Tracking of toddler fruit and vegetable preferences to intake and adiposity later in childhood

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Abstract

This study examined whether toddlers' liking for fruit and vegetables (FV) predicts intake of FV later in childhood, how both relate to childhood adiposity and how these were moderated by factors in infancy. Children in the Gateshead Millennium Study were recruited at birth in 1999-2000. Feeding data collected in the first year was linked to data from a parental questionnaire completed for 456 children at age 2.5 years (30m), and to anthropometry, skinfolds and bioelectrical impedance (BIA) and 4 day food diary data collected for 293 of these children at age 7 years. Aged 30 months, 50% of children were reported to like 8 different vegetables and 3 fruits, but at 7 years children ate a median of only 1.3 (range 0-7) portions of vegetables and 1.0 portion of fruit (0-4). Early appetite, feeding problems and food neophobia showed significant univariate associations with liking for FV aged 30m, but the number of vegetables toddlers liked was the only independent predictor of vegetable consumption at age 7 years (odds ratio (OR) 1.28 $p<0.001$). Liking for fruit aged 30m also independently predicted fruit intake (OR 1.31 $p=0.016$), but these were also related to deprivation (OR 2.69 $p=0.001$) maternal education (OR=1.28 $p=0.039$) and female gender (OR 1.8, $p=0.024$). Children eating more FV at age 7 years had slightly lower body mass index and skinfolds. An early liking for FV predicted increased later intake, so increasing early exposure to FV could have long term beneficial consequences.

Key words: Obesity, vegetables, body composition, eating behaviour, child

Key Messages

- Aged 30m, half the children were reported to like at least eight different vegetables and three fruits, but by age seven years reported median intake was just 2.5 portions of FV per day, half the recommended intake.
- An early liking for fruit and vegetables predicted later intake and this was not explained by socio-economic differences
- Intake of fruit and vegetables was weakly related to lower adiposity

Introduction

There are many clear benefits to fruit and vegetable (FV) consumption, from childhood onwards, in enriching the fibre and micronutrient content of the diet while reducing its energy density. Despite this, actual intake levels remain low, particularly in children (Tepper et al., 2009, Bates et al., 2014). People tend to eat foods they like and enjoy (Resnicow et al., 1997) and many children dislike vegetables, possibly because of their bitter / sour flavour (Beauchamp and Mennella, 2009). Children have an innate preference for sweet and salty tastes over bitter and sour tastes (Berridge, 2000, Schwartz et al., 2009) and studies in older children found that they prefer fatty, sugary foods most and vegetables least (Cooke and Wardle, 2005). This is likely to impact on the learned element of food preference (Birch and Fisher, 1998) and early preferences appear to track over time (Nicklaus et al., 2004, Blossfeld et al., 2007). Thus, gaining an understanding of food preference development in the early years could inform strategies to influence lifelong healthy eating patterns. Toddlers and young children tend to be neophobic to new foods, but very young infants usually accept new foods and tastes well, as long as they receive repeated exposures (Maier et al., 2007). Recent experimental research has demonstrated that if vegetables are tasted early they can be well accepted (Hausner et al., 2012, Caton et al., 2013, Hetherington et al., 2015)

Previous longitudinal studies have found that intake of home-cooked and raw FV in early childhood predicts increased intake later childhood (Coulthard et al., 2010) with other influences being the child's faddiness /pickiness), mother's intake and parental rules (Jones et al., 2010, Skinner et al., 2002). Studies in 4 European countries, including the UK (de Lauzon-Guillain et al., 2013, Jones et al., 2015) and from Canada (Burnier et al., 2011) also found that longer breast feeding duration predicted higher FV intake in children aged 2-4 years and that maternal FV intake did not explain the association. It has been suggested that increasing FV intake is important for childhood obesity prevention (Epstein et al., 2008) and one study found an inverse association between body mass index (BMI) and FV intake in children (Heo et al., 2011). Thus the early complementary feeding (CF) period, where solids food are gradually added to supplement breast milk, may be a critical time for the development of taste preferences. However there are still only a few, relatively small studies that have tracked actual taste preference from infancy into childhood: so it is still not clear if that period is actually critical to later eating behaviour and adiposity. The Gateshead Millennium Study (GMS) birth cohort presented an opportunity to examine this question. While not originally set up for this purpose, mothers were surveyed when their child was 2½ years (30m) about whether a range of foods had been tasted and liked as part of a study of feeding behaviour problems. Then at the age of 7 years the study assessed children's actual intake of food both at home and at school, as well as collecting a wide range of anthropometric measurements. It was thus possible to examine the extent to which reported food preferences as a toddler tracked on to later eating behaviour and adiposity.

