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Original Article

The associations between feeding difficulties and behaviours and dietary patterns at 2 years of age: the ALSPAC cohort

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Abstract

Little is known about the dietary patterns of toddlers. This period of life is important for forming good dietary habits later in life. Using dietary data collected via food frequency questionnaire (FFQ) at 2 years of age, we examined the dietary patterns of children from the Avon Longitudinal Study of Parents and Children (ALSPAC). Principal component analysis was performed for 9599 children and three patterns were extracted: 'family foods' associated with traditional British family foods such as meat, fish, puddings, potatoes and vegetables; 'sweet and easy' associated with foods high in sugar (sweets, chocolate, fizzy drinks, flavoured milks) and foods requiring little preparation (crisps, potatoes, baked beans, peas, soup); 'health conscious' associated with fruit, vegetables, eggs, nuts and juices. We found clear associations between dietary pattern scores and socio-demographic variables, with maternal education being the most important. Higher levels of education were associated with higher scores on both the 'family foods' and the 'health conscious' patterns, and decreased scores on the 'sweet and easy' pattern. Relationships were evident between dietary pattern scores and various feeding difficulties and behaviours. Notably, children who were introduced late to lumpy (chewy) solids (after 9 months) scored lower on both the 'family foods' and the 'health conscious' patterns. Further analyses are required to determine the temporal relationship between perceived feeding difficulties and behaviours, and it will be important to assess the contribution of the age of introduction to lumpy solids to these relationships.

Keywords: dietary patterns, PCA, ALSPAC, toddlers.

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Introduction

Two-year-old children may be at a crucial time for the development of dietary habits. The transition from milk feeding to a mixed diet should have been achieved and it is a period when more varied family foods are being introduced and children begin to develop their own food preferences. It can be a challenging time for caregivers who may be confused by the information and/or advice offered from a multitude of sources, such as health visitors, friends and family members, magazines and commercial companies.

We have previously reported that the age of introduction to lumpy solids (i.e. foods that need chewing) was associated with the types of foods eaten at 15 months of age (Northstone *et al*. 2001). However, examining individual foods is difficult from a public health point of view as foods are usually consumed in combination as part of a mixed diet rather than

individually. The use of dietary patterns to examine the types of foods that are eaten together can overcome this issue. Principal component analysis (PCA) is a popular method of obtaining dietary patterns using the correlations that are evident between food groups to obtain underlying or latent patterns that exist in the data (Newby & Tucker 2004).

To our knowledge, only two other studies have examined dietary patterns at such a young age – Robinson *et al*. (2007) used PCA to extract infant dietary patterns at 6 and 12 months in a UK cohort and Ystrom *et al*. (2009) examined the 18-month diet in the Norwegian mother and child cohort study. In the Avon Longitudinal Study of Parents and Children (ALSPAC), we have obtained dietary patterns throughout childhood but have not examined patterns prior to the age of 3 years (North *et al*. 2000; Northstone & Emmett 2008).

It is important to try to fill the gap in the knowledge for this age group. Therefore, the current paper aims to describe dietary patterns in the ALSPAC cohort at the age of 2 years. We also examine the associations between the dietary patterns obtained and current feeding difficulties and behaviours as reported by the main caregiver.

Methods

The ALSPAC is an ongoing longitudinal cohort study that was designed to investigate the determinants of growth, health and disease during childhood and beyond (Golding *et al.* 2001). Pregnant women with an expected date of delivery between April 1991 and December 1992, resident in the former Avon Health Authority area in Southwest England, were eligible to participate in the study. A cohort of 14 541 pregnant women was established, resulting in 13 988 children alive at 12 months of age. Ethical approval for the study was obtained from the ALSPAC Law and Ethics committee and the three local research-ethics committees.

