify your child as a picky eater?’). (v) Child height and weight for BMI calculation
6 (weight in kilograms divided by the square of the height in meters). In the Spoon-Fed group
7 these measurements were made using standardized procedures when assessed in our lab. We
8 calculated BMI z-scores using the WHO Growth Standards¹². BMI percentile ranks were
9 calculated using the Centers for Disease Control and Prevention Child and Teen BMI
10 Calculator¹³ and the National Health Service Choices BMI Calculator¹⁴ (which uses UK90
11 reference data for children over 4 years¹⁵ and WHO Growth Standards data for children under
12 4 years)¹². (vi) Socio-Economic Status (via postcode using the Income Deprivation Affecting
13 Children Index (IDACI) score and rank for 2007 and National Statistics 2001 Area
14 Classification of Super Output Areas and Data Zones (SOA))¹⁶. These measures are
15 frequently used in social and health related research with children and by government
16 departments¹⁷. Socio-Economic Status has been shown to influence eating practices and
17 behaviours¹⁸⁻²⁰. (vii) Marlowe-Crowne Social Desirability Scale (short form)²¹. Parents who
18 returned a completed questionnaire were entered into a prize draw for £50. Ethical approval
19 was granted by the University of Nottingham School of Psychology Ethics Committee.
20 Parents completed a consent form prior to participation in the study.

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23 Data were analyzed using PASW Statistics 18.0²². Pearson’s correlations and t-tests
24 were used to examine relationships between outcome measures and groups respectively. Non-
25 parametric tests (Spearman’s rank correlations, Mann-Whitney *U*) were used when there was
26 significant skew or problems with homogeneity (Bonferroni-corrected for multiple
27 comparisons). Missing food preference data was accounted for in the calculation of averages
28 across categories. Cases with other missing data (e.g. BMI) were excluded from analyses.
29 Preliminary analyses showed that exposure and preference ratings were not contaminated by
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socially desirable responding and only liking of vegetables was significantly related to Socio-Economic Status (IDACI score), ($r_s = -.25, p=.005$) (higher social class associated with increased liking of vegetables).

As no formal definition of Baby-Led Weaning exists⁶ parental self-report of weaning style was used to generate weaning groups. To verify the veracity of self-reported weaning style responses to items concerning weaning methods were interrogated. This confirmed that the Baby-Led children were more likely to have handled food from the introduction of solid foods, were given finger foods earlier and fewer had been spoon-fed with puréed foods at all (Table 1). Thus, the two groups differed significantly on criteria typically used to characterise Baby-Led Weaning⁶.

Results

Insert Table 1 here

The Baby-Led group was significantly younger than the Spoon-Fed group (Table 1) and overall age and preference were significantly correlated (collapsed across food categories, $r_s = .28, p=.001$; and for the individual food categories of dairy, $r_s = .35, p<.0001$; snacks, $r_s = .21, p<.009$ and meals, $r_s = .26, p=.001$). To control for this effect of age a case-controlled aged-matched sample of 74 participants (37 pairs) was generated to analyze the food preference data (see Table 2 for details).

Between the two weaning groups, significant differences in preference were found for only one food category – the Baby-Led group liked carbohydrates more than the Spoon-Fed group, $t(72)=-3.11, p=.003, d=-.53$. Indeed, carbohydrates was the most liked food category for the Baby-Led group whereas sweet foods was most liked by the Spoon-Fed group (Table 2). The Baby-Led group also liked proteins ($t(72)=-2.71, p=.008, d=-.63$) and whole meals

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($U= 448.00, p=.02, d = -.40$) more than the Spoon-Fed group but these differences did not survive Bonferroni adjustment.

Insert Table 2 here

Next we investigated the effects of exposure on food preferences in the matched sample^{10,11} (Table 3). Across group comparisons revealed increased exposure to vegetables, fruit, carbohydrates, protein, meals and sweets in the Spoon-Fed group. Exposure was significantly associated with liking of dairy foods ($r_s = .58, p<.0001$), snacks ($r_s = .1, p<.001$), vegetables ($r_s = .47, p<.0001$) and proteins ($r_s = .44, p<.0001$). No association was found for carbohydrates ($r_s = 0.19, p=.11$), sweet foods ($r_s = .19, p=.11$), fruits ($r_s = .10, p=.39$) and meals ($r_s = .17, p=.14$). This suggests that, for carbohydrates, the only food category with significant group differences, weaning style was more influential than exposure on preference ratings.