However simply describing an association is not enough, as dietary patterns are strongly related to socio-economic characteristics, so their potentially confounding role needed to be explored and adjusted for if necessary. Earlier analyses in the GMS cohort have already found enduring associations between infant weight gain and maternal rating of the child's appetite (Wright et al., 2006b), so we also had to consider the possibility that liking for FV simply reflects overall enthusiasm for food. We thus designed a series of analyses to first examine two main hypotheses:

- That children with the highest exposure to and liking for FV at age 30m would go on to eat more portions of FV at age 7 years
- That children with the greatest early liking for FV and the highest intake in childhood would have the lowest level of adiposity.

We then aimed to formally test the further hypotheses that:

- children with higher appetite would like and eat more FV, while those with feeding problems and neophobia would eat less
- children from more affluent or educated families and those with the longest breast feeding duration and the earliest onset of solid feeding would like and eat more FV
- these associations may confound the association between early preference and later intake.

Method

Participants

This analysis uses data from the Gateshead Millennium Study (GMS), a population based cohort study of feeding and growth which recruited mothers of 1029 infants shortly after birth in 1999-2000 (Parkinson et al., 2011). The cohort were predominantly white Caucasian, reflecting the makeup of the region. Children from a religious community who made up 3% of the original cohort were excluded due to their very different lifestyles and dietary patterns (Wright et al., 2010), and preterm infants were also excluded. Ethical approval for this study was obtained from the Gateshead and South Tyneside Local Research Ethics Committee.

Procedure

Families were sent 5 postal questionnaires during the first year and another at 30m. Participants and their familes were then studied in school and at home at the age of 7 years. For this analysis data from the 30m questionnaires (Wright et al., 2007a) and dietary intake records and anthropometry collected at age 7 years were analysed as well as baseline and behavioral data collected in the first year (Wright et al., 2006b).

Measures

Demographic variables

The family postcode at birth was used to allocate their residential area to a deprivation quintile compared to the deprivation levels for the UK Northern region (Townsend et al., 1988). In addition the roughly 50% families lacking one or more of three amenities (wage earner in household, own home, own car) at birth were defined as relatively deprived (Wright et al., 2006c).

Eating behaviour variables

The age at which children were introduced to complementary foods and length of breastfeeding had been captured during the first year (Wright et al., 2004, Wright et al., 2006a) and mothers were asked to rate their child's "appetite" at age 6 weeks and 12 months on a 5 point scale from 'very good' to 'very poor'. An eating avidity score (a more global measure of enthusiasm for food) was also determined at 13 months, using a scoring system based on questionnaire responses regarding children's feeding behaviour described previously (Wright et al., 2011). In the 30m questionnaire parents rated their child's preference for unfamiliar foods on a 5 point scale recoded to 'dislikes', 'no preference', 'likes'. In addition parents were asked if they felt their child generally had a "feeding problem" or specifically showed problematic poor eating, faddiness or mealtimes behaviour (described in detail (Wright et al., 2007a)).

Toddler fruit and vegetable preference and exposure

The 30m questionnaire included a modified food preference questionnaire based on the Survey of the Diets of British School children (Department-of-Health, 1989) already used in older children (Drewett et al., 2006). This included 11 vegetables (carrots, tomatoes, baked beans, peas, cabbage, lettuce, cucumber, onions, okra, yam, gourd) and 7 fruits (oranges, apples, banana, tinned peaches, mangoes, lychees, guava) and carers were asked to indicate their child's like or dislike of each food item using a rating scale (1=dislikes a lot, 2=dislikes a little, 3=neither likes nor dislikes, 4=likes a little, 5=likes a lot, 6=never tried). Four test items (yam, okra, gourd and guava) were included to detect individuals who had ticked all options due to questionnaire fatigue, given the low availability of these items in the UK at the time of data collection. However there was no evidence of this effect so no questionnaires were excluded from the dataset and these items were left in to allow assessment of exposure to more obscure fruits and vegetables. For each child the number of vegetables, fruits and FV combined tried and liked was calculated.