Dietary information was collected via parental-completion food frequency questionnaire (FFQ) at the age of 2 years as part of a larger questionnaire that was sent through the mail with a reply envelope. This FFQ contained a set of questions enquiring about the frequency of consumption of 53 different types of foods and drinks. The FFQ was an expansion of the ones used previously at 6 and 15 months (Northstone *et al*. 2001), was designed by experienced dietitian (PE) and covered the majority of the foods and drinks likely to be consumed by young British children. The caregiver, usually the mother, was asked to record how often the study child consumed each of the food types 'nowadays'. For milks and other drinks, this was recorded as times per week and for foods this was recorded as times per month. All frequencies were converted to times per week to ensure that they were measured on the same scale.

A series of questions was included with the FFQ in order to establish various behaviours and difficulties that the mother may have experienced when feeding her child. Mothers were asked whether the child had the same main meal as the mother, whether the child fed his/herself, drank from a cup or beaker, or had definite likes and dislikes. She was also asked whether she had experienced any overall difficulties in feeding her child during the preceding nine months and whether she felt that there were times when her child had not eaten enough food, had refused to eat the right foods, had been choosy with foods, had over-eaten or had been difficult to get into a feeding routine. In addition, the age at which lumpy solids were first introduced was determined. The groupings of responses can be seen in Table 3.

Key messages

- Different dietary patterns are evident as early as 2 years of age.
- These patterns are socially determined and there is evidence of associations with feeding difficulties and behaviours.
- Late introduction to lumpy solids may be detrimental to following a healthy diet during toddlerhood.

A wide variety of factors were considered firstly as variables that may be associated with the dietary pattern scores and secondly as potential confounders that may explain any relationships evident between the dietary pattern scores and the feeding behaviours. The following variables were examined: child's gender, maternal age at delivery, highest level of maternal education, housing tenure; parity (all recorded during pregnancy), then when the child was 21 months old, whether the mother was working, whether she had a partner and a measure of financial difficulty being experienced. This was calculated from questions about five items (food, clothing, heating, rent/mortgage and things for child) which the mother may or may not have had difficulty affording. Table 2 shows the categorisation of these variables. Finally, we included a measure of maternal diet during pregnancy; dietary patterns had previously been derived in this cohort of mothers using PCA (Northstone *et al*. 2008) and we have included the 'health conscious' pattern score as a potential confounder in this study.

Statistical methods

PCA with varimax rotation (Gorsuch 1974; Kline 1994) was performed on the food items. The methods have been described in detail elsewhere (North *et al*. 2000). Briefly, the number of components best representing the data was primarily chosen on the basis of the scree plot (Cattell 1966) and the interpretability of the components. Children were excluded from each PCA if they had more than 15 dietary items unanswered in the FFQ (823 children were excluded on this basis). If fewer items were missing, we made the assumption that the child did not consume those items and they were given a value of 0. Thirty-one food groups were entered into the PCA (the way the foods were combined into groups is shown in Appendix 1).

Foods with loadings above 0.25 on a component were considered to have a strong association with that component and were deemed to be the most informative in describing the dietary patterns. Labels were given to each component. While these do not perfectly describe each underlying pattern, they aid in the reporting and discussion of the results. For each child, a score was created for each component identified by multiplying the factor loadings by the corresponding standardised value (subtracting the mean from the frequency and dividing by the standard deviation) for each food and summing across the food items. All component scores were approximately normally distributed and had a mean of 0 and a standard deviation of 1. We repeated the PCA in two randomly selected split-half samples to assess repeatability of the method and the results were highly comparable in terms of both the factor loadings and the component scores obtained (data not shown).

Independent associations between the sociodemographic characteristics and each dietary pattern score were examined using general linear models; adjusted parameter estimates (standard errors) are presented. Relationships between the dietary pattern scores and the various feeding difficulties and behaviours were initially assessed using analysis of variance; such that mean differences in dietary pattern scores were examined. General linear models were then used to further examine these associations adjusting for the potential confounding factors. Adjusted parameter estimates and 95% confidence intervals are presented. All analyses were performed using SPSS for Windows v.18.0 (SPSS Inc., Chicago, IL, USA).