Insert Table 3 here

Finally we investigated the influence of weaning method on health-related outcomes. BMI scores (percentile rank) differed significantly between groups (Table 1) – lower BMI were associated with Baby-Led Weaning in the whole sample. (This difference was also evident in the matched sample - NHS percentile rank ($U= 276.50 p=.008$) and CDC percentile rank ($U=268.50, p=.005$). As can be seen from Table 1 the mean percentile rank BMI for the Baby-Led group was close to the expected average (percentile rank of 50) for both the NHS and CDC classification systems. In contrast, the mean percentile rank for the Spoon-Fed group was above the average level, indicating more children in this group were likely to be classed as overweight.

BMI z-scores were also found to differ significantly between the weaning groups (see Table 4). To investigate this further we determined the number of children in each group classified as significantly underweight (z-score >-2) and those who were obese (z-score of $>+2$) – clinically the most concerning cases. Using this criterion we found there to be an increased incidence of obese children in the Spoon-Fed group ($n=8$) as compared to the Baby-Led group ($n=1$). In contrast, more children in the Baby-Led group were classified as significantly underweight ($n=3$) compared to the Spoon-Fed group ($n=0$) (Fishers exact test, $p=.02$, two-tailed). A similar pattern of results was found when child BMI was classified according to percentile rank (see Table 4).

Table 4 about here

BMI (WHO z-score) was not correlated with socially desirable responding in the Baby-Led group (where self-report of height and weight measurements was used, $r_s = -.13$, $p=.29$). Also BMI (WHO z-score) did not correlate with Socio-Economic Status (IDACI score) ($r_s = -.07$, $p=.51$), or breastfeeding duration ($r_s = -.10$, $p=.29$) in the whole sample. (There was also no correlation between BMI scores and breastfeeding duration in the matched sample ($r_s = -.11$, $p=.43$)). The same pattern of results was found when using the percentile rank BMI measures. (No difference between the two weaning groups was found in the prevalence of picky eaters (Table 1).

Discussion

Understanding the factors that contribute to healthy nutrition in early childhood is crucial as this could be the optimal time to modify food preferences so as to foster healthy diets in obesigenic food environments¹⁰. Our findings show that Baby-Led Weaning has a positive

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3 impact on the liking of carbohydrates - foods that form the building blocks of healthy
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5 nutrition (i.e. those found at the bottom of the food pyramid)⁹. This is a significant finding
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7 since, to date, the factors thought to be most influential on early food preferences are
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9 sweetness and familiarity (exposure)¹⁰. Consistent with previous research the Spoon-Fed
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11 group preferred sweet foods most, whereas the Baby-Led group most preferred carbohydrates
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13 (even though significantly higher exposure to carbohydrates was reported in the Spoon-Fed
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15 group).
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19 Children weaned using the Baby-Led method are more likely to encounter
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21 carbohydrates in their whole food format earlier than Spoon-Fed children as these foods are
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23 ideal early finger foods (e.g. toast and pitta breads) so **age of introduction may impact on**
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25 **behaviour**. However, our data show that exposure *per se* did not influence preference for
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27 carbohydrates, so another factor must be driving preference here. Presenting carbohydrates to
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29 infants in their whole food format, such as toast, rather than a puréed form may highlight
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31 awareness of perceptual features (such as texture) that is masked when food is puréed.
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33 Previous research has shown that food presentation significantly influences food
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35 preferences²³, so it is possible that differences in the presentation of foods across the two
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37 weaning groups impacted on preferences. It is also possible that carbohydrates are easier to
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39 masticate compared to some other foods such as meat (which may be easier to eat when
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41 pureed and spoon-fed). Interestingly, the Baby-Led group showed increased preference for
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43 all food categories except sweets compared to the Spoon-Fed group (although this was only
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45 significant for carbohydrates).
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51 **Our results also showed that Baby-Led Weaning was associated with lower BMI (in**
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53 **terms of mean percentile rank) that could not be accounted for by differences in birth weight,**
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55 **parental BMI or Socio-Economic Status. The analysis of BMI z-scores revealed an increased**
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57 **incidence of underweight the Baby-Led children (3/63) and an increased incidence of obesity**
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3 the Spoon-Fed children (8/63). It should be noted that there was some missing data on BMI
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5 in the Baby-Led group (32%). However, in both groups the vast majority of the children were
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7 of an average/healthy weight (see Table 4). In contrast to past literature²⁴ breastfeeding
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9 duration and BMI were not significantly associated. This discrepancy may be due to the fact
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11 that the vast majority of the mothers in this sample breast fed their babies and for much
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13 longer periods of time than might be expected from past research²⁵. Nonetheless, duration of
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15 breastfeeding may have a mediating effect which requires investigation in relation to the
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17 impact that weaning style has on BMI. No difference in the prevalence in picky eating was
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19 found across groups. Moreover, 93.5% of the Baby-Led group reported that their child had
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21 never experienced a choking incident (a serious concern for parents and practitioners)².