7 year fruit and vegetable intake

FV intake was assessed at 7 years using FAST (Food Assessment in Schools Tool). This is a prospective dietary assessment method which incorporates elements of the food diary and food frequency methods, which was designed specifically for use by non-specialists to record food intake of primary-school children over 4 days (Adamson et al., 2003, Basterfield et al., 2014). This tool has previously been compared to 4-day weighed intake and shown to be as reliable at characterising the average number and weight of portions eaten (Adamson et al., 2003). Researchers and lay observers recorded foods eaten by each child during the school day, and parents and other carers recorded foods eaten at all other times. In line with the FAST protocol, observers were all advised to record consumption of one portion of any food item as long as one or more mouthful was eaten. All foods consumed were allocated to one of 43 food groups which included 'fruit' 'fruit juice' and 'vegetable'. Total 4-day portions were used to calculate average number of daily portions of fruits, vegetables and total FV. Potatoes were not included and fruit juice was counted separately, in line with UK recommendations (Public-Health-England, 2013).

Anthropometric variables

Children's length and weight were obtained by the GMS study nurse at a 13 month health check clinic. At 7 years the research staff measured height (Leicester portable measure) and weight and leg-to-leg bioelectrical impedance (BIA) using the Tanita TBF-300MA. Triceps and subscapular skinfolds were measured using Holtain skinfold callipers (Wright et al., 2012).

Statistical Analyses

Statistical analysis was carried out using the Statistical Package for the Social Sciences for Windows version 21.0 (IBM Corp., Armonk, NY, USA). Height and weight were converted into Z scores compared to the UK 1990 (Freeman et al., 1995) and skinfolds to Tanner's reference (Tanner and Whitehouse, 1975); BIA measures were converted into Z scores for fat and lean adjusted for height and age standardised to reference data from the Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) cohort, using a method described earlier (Sherriff et al., 2009).

Separate counts for fruit, and vegetable consumption were low on average and upwardly skewed, so the associations with 30 month liking and exposure was assessed using Spearman's correlations and the independence of predictors of intake was assessed using two separate multiple logistic regression models with a binary outcome of ≤ 1 portion per day, > 1 portion per day. The combined total FV intake was normally distributed, so a linear regression analysis approach could be used to assess the independence of predictors of total FV intake. For the assessment of predictors of intake all multivariable models were constructed by first entering all predictor variables with a p-value of 0.1 or less on univariate analysis. The least predictive non-significant variables were then removed sequentially and regression repeated until only significant independent predictors remained in the model. Linear regression was also used to assess the extent to which the association of total FV intake with adiposity was confounded by socio demographic factors; for these models maternal education, Townsend deprivation score and height SDS were forced into the model with total FV.

Results

Table 1 provides a description of the socio-demographic characteristics of participants and Figure one details the number included at each stage. Postal questionnaires at 30m were completed by 456 (49%) parents. The 7-8 year wave was completed by 550 children; 293 (32%) with 30m food preference data and a FAST food diary. This subsample were relatively less deprived and more educated than the cohort as a whole, but a substantial proportion of all social strata were still represented (Table 1).

At age 30m the children were reported as liking a median of 4 vegetables and 3 fruits of those listed (Table 2). Of the common vegetables the most popular were carrots and baked beans and the least popular were onions and lettuce. At 7 years children ate a median (Inter quartile range) of only 1.3 (0.5 to 2.0) portions of vegetables and 1.0 (0.63 to 1.75) of fruit averaged over 4 days, giving a median total FV intake of 2.5 portions per day (1.5 to 3.5). If fruit juice was included this increased to 3.0 (1.8 to 4.3).

Liking for FV at 30m was significantly positively associated with intake at 7 years, and the number of FV tried at 30m was also significantly predictive of FV intake, but not the number of fruits tried (Table 3). When placed together in a linear regression model with total intake as outcome (Table 4) , toddler liking for both vegetable and fruit remained independently predictive, while the number tried did not. The combined model predicted around 10% of the variance in later intake (Veg liked beta = 0.22; fruit liked beta=0.16 all $P<0.001$; adjusted R^2 0.10).