Results

10 422 mothers returned the 24-month questionnaire (74.5% of the baseline cohort of 13 988). Of these, 9599 (92%) had sufficient data from the FFQ to produce dietary patterns. Those included in the study are more likely to have older mothers, with higher levels of education and to live in owner-occupied or rented accommodation (data not shown, all $P < 0.0001$). They were also more likely to have mothers experiencing no financial difficulties, who were employed and who were living with their partners when their study child was 2 years old (all $P < 0.0001$). There was no difference in the proportion of boys and girls.

The factor loadings obtained from the PCA are shown in Table 1. Three patterns were deemed appropriate as best representing the data and they explained 25.5% of the variance. Factors of a higher

Table 1. Factor loadings of various food items in the three principal components identified (loadings above 0.25 are shown in bold) in 2-year-old children based on a food frequency questionnaire

Food item (variance explained)	'Family foods' (12.9%)	'Sweet and easy' (7.4%)	'Health conscious' (5.2%)
Bread	**0.612**	–0.176	0.100
Breakfast cereal	**0.570**	–0.143	–0.038
Biscuits	**0.594**	0.047	–0.157
Ready-prepared baby food	0.068	0.047	0.035
Milk-based puddings	**0.401**	0.001	0.194
Fruit-based puddings	**0.421**	0.026	**0.283**
Meat	**0.622**	0.241	–0.007
Offal	0.032	0.101	0.098
Fish	**0.347**	0.214	**0.286**
Eggs	0.077	0.228	**0.376**
Cheese	**0.379**	0.006	**0.408**
Potatoes	**0.627**	**0.321**	0.042
Baked beans	0.095	**0.504**	0.197
Peas	0.230	**0.427**	0.231
Legumes	–0.054	–0.081	**0.632**
Raw vegetables	0.048	–0.105	**0.538**
Other vegetables	**0.641**	0.118	**0.334**
Soup	–0.069	**0.374**	0.077
Fresh fruit	**0.263**	0.080	**0.549**
Yogurts	**0.309**	0.068	0.245
Fruit juice	0.088	0.084	**0.266**
Squash/cordial	**0.250**	0.209	–0.226
Fizzy drinks	–0.080	**0.519**	–0.074
Tea/coffee	–0.120	**0.438**	–0.082
Formula milk	–0.102	–0.021	0.139
Cow's milk	**0.252**	–0.133	0.034
Flavoured milk	–0.069	**0.254**	0.007
Sweets	0.044	**0.626**	–0.129
Nuts	–0.017	–0.127	**0.409**
Chocolate	0.172	**0.512**	–0.155
Crisps	0.114	**0.458**	0.024

order contributed less than 3% more and were not consider useful in interpreting the potential dietary behaviours of 2 year olds. Loadings above 0.25 are shown in bold. The first component had high loadings on traditional British family foods such as meat, fish, puddings, potatoes and vegetables. We chose to label this pattern 'family foods'. Many of the food loadings highly on the second component were high in sugar such as sweets, chocolate, fizzy drinks and flavoured milks. Other foods associated this pattern such as crisps, potatoes, baked beans, peas and soup were foods requiring little in the way of cooking; therefore, this pattern was labelled 'sweet and easy'. The final pattern was associated with foods often recommended as the basis for a healthy diet, such as fruit, vegetables, eggs, nuts and juices. This pattern was therefore labelled 'health conscious'.

Table 2 presents the adjusted parameter estimates for the dietary pattern scores according to the various socio-demographic characteristics considered. Higher scores on the 'family foods' pattern were seen with increasing maternal age and education level (both $P < 0.0001$). Lower scores were seen in children living in council/housing association accommodation and in non-Whites (both $P < 0.0001$). Lower scores on the 'sweet and easy' pattern were seen with increasing maternal age and education (both $P < 0.0001$) and higher scores were evident in those living in council/housing association accommodation, increasing parity, mothers who did not work (all $P < 0.0001$) and those with increasing financial difficulties ($P = 0.007$). Finally, for the 'health conscious' pattern, higher scores were seen with increasing maternal age and education and in non-Whites (all $P < 0.0001$), while lower scores were evident with increasing parity ($P < 0.0001$). The mother themselves having a 'health conscious' dietary pattern (as assessed in pregnancy) was associated with the same pattern in the child ($P < 0.0001$).

