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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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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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

healthy foods like carbohydrates. This has implications for combating the well-documented rise of obesity in contemporary societies.

Article summary

Article focus

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

Key messages

- Our study suggests that Baby-Led Weaning has a positive impact on the liking of foods that form the building blocks of healthy nutrition such as carbohydrates.
- 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.

Strengths and limitations of this study

One limitation of the present study is that we relied on self-report. However, using a self-report questionnaire is a standard approach when dealing with food preferences and we controlled for self-presentation effects (none were uncovered). A second criticism that may 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 wean[1]. 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 infants[4], is associated with (i) reduced maternal anxiety about weaning and feeding[5] and (ii) a maternal feeding style which is low in control[6]. 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 preferences[7]) 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.,* 2001[8]), which was analysed by standard food categories e.g. carbohydrates, proteins, dairy[9], and included a category called 'meals' for whole meals like lasagne[8]. See eTable 1 for details. (iii) Exposure (frequency of consumption) rated from 1 "more than once a day" to 7

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

Results

Data were analyzed using PASW Statistics 18.0[19]. 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 across categories. Cases with other missing data (e.g. Body Mass Index) were excluded from analyses. Preliminary analyses showed that exposure and preference ratings were not

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 exists[6] 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 Weaning[6].

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

obesigenic food environments[10]. 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 preferences[20], 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

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 societies[21].

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.

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Author contributions. ET and NP designed the study and secured the funding for it. ET collected and analysed the data and wrote the paper. NP contributed to the analysis and write up of the paper. ET is the guarantor for the study and both authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the

data analysis. All authors have completed the Unified Competing Interest form at www.icmje.org/coi_disclosure.pdf (available on request from the corresponding author) and declare that ET and NP have no non-financial interests that may be relevant to the submitted work. With regards to data sharing consent was not obtained but the presented data 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 Index[i]

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

[i]Means 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 (χ^2= .22, *p*= .82).

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Table 3. Mean exposure ratings by weaning group - means and standard deviations presented[i].

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

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
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
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) 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
		(b) Indicate number of participants with missing data for each variable of interest	13
Outcome data	15*	Report numbers in each exposure category, or summary measures of exposure	13-15
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	5
		(*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

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

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

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		(*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
		(b) Indicate number of participants with missing data for each variable of interest	13
Outcome data	15*	Report numbers in each exposure category, or summary measures of exposure	13-15
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	5
		(*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

*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.

1

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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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

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

Article summary

Article focus

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

Key messages

- Our study suggests that Baby-Led Weaning has a positive impact on the liking of foods that form the building blocks of healthy nutrition such as carbohydrates.
- 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.

Strengths and limitations of this study

One limitation of the present study is that we relied on self-report. However, using a self-report questionnaire is a standard approach when dealing with food preferences and we controlled for self-presentation effects (none were uncovered). A second criticism that may

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 wean[1]. 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 infants[4], is associated with (i) reduced maternal anxiety about weaning and feeding[5] and (ii) a maternal feeding style which is low in control[6]. 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 preferences[7]) 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.,* 2001[8]), which was analysed by standard food categories e.g. carbohydrates, proteins, dairy[9],

and included a category called 'meals' for whole meals like lasagne[8]. See eTable 1 for details. (iii) Exposure (frequency of consumption) rated from 1 "more than once a day" to 7 "less than once per month", as this is closely related to food preferences[10, 11]. (iv) Picky eating (a single item requiring a 'yes/no' response to 'Would you classify your child as a picky eater?'). (v) Child height and weight for Body Mass Index calculation (for children aged 24 months and over) using the Centers for Disease Control and Prevention Child and Teen Body Mass Index Calculator[12] – in the Spoon-Fed group these measurements were made using standardized procedures when assessed in our lab. (vi) Socio-Economic Status (via postcode using the Income Deprivation Affecting Children Index (IDACI) score and rank for 2007 and National Statistics 2001 Area Classification of Super Output Areas and Data Zones (SOA[13])). These measures are frequently used in social and health related research with children and by government departments[14]. Socio-Economic Status has been shown to influence eating practices and behaviours[15-17]. (vii) Marlowe-Crowne Social Desirability Scale (short form)[18] . Parents who returned a completed questionnaire were entered into a prize draw for £50. Ethical approval was granted by the University of Nottingham, School of Psychology Ethics Committee. Parents completed a consent form prior to participation in the study.

Results

Data were analyzed using PASW Statistics 18.0[19]. 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

across categories. Cases with other missing data (e.g. Body Mass Index) were excluded from analyses. Preliminary analyses showed that exposure and preference ratings were not 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 exists[6] 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 Weaning[6].

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 (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 environments[10]. 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 preferences[20], 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 pureed 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).

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 societies[22].