At age 7 years intake of FV was weakly inversely related to BMI, BIA fat and skinfolds Z scores. Adjustment for maternal education and deprivation score tended to slightly attenuate the associations, so that only the association with skinfolds remained significant (Table 4). No other significant associations were found.

Appetite at 12 months and 30m were significantly positively associated with vegetable liking at 30m, but not later intake (Table 5). The eating score at age 12m was unrelated to both toddler preferences and later intake (data not shown). Dislike of unfamiliar foods (neophobia) and feeding problems showed significant negative associations with toddler's liking and trying of FV, but only neophobia significantly predicted vegetable and FV intake at 7 years.

Toddler's FV preference and exposure were largely unrelated to socio-demographic characteristics and where there were associations they were inconsistent, with more deprived mothers reporting their toddler to like vegetables slightly more, while more educated mother reported more liking for fruit. At age 7 years FV intake was higher in more affluent and more educated families. Breast feeding duration and age of CF showed no association with toddler liking and trying of FV (Table 6).

In multivariate logistic regression the number of vegetables liked aged 30m was the only independent predictors of vegetable consumption at age 7 years (Table 7) while whether breast fed was the only other variable approaching significance (OR 1.19 p=0.08). Similarly liking for fruit aged 30m was a significant independent predictor of higher fruit intake aged 7 years, but fruit intake was also associated with relative deprivation; liking for vegetables (OR 1.13 p=0.06) and lower maternal education (OR 0.64 p= 0.09) were also borderline significant predictors (table 7). Using multivariate linear regression with total FV intake aged 7-8years as a continuous outcome, liking for fruit and for vegetables aged 30m were independent predictors as well as relative deprivation (table 7).

Discussion

This study adds to the evidence regarding predictors of FV intake by analysing toddlers' liking and trying of FV in the UK, using longitudinal data from a cohort study. As toddlers the participants were reported to like 8 different vegetables and 3 fruits. However by age seven reported intake was about half the recommended level, with a median intake of just 2.5 portions of FV per day.

We hypothesised that children with the highest exposure to and liking for FV at age 2½ years would go on to eat more portions of FV at age 7 years and toddler liking was strongly associated with later intake, which suggests that an early liking for FV tracks into childhood and influences later intake. This is in keeping with a previous review (Rasmussen et al., 2006) and a smaller US cohort study (Skinner et al., 2002).

Socio-economic factors are well recognised correlates of FV intake so it was not surprising that they were the strongest predictor of total FV intake. This has been shown in earlier studies in children (Jones et al., 2010) and FV intake has been shown to decline as food insecurity increases (Kendall et al., 1996). Remarkably, though, there was no clear association between toddler FV liking and socio-economic factors.

Previous research on this cohort found parental rated appetite to be positively related to both weight gain (Wright et al., 2006b) and to total number of foods liked (Wright et al., 2007b) so we hypothesised that children with higher appetite would like and eat more FV and that could have resulted in a spurious positive association between early FV liking and adiposity. However, while evidence was found for an association between appetite at 12m and 30m and liking for vegetables, there was no association with later intake; indeed early liking showed a non-significant but negative association with adiposity. Parent-perceived feeding problems and dislike for unfamiliar foods were not surprisingly associated with fewer FV liked and tried as a toddler and dislike for unfamiliar foods also predicted later intake. This is in keeping with a previous study that found food neophobia to be one of the strongest predictors of later food preference (Skinner et al., 2002).

Previous studies have reported positive relationships between breast feeding duration and children's later vegetable intake (de Lauzon-Guillain et al., 2013, Burnier et al., 2011) and it has been suggested that the mechanism for this could be early flavour learning (Cooke and Fildes, 2011, Mennella et al., 2001, Mennella et al., 2009). However the current study found only a weak association with breastfeeding duration which became non-significant after adjustment for deprivation.