We present the adjusted associations between the pattern scores and the various measures of feeding behaviours and difficulties in Table 3 (unadjusted associations are presented as Table S1). Even after adjustment, many associations were evident between the dietary patterns and feeding difficulties/behaviours. For the 'family foods' pattern, lower scores tended to be seen in children who had specific feeding difficulties (not eaten enough, refused to eat right foods and being difficult to get into a routine); however, increased scores were seen with those children who were reported as having over-eaten ($\beta = 0.089$, $P = 0.002$). Children who were described as having definite likes and dislikes scored lower on this pattern ($\beta = –0.244$, $P < 0.0001$), while children who usually used a cup or beaker scored higher ($\beta = 0.163$, $P < 0.0001$). Children who were introduced to lumpy solids both early and late had lower scores on this pattern compared with the normal group ($\beta = –0.021$ and –0.130, respectively, $P < 0.0001$).

Table 2. Adjusted* parameter estimates (standard error) for dietary pattern scores according to socio-demographic factors

	'Family foods'	'Sweet & easy'	'Health conscious'
Maternal age			
<20 (7.2%)	0.00	0.00	0.00
21–25 (23.5%)	–0.02 (0.06)	–0.21 (0.06)	0.05 (0.06)
26–30 (39.3%)	0.15 (0.06)	–0.40 (0.06)	0.09 (0.06)
31+ (30.0%)	0.19 (0.06)	–0.56 (0.06)	0.34 (0.06)
F (*P*)	15.15 (<0.0001)	53.42 (<0.0001)	39.83 (<0.0001)
Maternal education			
<O level (30.0%)	0.00	0.00	0.00
O level (34.6%)	0.35 (0.03)	–0.10 (0.03)	0.17 (0.03)
>O level (35.4%)	0.50 (0.03)	–0.47 (0.03)	0.60 (0.03)
F (*P*)	145.1 (<0.0001)	179.51 (<0.0001)	248.53 (<0.0001)
Housing tenure			
Owner/occupied (78.5%)	0.00	0.00	0.00
Council/housing association (14.2%)	–0.27 (0.04)	0.20 (0.04)	–0.01 (0.04)
Rented/other (7.3%)	–0.10 (0.03)	–0.09 (0.04)	0.11 (0.04)
F (*P*)	26.42 (<0.0001)	19.16 (<0.0001)	3.18 (0.042)
Parity			
0 (44.6%)	0.00	0.00	0.00
1 (35.1%)	0.04 (0.02)	0.09 (0.02)	–0.17 (0.02)
2+ (20.2%)	0.02 (0.03)	0.17 (0.03)	–0.19 (0.03)
F (*P*)	1.73 (0.177)	16.41 (<0.0001)	31.08 (<0.0001)
Financial difficulties			
None (32.0%)	0.00	0.00	0.00
Some (59.3%)	–0.06 (0.02)	0.07 (0.02)	0.07 (0.02)
Many (8.6%)	–0.08 (0.04)	0.09 (0.02)	0.04 (0.04)
F (*P*)	3.47 (0.031)	5.02 (0.007)	4.46 (0.012)
Maternal employment			
Yes (47.1%)	0.00	0.00	0.00
No (52.9%)	–0.01 (0.02)	0.11 (0.02)	–0.06 (0.02)
F (*P*)	0.40 (0.526)	29.7 (<0.0001)	6.55 (0.011)
Mother has partner			
No (5.3%)	0.00	0.00	0.00
Yes, not living with (2.6%)	–0.04 (0.09)	0.02 (0.09)	–0.19 (0.05)
Yes, living with (92.1%)	0.08 (0.05)	–0.04 (0.05)	–0.06 (0.09)
F (*P*)	2.18 (0.113)	0.61 (0.542)	2.33 (0.097)
Gender			
Boys (51.7%)	0.00	0.00	0.00
Girls (48.3%)	0.03 (0.02)	–0.01 (0.02)	–0.08 (0.02)
F (*P*)	2.49 (0.115)	0.40 (0.526)	15.62 (<0.0001)
Ethnicity			
White (94.2%)	0.00	0.00	0.00
Non-White (5.8%)	–0.48 (0.06)	–0.06 (0.06)	0.42 (0.06)
F (*P*)	72.25 (< 0.0001)	1.02 (0.312)	54.11 (<0.0001)
Maternal 'health conscious' pattern score			
Per 1 SD increase	0.73 (0.04)	–0.44 (0.04)	1.25 (0.04)
F (*P*)	1.87 (0.059)	1.16 (0.244)	3.29 (<0.0001)

*Adjusted for all other factors in Table 2.