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26 Our results suggest that Baby-Led Weaning promotes healthy food preferences in
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28 early childhood that could protect against obesity. This finding is of note given the serious
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30 problems with childhood obesity facing many modern societies²⁶. The Baby-Led approach
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32 was, however, associated with a higher incidence of underweight relative to the Spoon-Fed
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34 group. The factors underlying this require exploration in future research.

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38 To the best of our knowledge, this is the first study to have examined the impact of
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40 weaning method on food preferences and health outcomes in early childhood. Future research
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42 should determine whether our findings hold for more specialist populations, such as babies
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44 born prematurely or with specific health difficulties. Moreover, careful consideration should
45
46 be given to the classification of weaning method. In the present study we relied on parents
47
48 identifying themselves as having used Baby-Led Weaning (and we checked the reliability of
49
50 this self-report by asking some specific questions about their weaning practices). This gave
51
52 rise to a dichotomous variable – either the parents used Baby-Led Weaning or they did not.
53
54 However, it may be more sensitive to consider weaning methods as a continuum where
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56 parents rate the percentage use of pureed foods in their child's diet over time⁵. In addition,
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3 previous studies have shown that parents who used the Baby-Led approach to weaning are
4 less controlling and more willing to hand control over to the child when introducing solid
5 foods⁶. Future research needs to address the contribution of this factor into any effect of
6 weaning method on food preferences.
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12 A large, controlled prospective study is now required which examines weaning
13 practices in tandem with the other key factors including BMI, milk feeding practices (breast
14 vs. bottle/formula fed), Socio-Economic Status, locus of control, and picky eating. In
15 particular, a study is needed that includes a greater proportion of children who have been
16 formula/bottle fed in order to compare the relative impacts of weaning method and milk
17 feeding practices on food preferences and health outcomes in early childhood.
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29 **Acknowledgments:** Dr Sarah Knowles BSc (Hons), MSc, PhD (now at School of
30 Community Based Medicine, University of Manchester, UK) assisted with data collection
31 and input. Joanne Pybis BSc (Hons), MSc (now at British Association for Counselling and
32 Psychotherapy) assisted with the data collection for the Spoon-Fed group as part of her PhD
33 research funded by the Economic and Social Research Council (ESRC). We thank the parents
34 who took part in the study from the Nottingham Toddler lab, the 'I Want My Mum forum'
35 and the 'Baby-Led Weaning forum'. We thank Professor Paul McGraw and Dr Scott
36 Campbell for comments on an earlier draft of this paper.
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47 **Competing interests:** Within the last five years ET and NP have received co-funding from
48 Nutricia/Danone to support an ESRC CASE PhD studentship.
49
50
51

52 **Funding:** The study was funded by a School of Psychology (University of Nottingham)
53 pump-priming grant. The researchers are independent of the funders. Our funders had no role
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3 in the design and conduct of the study; collection, management, analysis, and interpretation
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5 of the data; and preparation, review, or approval of the manuscript.
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7

8 **Author contributions.** ET and NP designed the study and secure the funding for it. ET
9
10 collected and analysed the data and wrote the paper. NP contributed to the analysis and write
11
12 up of the paper. ET is the guarantor for the study and both authors had full access to all of the
13
14 data in the study and take responsibility for the integrity of the data and the accuracy of the
15
16 data analysis. With regards to data sharing, consent was not obtained but the presented data
17
18 are anonymous and the risk of identification is low.
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22 The Corresponding Author has the right to grant on behalf of all authors and does grant on
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Tables and figures

Table 1. Outcomes on weaning style and infant feeding, Socio-Economic Status scores, picky eating and BMIⁱ