We also hypothesised that children with the greatest early liking for FV and the largest intake in childhood would have the lowest level of adiposity. Intake at 7 years was inversely associated with adiposity and there was a similar non-significant trend for toddler liking. These were weak effects, but consistent and were only slightly attenuated by adjustment for maternal education and deprivation. It has been proposed that increasing FV intake could be as effective as reducing fat and sugar in childhood obesity prevention (Epstein et al., 2001), but there has been little formal research to test this and the limited research done in children found only weak associations with BMI (Heo et al., 2011)(Heo et al., 2011)(Rolls et al., 2004). This is the first study to examine the association specifically with adiposity and our findings add some support for increasing FV intake as part of the process of obesity prevention, but also suggest that its effects might not be as substantial as hoped.

The population sample of the GMS provided a large broadly representative sample, but only a third of the sample could be included when linking both the 30 month questionnaire and the FAST food diary data, which meant that the power to detect influences tracking into childhood was lower than the power to detect infancy influences on toddler preferences. Those in the subsample were more affluent and educated, but all social groups remained reasonably represented, so the comparisons of different subgroups within the cohort should be generalisable to other populations. We tested a large number of potentially predictive variables so individual significant results must be treated with caution.

The data on foods tried and liked aged 30m relied on maternal recall, which may have been subject to response bias. The food frequency instrument used had been developed some 15 year earlier (Department-of-Health, 1989), and as a result may not have included the full range of FV later available to toddlers, and was particularly limited in the range of common fruits, making it probably more informative about vegetable than fruit preferences. However the common vegetables included were valid, as illustrated by the fact that 85% or more of children had tasted them, suggesting that they did represent a minimum set of vegetables that a toddler could encounter.

While food diaries are often not a good measure of habitual intake and typically overestimate FV consumption (Bingham et al., 1994), the tool used in this study was designed specifically for use by non-specialists. Completion of FAST diaries required motivation and compliance by parents, but this was minimised by direct observation of children by the research team in school and we succeeded in obtaining 4 day food intake data for 80% of those children participating in the 7 year wave. We did not assess FV contained in composite dishes which would lead to some underestimation, but it has previously been shown to provide a robust measure of actual FV intake (Adamson et al., 2003). Given the known relationship between FAST estimates and actual intake for this age and gender (Adamson et al., 2003), this implies a median daily intake of just 137g of solid fruit and vegetables. This low intake in mid childhood is consistent with findings from a UK dietary survey (Bates, 2012) and in keeping with suggestions that as children get older and more independent, they are more influenced by environmental factors both inside and outside the home (Hetherington et al., 2011).

It might be argued that it is not valid to relate preferences at one age to intake at another. However, infants and toddlers have little scope to choose what foods they eat, making parental rating of liking most useful. In a smaller study liking could be tested by direct observation and experiment, but this is not feasible in large scale studies. In contrast older children do choose what they eat, so what they actually eat is likely to be the most valid measure of food preference, as well as the most meaningful in health terms.

Family environment also influences children’s FV intake (Cooke et al., 2004) and the lack of data regarding family intake patterns places limitations on this analysis. Cohort studies have found that maternal preference predicts child food preferences and vegetable variety (Skinner et al., 2002) and maternal consumption and parental eating rules increase intake (Jones et al., 2010). Future analyses which include family environment influences would add a further perspective on this investigation.

Children with an early liking for FV did eat more FV later in childhood and this association could not simply be explained by socio demographic factors or by feeding and appetite patterns in early life. A relatively deprived child with above average liking for vegetables as a toddler was eating about the same mean number of portions by age 7 years (2.61) as a non-deprived child with below average liking (2.5) but it is also of note that an affluent child with high liking was still eating well short of the recommended five FV portions (3.4). This suggests that the child liking strongly influences actual intake, independent of the larger food culture they live within. If early liking could be promoted there would certainly be scope for increasing intake, since those in the top quartile for intake ate more than twice the number of portions than those in the bottom quartile. A more pessimistic view might be that the enduring effect of early liking may simply reflect a genetic predisposition to like or avoid bitter or sour foods (Tepper et al., 2009), since in this study exposure alone was not associated with increased later FV intake. The key question, therefore is whether the right sort of early exposure can successfully enhance liking in the long term. Repeated exposure to bitter tastes is said to increase liking (Beauchamp and Mennella, 2009, Maier et al., 2007, Cooke, 2007) and can be effective in increasing vegetable acceptance during complementary feeding (Remy et al., 2013). A recent randomised controlled trial investigating techniques to increase FV intake concluded that behaviour-specific interventions had the potential to impact later intake (Chapman and Armitage, 2012). These are promising approaches, but a recent Cochrane review reported a lack of evidence that interventions to promote FV intake in preschool children actually increased vegetable consumption and only limited evidence on fruit (Wolfenden et al., 2012), so there is a need now to test the long term impact of these intervention approaches.