The 'sweet and easy' pattern was negatively associated with the child drinking from a cup or beaker ($\beta = -0.080$, $P = 0.007$) and the child having definite likes and dislikes ($\beta = -0.160$, $P < 0.0001$). As with the 'family foods' pattern, children reported as having over-eaten scored higher on the 'sweet and easy' pattern ($\beta = 0.075$, $P = 0.006$).

Higher scores on the 'health conscious' pattern were seen in those children who ate the same main meal as their mother and those who usually fed them-

Table 3. Adjusted* parameter estimates (standard error) for dietary pattern scores according to different feeding behaviours and difficulties at 2 years of age

	'Family foods'	'Sweet & easy'	'Health conscious'
Ch eats same main meal as mother			
Always ($n = 6035$)	0.128 (0.06)	0.288 (0.05)	0.356 (0.06)
Sometimes ($n = 1758$)	0.115 (0.06)	0.171 (0.06)	0.293 (0.06)
Never ($n = 315$)	0.00	0.00	0.00
F (P)	2.72 (0.066)	1.15 (0.283)	19.71 (<0.0001)
Ch feeds him-/herself			
Usually ($n = 7448$)	0.036 (0.04)	0.079 (0.03)	0.127 (0.04)
Sometimes/never ($n = 810$)	0.00	0.00	0.00
F (P)	1.06 (0.302)	5.35 (0.021)	12.73 (<0.0001)
Ch drinks from a cup/beaker			
Usually ($n = 7650$)	0.163 (0.03)	–0.080 (0.03)	0.049 (0.03)
Sometimes/never ($n = 995$)	0.00	0.00	0.00
F (P)	28.57 (<0.0001)	7.19 (0.007)	2.53 (0.112)
Ch has definite likes/dislikes			
No, eats anything ($n = 4870$)	0.00	0.00	0.00
Yes, quite choosy ($n = 2579$)	–0.042 (0.04)	–0.014 (0.02)	–0.019 (0.02)
Yes, very choosy ($n = 813$)	–0.244 (0.02)	–0.160 (0.04)	–0.324 (0.04)
F (P)	23.16 (<0.0001)	15.64 (<0.0001)	41.54 (<0.0001)
Difficulties feeding ch in the last 9 months			
Yes ($n = 4202$)	0.061 (0.02)	0.055 (0.02)	0.103 (0.02)
No ($n = 4056$)	0.00	0.00	0.00
F (P)	0.48 (0.214)	2.35 (0.099)	23.66 (<0.0001)
Ch not eaten enough			
Yes ($n = 5396$)	–0.058 (0.02)	0.032 (0.02)	–0.036 (0.022)
No ($n = 2885$)	0.00	0.00	0.00
F (P)	7.00 (0.008)	2.21 (0.137)	2.65 (0.104)
Ch refused to eat the right foods			
Yes ($n = 5254$)	–0.039 (0.02)	–0.021 (0.02)	–0.074 (0.02)
No ($n = 3027$)	0.00	0.00	0.00
F (P)	3.27 (0.071)	1.00 (0.316)	11.55 (0.001)
Ch has over-eaten			
Yes ($n = 1347$)	0.089 (0.03)	0.075 (0.03)	0.041 (0.03)
No ($n = 6934$)	0.00	0.00	0.00
F (P)	10.00 (0.002)	7.49 (0.006)	2.11 (0.147)
Ch difficult to get into feeding routine			
Yes ($n = 1756$)	–0.188 (0.03)	0.023 (0.03)	–0.046 (0.03)
No ($n = 6525$)	0.00	0.00	0.00
F (P)	54.7 (<0.0001)	0.85 (0.356)	3.17 (0.075)
Age of introduction to lumpy solids			
Early, <6 months ($n = 839$)	–0.021 (0.03)	0.08 (0.03)	0.08 (0.03)
Normal, 6–9 months ($n = 5868$)	0.00	0.00	0.00
Late, 10+ months ($n = 1504$)	–0.130 (0.03)	0.01 (0.03)	–0.10 (0.03)
F (P)	12.06 (<0.0001)	3.18 (0.061)	11.25 (<0.0001)