Characteristics	Baby-Led (n=92)	Spoon-Fed (n=63)	P value
Child age at testing (months)	32.12 (10.30)	41.62 (13.58)	<.0001
Female [†]	57.6% [53/92]	39.7% [25/63]	.03
Handled food from introduction of solids	96.7% [89/92]	15.87% [10/63]	<.0001
Exposed to pureed food	32.6% [30/92]	100% [63/63]	.0001
First exposed to finger food (age in months)	6.49 (1.41)	7.10 (1.63)	.001
Child was breast fed*	98.9% [91/92]	88.9% [56/63]	.008
Duration (months) of breast feeding	23.70 (11.27)	9.50 (9.30)	<.0001
Socio-Economic Status: IDACI score	.11 (.08)	.14 (.11)	.17
Socio-Economic Status: IDACI rank	19566.81 (8304.26)	21679.33 (7218.74)	.16
Birth weight (lbs/oz)	7.64 (2.70)	7.09 (1.31)	.09
Child BMI: NHS UK Percentile rank	54.38 (28.91)**	64.79 (26.20)	.05
Child BMI: CDC US Percentile rank	48.46 (29.71)**	61.44 (26.98)	.009
Parent BMI	24.08 (5.46)	24.91 (1.31)	.91
Child is picky eater	18.5% [17/92]	23.8% [15/63]	.43

ⁱMeans and standard deviations are shown in brackets for continuous variables. Analyses were conducted on the whole sample. [†]In the matched sample (used to analyze weaning style preference data) there was no gender difference (Table 2). *There was no difference in breast-feeding between the groups in the matched sample (92% were breast fed in the Spoon-Fed group compared to 97% in the Baby-Led group), ($\chi^2 = .30$, $p = .62$). **BMI data were missing from 29/92 (32%) because parents had not weighed or measured their child recently. Within the Baby-Led group there was no difference in preference ratings between those children with BMI scores and those without (max $U = 151.5$, $p = .88$, for protein).

Table 2. Mean preference ratings by weaning group (presented in order of liking for each group)ⁱ

Baby-Led group (<i>n</i> =37; females=17)	Mean (SD)	Spoon-Fed group (<i>n</i> =37; females=15)	Mean (SD)
Carbohydrates	1.82 (.42)	Sweet foods	1.81 (.59)
Savoury snacks	1.83 (.59)	Savoury snacks	2.08 (.63)
Sweet foods	1.89 (.71)	Carbohydrates	2.12 (.41)
Fruit	1.97 (.58)	Fruit	2.15 (.46)
Protein	2.03 (.51)	Protein	2.38 (.60)
Dairy	2.25 (.89)	Dairy	2.44 (.97)
Meals	2.33 (.82)	Meals	2.62 (.62)
Vegetables	2.74 (.66)	Vegetables	2.87 (.62)

ⁱ Lower scores indicate greater liking. Case-controlled, chronological aged-matched pairs were formed. All cases and controls were matched for age. In 11 cases matches could be made using age alone – for each case there was one control participant of the same age. Where there were several control participants that matched a case on age we selected the control participant using age and Socio-Economic Status (*n*=20). Where more than one participant matched on age and Socio-Economic Status we then matched on gender (*n*=1). In some cases no information on Socio-Economic Status was available so matches were made using age and gender (*n*=5). There was no effect of gender in this matched sample ($\chi^2 = .22$, $p = .82$).

Table 3. Mean exposure ratings by weaning group - means and standard deviations presented¹.

Food category	Baby-Led group (<i>n</i> =37; females=17)	Spoon-Fed group (<i>n</i> =37; females=15)	<i>P</i> value	Effect size (<i>d</i>)
Carbohydrates	4.59 (.52)	4.07 (.69)	.001 ¹	.85
Savoury snacks	1.83 (.59)	2.08 (.63)	.13	-.41
Sweet foods	5.96 (.72)	4.64 (.79)	<.0001 ¹	1.78
Fruit	5.02 (.69)	4.31 (.45)	<.0001 ¹	1.22
Protein	4.97 (.70)	4.48 (.66)	.003 ¹	.72
Dairy	4.37 (1.41)	4.10 (1.00)	.30	.22
Meals	5.69 (.65)	5.02 (.75)	<.0001 ¹	.95
Vegetables	4.89 (.83)	4.42 (.67)	.005 ¹	.62

¹ Difference remains significant after Bonferroni adjustment for multiple comparisons (*. $.05/8 = .006$). Lower exposure scores indicate more frequent consumption.

Table 4. BMI by WHO z-scores and NHS/CDC percentiles by weaning group¹.