Conclusions

While intake of FV in mid-childhood was low, an early liking for vegetables and fruit predicted increased later intake. This suggests that further work to increase early exposure to and liking for vegetables could have long term beneficial consequences.

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Table 1: Socio-demographic characteristics of samples in this analysis and of differences between total and subsample (could be web supplementary table)

	Total sample	**FV preference & intake subsample**	**p (χ^2)**
Number	923	293	
Gender	%	%	
Male	50	48	
Female	50	52	0.3
Deprived			
Yes	49	30	
No	51	70	< 0.001
T-score quintile			
1 - most affluent	17	27	
2	21	24	
3	23	23	
4	20	15	
5 - most deprived	19	11	< 0.001
Maternal education			
>16 / Higher	30	40	
None/GCSE	70	60	< 0.001
Age started solids			
<3m	20	19	
3-4m	73	75	
>4m	7	6	0.9
Breastfeeding duration			
Never	49	44	
< 6 wks	25	27	
> 6 wks	10	12	
> 4m	16	17	< 0.2

Deprived – lacking either employment, car or own home
T-score - Townsend score quintile
FV – Fruit and Vegetable

Table 2: FV reported by parents in food preference questionnaire as liked or tried by children aged 30m (could be web supplementary table)

	Tried	**Liked**
Vegetables	Percentage	Percentage
Carrots	98.7	80.8
Baked beans	98.9	77.1
Peas	98.9	77.4
Tomatoes	93.1	48.2
Cabbage	89.4	48.2
Cucumber	85.9	42.4
Lettuce	85.1	30.8
Onions	85.7	29.1
Yam	12.4	7.1
Okra	6.2	2.0
Gourd	5.3	1.3
Fruit		
Apples	98.7	89.0
Banana	98.2	84.1
Oranges	96.2	75.7
Tinned peaches	70.2	49.7
Mangoes	39.7	23.0
Lychees	9.3	4.2
Guava	9.6	5.1
Total per child	Median (range)	Median (range)
Vegetables	8 (0-11)	4 (0-10)
Fruits	4 (0-7)	3 (0-7)

Table 3. Associations between FV reported by parents in food preference questionnaire as liked or tried for children aged 30m and FV intake aged 7 years. Values are Spearman's Ranked Correlations (r)

	7 years, number of portions eaten					
	Fruit		**Vegetables**		**Total F&V**	
Age 30m, number of	r	p	r	p	r	p
Vegetables liked	**0.19**	*0.001*	**0.31**	*<0.001*	**0.28**	*<0.001*
Fruits liked	**0.23**	*<0.001*	**0.19**	*0.001*	**0.25**	*<0.001*
FV liked	**0.25**	*<0.001*	**0.30**	*<0.001*	**0.27**	*<0.001*
Vegetables tried	**0.13**	*0.022*	**0.15**	*0.011*	**0.15**	*0.012*
Fruits tried	0.05	*0.42*	0.05	*0.35*	0.07	*0.27*
FV tried	**0.15**	*0.009*	**0.10**	*0.07*	**0.15**	*0.007*

Table 4. Associations of FV liked at age 30m and FV intake aged 7with of body composition Z scores at age 7-8. Values are standardised regression coefficients (Beta)

	Number	**BMI**		**Fat (BIA)**		**Skinfolds**	
Model one: adjusted for height only		Beta	P	Beta	P	Beta	P
FV liked age 30m	346a[a]	-0.01	*0.86*	-0.08	*0.13*	-0.09	*0.09*
FV eaten age 7 yrs	292[b]	**-0.10**	*0.02*	**-0.11**	*0.02*	**-0.15**	*0.001*
Model two: adjusted for height, maternal education and Townsend deprivation score							
FV liked age 30m	341[a]	-0.01	*0.84*	-0.08	*0.13*	-0.09	*0.09*
FV eaten age 7 yrs	267[b]	-0.07	*0.10*	-0.08	*0.09*	**-0.10**	*0.03*