*Adjusted for all other factors in Table 2.

selves (both $P < 0.0001$) and who were reported as having difficulties feeding in the preceding nine months ($\beta = 0.103$, $P < 0.0001$). Strong negative associations were seen with this pattern and the child having definite likes and dislikes ($\beta = –0.324$, $P < 0.0001$), being more likely to refuse to eat the right foods ($\beta = –0.074$, $P = 0.001$) and to have been introduced to lumps after 9 months of age ($\beta = –0.10$, $P < 0.0001$).

Discussion

Three clear dietary patterns have been obtained from this cohort of 2-year-old children. The 'family foods'

pattern was the strongest to immerge and was potentially relatively well-balanced and appropriate for this age group. The foods that loaded highly on this pattern included foods high in carbohydrates, fruit and vegetables, milk/dairy products, meat and fish. These foods form part of the toddler feeding guidelines currently provided to mothers in the United Kingdom (Department of Health 2009). The third pattern named 'health-conscious' also loaded on to foods that are recommended in the guidelines, e.g. fish, eggs, cheese, fruits and vegetables. However, the second pattern 'sweet and easy' was described by many food that are unlikely to provide a balanced diet for a toddler, namely fizzy drinks, sweets, chocolates, crisps and flavoured rather than plain milk.

Few other studies have examined dietary patterns in such young children and none, to our knowledge, have examined the associations with feeding difficulties. Two dietary patterns were revealed in 18-month old from the Norwegian mother and child study (Ystrom *et al*. 2009): an unhealthy diet (foods rich in sugar and fat such as chocolate, sweets, soda, cakes and desserts) and a wholesome diet (foods rich in fibre, vitamins and minerals such as fish, pasta, vegetables, fruit, rice and meat). These are similar in composition to our 'sweet and easy' pattern and a combination of the 'family foods' and 'health conscious' pattern, respectively. Robinson *et al*. (2007) studied infants born in the United Kingdom between 1999 and 2003, 10 years later than the ALSPAC cohort. At 6 and 12 months of age, they extracted two patterns at both ages from FFQ data: an 'infant guidelines' pattern, associated with fruit, vegetables and home prepared foods, and an 'adult foods' pattern, associated with bread, savoury snacks, biscuits and chips. At 6 months, there was a third pattern associated with the consumption of commercial ready-prepared infant foods. These do not match well with our patterns at 2 years probably because these much younger children are still at the weaning stage. Indeed, the commercial baby foods and milks that were included in our 2-year FFQ did not contribute substantially to any of the patterns we obtained, thus confirming that our children had passed the weaning stage. Work is ongoing examining the dietary patterns that emerge before the age of 2 years and it will be interesting to see how these patterns relate to those presented here.

The patterns obtained at 2 years of age differed from the patterns we reported at 3 in the same cohort (North *et al*. 2000). At 3, we extracted four patterns labelled 'junk', 'healthy', 'traditional' and 'snacks'. It is the emergence of the 'junk' pattern at 3 years that appears to discriminate the most between the two ages. The foods associated with the 'healthy', 'traditional' and 'snacks' patterns at 3 are similar to those associated with the 'health conscious', 'family foods' and 'sweet and easy' patterns at the age of 2. At both ages, we show clear dietary pattern score variations with socio-demographic status; in particular, maternal education is the most important factor in determining pattern scores.