WHO z-score [†]	Baby-Led group (n=63)	Spoon-Fed group (n=63)
-3	1 (1.6%)	0 (0%)
-2	2 (3.2%)	0 (0%)
-1	5 (7.9%)	3 (4.8%)
0	39 (61.9%)	40 (63.5%)
1	15 (23.8%)	12 (19.0%)
2	1 (1.6%)	8 (12.7%)
3	0 (0%)	0 (0%)
NHS percentiles		
Underweight (<2)	3 (4.7%)	0 (0%)
Healthy weight (2-90)	51 (81.0%)	53 (84.1%)
Overweight (91-97)	9 (14.3%)	2 (3.2%)
Obese (98+)	0 (0%)	8 (12.7%)
CDC percentiles		
Underweight (0-4)	6 (9.5%)	1 (1.6%)
Healthy weight (5-85)	49 (77.8%)	47 (74.6%)
Overweight (86-95)	7 (12.7%)	8 (12.7%)
Obese (96+)	1 (1.6%)	7 (11.1%)

ⁱ Most participants had a BMI in the average/healthy range across measures. [†]WHO have suggested a set of cut-offs based on single standard deviation spacing. Thinness: <-2SD, Overweight: between +1SD and <+2SD, Obese: >+2SD

eTable 1. Food items and food categories

Fruits	Vegetables	Carbohydrates	Protein	Dairy	Sweet foods	Savoury snacks	Meals
Apple	Aubergine	Bagel	Bacon	Babybel	Banana Angel Delight	Cream cracker	Chicken soup
Banana	Avocado	Baguette	Baked beans	Blue cheese	Boiled sweet	Crisps	Cottage pie
Blackberry	Babycorn	Baked potato	Beef	Dairylea	Bourbon	Doritos	Curry
Blueberry	Broccoli	Boiled potato	Boiled egg	Red cheese	Cheesecake	Hoolahoops	Lasagne
Cherry	Butternut squash	Brown bread	Burger	White cheese	Chocolate Angel Delight	Onion baji	Macaroni cheese
Grape – green	Cabbage - green	Brown roll	Chicken		Chocolate digestive	Pork pie	Mushroom soup
Grape – red	Cabbage - red	Cheerios	Cod		Chocolate éclair	Quavers	Oxtail soup
Grapefruit	Carrot	Chips	Crabstick		Cookie	Ritz	Pie
Kiwi	Cauliflower	Cocopops	Fish finger		Cream Slice	Ryvita	Pizza
Mango	Celery	Cornflakes	Fried egg		Custard cream	Samosa	Spagetti bolognaise
Melon	Corn on cob	Croissants	Ham		Danish pastry	Sausage roll	Sweet/sour chicken
Orange	Courgette	Crumpet	Kidney beans		Dark chocolate	Spring roll	Tomato soup
Peach	Cucumber	Mashed potato	Lamb		Digestive	Tuc cracker	Vegetable soup
Pear	Mangetout	Muesli	Mackerel		Fairy cake - chocolate	Wotsits	
Pineapple	Mushroom	Naan bread	Pork		Fairy cake - plain		
Plum	Onion	Pancakes	Salami		Fruitcake		
Raspberry	Parsnip	Pasta	Salmon		Ice cream – chocolate		
Strawberry	Peas	Pitta bread	Sausage		Ice cream –strawberry		
Tangerine	Pepper- green	Potato waffle	Scrambled egg		Ice cream –vanilla		
Watermelon	Pepper - orange	Rice	Tuna		Jam doughnut		
	Pepper - red	Rice crispies	Tuna mayo		Jelly sweet		
	Pepper - yellow	Roast potato			Milk chocolate		
	Sweet corn	Shreddies			Strawberry Angel Delight		
	Sprouts	Sugar Puffs			White chocolate		
	Spinach	Weetabix					
	Tomatoes	White bread					
		White roll					
		Yorkshire pudding					

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STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

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
		(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 pre-specified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	4-6
		(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	6, 16
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	4-8
Bias	9	Describe any efforts to address potential sources of bias	6, 18
Study size	10	Explain how the study size was arrived at	6, 16
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	6-8
		(b) Describe any methods used to examine subgroups and interactions	6
		(c) Explain how missing data were addressed	5
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	6,16

		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(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	4,16
		(b) Give reasons for non-participation at each stage	4,16
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	15
		(b) Indicate number of participants with missing data for each variable of interest	15
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	-
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	15
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures	-
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	6-8
		(b) Report category boundaries when continuous variables were categorized	n/a
		(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	6-8,16
Discussion			
Key results	18	Summarise key results with reference to study objectives	8-11
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	8-11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8-11
Generalisability	21	Discuss the generalisability (external validity) of the study results	8-11
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	11

*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.