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

percentage use of pureed foods in their child's diet over time[5]. In addition, previous studies have shown that parents who used the Baby-Led approach to weaning are less controlling and more willing to hand control over to the child when introducing solid foods[6]. Future research needs to address the contribution of this factor into any effect of weaning method on food preferences.

A large, controlled prospective study is now required which examines weaning practices in tandem with the other key factors including Body Mass Index, milk feeding practices (breast vs. bottle/formula fed), Socio-Economic Status, locus of control, and picky eating. In particular, a study is needed that includes a greater proportion of children who have been formula/bottle fed in order to compare the relative impacts of weaning method and milk feeding practices on food preferences and health outcomes in early childhood.

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Competing interests: Within the last five years ET and NJP have received co-funding from Nutricia/Danone to support an ESRC CASE PhD Studentship.

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in the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

Author contributions. ET and NP designed the study and secured the funding for it. ET collected and analysed the data and wrote the paper. NP contributed to the analysis and write up of the paper. ET is the guarantor for the study and both authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. With regards to data sharing consent was not obtained but the presented data 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 Index[i]

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

[i]Means 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), (χ =.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 (χ^2= .22, *p*= .82).

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Table 3. Mean exposure ratings by weaning group - means and standard deviations presented[i].

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

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

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

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

Article summary

Article focus

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

Key messages

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

Strengths and limitations of this study

One limitation of the present study is that we relied on self-report. However, using a self-report questionnaire is a standard approach when dealing with food preferences and we controlled for self-presentation effects (none were uncovered). A second criticism that may 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 wean[1]. 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 infants[4], is associated with (i) reduced maternal anxiety about weaning and feeding[5] and (ii) a maternal feeding style which is low in control[6]. 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 preferences[7]) 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.,* 2001[8]), which was analysed by standard food categories e.g. carbohydrates, proteins, dairy[9], and included a category called 'meals' for whole meals like lasagne[8]. See supplementary information in eTable 1 for details. (iii) Exposure (frequency of consumption) rated from 1

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

Data were analyzed using PASW Statistics 18.0[22]. 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 across categories. Cases with other missing data (e.g. BMI) were excluded from analyses. Preliminary analyses showed that exposure and preference ratings were not 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 exists[6] 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 Weaning[6].

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

(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 environments[10]. 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 (i.e. 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) so age of introduction may impact on behaviour. 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 preferences[23], 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 pureed 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).

Our results also showed that Baby-Led Weaning was associated with lower BMI (in terms of mean percentile rank) that could not be accounted for by differences in birth weight, parental BMI or Socio-Economic Status. The analysis of BMI z-scores revealed an increased incidence of underweight the Baby-Led children (3/63) and an increased incidence of obesity

the Spoon-Fed children (8/63). It should be noted that there was some missing data on BMI in the Baby-Led group (32%). However, in both groups the vast majority of the children were of an average/healthy weight (see Table 4). In contrast to past literature[24] breastfeeding duration and BMI were not significantly associated. This discrepancy may be due to the fact that the vast majority of the mothers in this sample breast fed their babies and for much longer periods of time than might be expected from past research[25]. Nonetheless, duration of breastfeeding may have a mediating effect which requires investigation in relation to the impact that weaning style has on BMI. No difference in the prevalence in picky eating was found across groups. 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].

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

To the best of our knowledge, 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 percentage use of pureed foods in their child's diet over time[5]. In addition,

previous studies have shown that parents who used the Baby-Led approach to weaning are less controlling and more willing to hand control over to the child when introducing solid foods[6]. Future research needs to address the contribution of this factor into any effect of weaning method on food preferences.

A large, controlled prospective study is now required which examines weaning practices in tandem with the other key factors including BMI, milk feeding practices (breast vs. bottle/formula fed), Socio-Economic Status, locus of control, and picky eating. In particular, a study is needed that includes a greater proportion of children who have been formula/bottle fed in order to compare the relative impacts of weaning method and milk feeding practices on food preferences and health outcomes in early childhood.

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Author contributions. ET and NP designed the study and secure the funding for it. ET collected and analysed the data and wrote the paper. NP contributed to the analysis and write up of the paper. ET is the guarantor for the study and both authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. With regards to data sharing, consent was not obtained but the presented data are anonymous and the 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 BMI[i]

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

[i]Means 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), (χ^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 (*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. 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 (χ^2= .22, *p*= .82).

Table 3. Mean exposure ratings by weaning group - means and standard deviations presented[i].

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.

Table 4. BMI by WHO z-scores and NHS/CDC percentiles by weaning group[i].

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*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—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 *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	4-6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—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*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	6,16

		Cross-sectional study—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) *Cohort study*—Summarise follow-up time (eg, average and total amount)	-
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	-
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	15
		Cross-sectional study—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.