A particular advantage of the current study is that it is the first to examine the associations between dietary patterns and different feeding behaviours and difficulties at an early age. The child eating with the mother and self-feeding were important for the 'health conscious' pattern. Confusingly, the mothers feeding this pattern tended to experience more difficulty feeding their child, although they were less likely to describe the child as choosy. Drinking from a cup/beaker as opposed to a feeding bottle discriminated between the 'family foods' and 'sweet & easy' patterns. Children eating family foods were much more likely to use a cup, while those with a 'sweet & easy' style of eating were less likely to do so. We have shown previously in a subsample of this cohort, who had diet records completed at age 18 months, that cows' milk intakes were higher and iron intakes lower if a feeding bottle was used rather than a cup/beaker for all drinks (Northstone *et al*. 2002). A further analysis investigating the same children showed that iron status at age 18 months was negatively associated with the amount of cows' milk consumed (Cowin *et al*. 2001).

Of note are the associations we have shown between dietary pattern scores and the age of introduction to lumpy solids. Children introduced late (after 9 months) scored lower on both the 'family foods' and the 'health conscious' patterns. This is in line with our previous findings that late introducers consumed less fruit and vegetables at 15 months of

age (Northstone *et al*. 2001) and that this persisted at 7 years of age (Coulthard *et al*. 2009). We have not found any evidence to suggest that early introduction to lumps is detrimental to later diet quality, despite the current recommendations that infants should be exclusively breastfed up to 6 months of age, with mashed foods being introduced between 6 and 9 months (World Health Organization 2001). Strong evidence of an association was also seen between dietary pattern scores and whether the mother felt that her child had definite likes or dislikes. Children who were described as 'very choosy' scored lower across all dietary pattern scores. Those children who are particularly choosy usually consume a smaller variety of foods and will therefore contribute less to any kind of dietary summary.

In terms of the associations that we have demonstrated between feeding difficulties and dietary pattern scores, we cannot assume any kind of causal relationship. It may be that a child's adherence to a particular dietary pattern resulted in particular feeding difficulties or it may be that the child followed a particular pattern as a result of their feeding difficulties. However, we have previously shown that the age of introduction to lumpy solids was associated with both concurrent and subsequent feeding difficulties (Northstone *et al*. 2001). The contribution of age of introduction to lumpy solids to future diet type therefore warrants further investigation.

Clear associations were seen across all the dietary pattern scores and whether the mother felt her child had particular likes/dislikes or was deemed to be choosy/fussy with food. Refusing foods and fussiness are a normal part of development, and provided these aspects of behaviour do not persist, mothers are advised not to worry (Department of Health 2009). Nevertheless, it can be a particularly anxious time for parents who are bombarded with healthy eating messages regarding a balanced diet.

There are a number of limitations in our study. Firstly, all the feeding behaviours and difficulties are self-reported by the mother and are therefore not objective measures. In terms of the method of obtaining dietary patterns, PCA itself has faced criticism as the method is data dependent and therefore patterns obtained cannot be directly compared across studies, countries and cultures; in addition, a number of subjective decisions have to be made during the analytical process (Martinez *et al*. 1998; Hu 2002). A further potential limitation of this study is that dietary intake was assessed using FFQs rather than weighed dietary records, and some foods were not covered in the FFQ, notably rice and pasta. However, studies comparing the results of PCA using FFQs and weighed dietary records (Hu *et al*. 1999; McNaughton *et al*. 2005) have found the resulting patterns to be comparable. Although only a quarter of the variation in the diet was explained by the three patterns obtained in this study, this figure is higher than the variance explained at later time-points in ALSPAC children (17–23%; Northstone *et al*. 2005) and by the patterns obtained by Robinson *et al*. (2007) at 6 and 12 months (15.6% and 13.4%, respectively). It is also similar to the amount of variance explained by the dietary patterns obtained in the parent's diet (25% for mothers and 26% for their partners; Northstone & Emmett 2010).

In conclusion, clear patterns of diet were evident at 2 years of age in a UK cohort. These patterns were associated with a number of socio-demographic characteristics and feeding difficulties and behaviours; although as discussed, we cannot assume a causal relationship due to the cross-sectional nature of the study. Further analyses are required to determine the temporal relationship of these associations and the contribution of the age of introduction to lumpy solids to the relationship.