[a]Skinfolds missing for 27; fat missing for 1 [b] Skinfolds missing for 21, fat missing for 1

Table 5. Associations of early eating behaviour with FV liked and tried aged 30m and intake aged 7 years

Median (range)	**FV liked and tried aged 30m**				**7 years FV intake (portions)**		
6wks – Appetite	**Vegetables liked**	**Fruit liked**	**Vegetables tried**	**Fruit tried**	**Vegetables**	**Fruit**	**All FV**
All other categories	4 (0-10)	3 (0-7)	8 (0-11)	**4 (1-7)**	1.3 (0-6.8)	1 (0-4)	2.5 (0-10.3)
Very good	4 (0-10)	4 (0-7)	8 (0-11)	**4 (0-7)[a]**	1.3 (0-5)	1 (0-4.3)	2.5 (0-7.5)
12m - Appetite							
All other categories	**3 (0-8)**	3 (0-6)	8 (4-11)	4 (0-7)	1.0 (0-2.3)	1.0(0-4)	2.3 (0.5-8.3)
Good	**4 (0-10)**	3 (0-7)	8 (0-11)	4 (1-7)	1.3 (0-4.8)	1.3 (0-4)	2.5 (0-7)
Very good	**5 (0-10)[c]**	4 (0-7)	8 (4-11)	4 (3-7)	1.25(0-6.8)	1.1 (0-4)	2.6 (0-10.3)
30m - Appetite							
All other categories	**4 (0-9)**	3 (0-6)	8 (0-11)	4 (0-7)	1.3 (0-5.3)	1 (0-4)	2.5 (0-8.3)
Good	**4 (0-10)**	3 (0-7)	8 (3-11)	4 (2-7)	1.3 (0-4.8)	1.3 (0-4.3)	2.8 (0-7.5)
Very good	**5 (0-10)[c]**	4 (0-7)	8 (4-11)	4 (2-7)	1.3 (0-6.8)	1 (0-4)	2.3 (0-10.3)
30m - Unfamiliar foods							
Dislikes	**3 (0-9)**	**3 (0-7)**	**8 (0-11)**	**4 (0-7)**	**1 (0-4)**	1 (0-4)	**2.3 (0-5.8)**
Neither likes nor dislikes	**4 (0-10)**	**3 (0-7)**	**8 (4-11)**	**4 (2-7)**	**1.4 (0-4.8)**	1.3 (0-3.3)	**2.5 (0-7.3)**
Likes	**5 (0-9)[c]**	**4 (0-7)[c]**	**8 (3-11)[c]**	**4 (2-7)[c]**	**1.5 (0-6.8)[a]**	1.3 (0-4.3)	**2.8 (0-10.3)[a]**
30m - Feeding problems							
No	**5 (0-10)**	**4 (0-7)**	8 (3-11)	**4 (0-7)**	1.3 (0-6.8)	1 (0-4.3)	2.5 (0-10.3)
Yes	**3 (0-9)[c]**	**3 (0-6)[c]**	8 (0-11)	**4 (1-7)[c]**	1.1 (0-5)	1 (0-3.8)	2.4 (0-7)

[a]P <0.05 [b]$p<0.01$ [c]$p<0.001$

Tests used: Mann-Whitney U-test for binary variables; Jonckheere trend test for categorical variables;

Table 6. Associations of socio-demographic variables and infant feeding with number of FV liked and tried aged 30m and intake aged years.

Median (range)	FV liked and tried aged 30m				7 years FV intake (portions)		
Gender	**Vegetables liked**	**Fruit liked**	**Vegetables tried**	**Fruit tried**	**Vegetables**	**Fruit**	**FV**
Male	4 (0-9)	3 (0-7)	**8 (0-11)**	4 (1-7)	1.3 (0-6.8)	1.0 (0-4)	2.3 (0-10.3)
Female	4 (0-10)	4 (0-7)	**8 (4-11)[a]**	4 (0-7)	1.3 (0-4.8)	1.0 (0-4.3)	2.5 (0-7.5)
Deprived							
Yes	**5 (0-10)**	3 (0-7)	8 (4-11)	4 (2-7)	**1.0 (0-6.5)**	**0.8 (0-4)**	**2.0 (0-9.5)**
No	**4 (0-10)[a]**	3 (0-7)	8 (0-11)	4 (0-7)	**1.3 (0-6.8)[a]**	**1.3 (0-4.3)[c]**	**2.8 (0-10.3)[c]**
T-score quintile							
Most affluent	**4 (0-9)**	3 (0-7)	8 (2-11)	4 (1-7)	**1.3 (0-6.8)**	**1.3 (0-4)**	**2.8 (0.3-10.3)**
2	**5 (0-9)**	4 (0-7)	8 (0-11)	4 (1-7)	**1.3 (0-4.8)**	**1.5 (0-4)**	**2.8 (0-7.3)**
3	**4 (0-10)**	3.5 (0-7)	8 (0-11)	4 (1-7)	**1.3 (0-6.5)**	**1 (0-4)**	**2.5 (0-9.5)**
4	**5 (0-8)**	3 (0-6)	8 (4-11)	4 (2-7)	**1.0 (0-3.8)**	**0.8 (0-4.3)**	**2.0 (0-7.5)**
Most deprived	**4 (0-9)[a]**	3 (0-6)	8 (4-11)	4 (0-7)	**1.0 (0-4)[a]**	**0.8 (0-2)[c]**	**2.0 (0-5.8)[c]**
Maternal education							
Beyond age 16	5 (0-9)	**4 (0-7)**	8 (2-11)	4 (1-7)	1.3 (0-6.8)	**1.3 (0-4)**	**2.8 (0-10.3)**
Up to age 16 only	4 (0-10)	**3 (0-7)[a]**	8 (0-11)	4 (0-7)	1.3 (0-6.5)	**1 (0-4.3)[c]**	**2.3 (0-9.5)[b]**
Breastfeeding duration							
Never	5 (0-10)	3 (0-7)	8 (0-11)	4 (1-7)	**1 (0-6.8)**	1 (0-4)	2.3 (0-9.5)
< 6 wks	4 (0-10)	4 (0-7)	8 (4-11)	4 (0-7)	**1.3 (0-6.8)**	1 (0-4)	2.5 (0-10.3)
> 6 wks	4 (0-8)	3 (0-5)	8 (3-11)	4 (3-7)	**1.5 (0-4.5)**	1 (0.3-4.3)	3 (0.5-7.5)
> 4m	4 (0-9)	3 (0-7)	8 (4-11)	4 (2-7)	**1.3 (0-5)[a]**	1.3 (0-3)	2.8 (0.5-6.5)
Age at weaning							
<3m	4 (0-10)	4 (0-5)	8 (4-11)	4 (3-7)	1.3 (0-6.5)	1 (0-4.3)	2.3 (0-9.5)
3-4m	4 (0-10)	3 (0-7)	8 (2-11)	4 (1-7)	1.3 (0-5.3)	1 (0-4)	2.5 (0-8.3)
>4m	4 (0-8)	3 (0-7)	8 (0-9)	4 (1-7)	0.8 (0-3.5)	0.9 (0.5-3)	1.9 (0.5-4.5)

[a]P <0.05 [b]p<0.01 [c]p<0.001 Tests used: Mann-Whitney U-test for binary variables; Jonckheere trend test for categorical variables;

Abbreviations; FV - fruit and vegetables, T-score quintile **-** Townsend Index score quintile

Table 7 Results of multivariate models of predictors of intake at age seven years

Outcome	Independent significant predictors in final model	Univariate		Multivariate[2]	
Logistic regression models		**Odds ratio**	**P**	**Odds ratio**	**P**
Intake of >1 portion veg /day	Number of veg liked aged 30m	1.28	<0.001	1.28	<0.001
Intake of >1 portion fruit /day	Number of fruit liked aged 30m	1.46	<0.001	1.44	<0.001
	Relatively deprived	0.49	<0.001	0.34	<0.001
Linear regression model		**Beta[1]**	**P**	**Beta**	**P**
Total intake of FV	Number of veg liked	0.28	<0.001	0.24	<0.001
	Number of fruit liked	0.25	<0.001	0.13	0.031
	Relatively deprived	-0.21	<0.001	-0.22	<0.001

[1]Standardised regression coefficient

[2]mutually adjusted for other significant variables

Figure: Number of participants included at each stage