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None.

Conflicts of interest

PE and KN have both received support from time to time from commercial infant food manufacturers and have undertaken invited lectures.

Contributions

KN was responsible for the data analysis and interpretation and drafted the manuscript. PE was responsible for the design and collection of the dietary data and contributed to manuscript preparation. Both authors contributed to the intellectual content and approved the final version of the manuscript.

References

Cattell R.B. (1966) The scree test for the number of factors. *Multivariate Behavioural Research* **1**, 245–276.

Coulthard H., Harris G. & Emmett P. (2009) Delayed introduction of lumpy foods to children during the complementary feeding period affects child's food acceptance and feeding at 7 years of age. *Maternal and Child Nutrition* **5**, 75–85.

Cowin I., Emond A., Emmett P. & the ALSPAC Study Team (2001) Association between composition of the diet and haemoglobin and ferritin levels in 18-month-old children. *European Journal of Clinical Nutrition* **55**, 278–286.

Department of Health (2009) *Birth to Five*. Central office of information: London.

Golding J., Pembrey M., Jones R. & ALSPAC Study Team (2001) ALSPAC – The Avon Longitudinal Study of Parents and Children. I. Study methodology. *Paediatric and Perinatal Epidemiology* **15**, 74–87.

Gorsuch R.L. (1974) *Factor Analyses*. W.B. Saunders: Philadelphia.

Hu F. (2002) Dietary pattern analysis: a new direction in nutritional epidemiology. *Current Opinion in Lipidology* **13**, 3–9.

Hu F., Rimm E., Smith-Warner S.A., Feskanich D., Stampfer M.J., Ascherio A. *et al*. (1999) Reproducibility and validity of dietary patterns assessed with a food-frequency questionnaire. *American Journal of Clinical Nutrition* **69**, 243–249.

Kline P. (1994) *An Easy Guide to Factor Analysis*. Routledge: London.

Martinez M.E., Marshall J.R. & Sechrest L. (1998) Invited commentary: factor analysis and the search for objectivity. *American Journal of Epidemiology* **148**, 17–19.

McNaughton S.A., Mishra G.D., Bramwell G., Paul A.A. & Wadsworth M.E.J. (2005) Comparability of dietary patterns assessed by multiple dietary assessment methods: results from the 1946 British Birth Cohort. *European Journal of Clinical Nutrition* **59**, 341–352.

Newby P.K. & Tucker K.L. (2004) Empirically derived eating patterns using factor or cluster analysis: a review. *Nutrition Reviews* **62**, 177–203.

North K., Emmett P. & the ALSPAC Study Team (2000) Multivariate analysis of diet among three-year old children and associations with socio-demographic characteristics. *European Journal of Clinical Nutrition* **54**, 73–80.

Northstone K. & Emmett P.M. (2008) Are dietary patterns stable throughout early and mid-childhood? A birth cohort study. *British Journal of Nutrition* **100**, 1069–1076.

Northstone K. & Emmett P.M. (2010) Dietary patterns of men in ALSPAC: associations with socio-demographic and lifestyle characteristics, nutrient intake and comparison with women's dietary patterns. *European Journal of Clinical Nutrition* **64**, 978–986.

Northstone K., Emmett P., Nethersole F. & the ALSPAC Study Team (2001) The effect of age of introduction to lumpy solids on foods eaten and reported feeding difficulties at 6 and 15 months. *Journal of Human Nutrition and Dietetics* **14**, 43–54.

Northstone K., Emmett P. & the ALSPAC Study Team (2005) Multivariate analysis of diet in children at four and seven years of age and associations with socio-demographic characteristics. *European Journal of Clinical Nutrition* **59**, 751–760.

Northstone K., Emmett P. & Rogers I. (2008) Dietary patterns in pregnancy and associations with socio-demographic and lifestyle factors. *European Journal of Clinical Nutrition* **62**, 471–479.

Robinson S., Marriot L., Poole J., Crozier S., Borland S. & Lawrence W. (2007) Dietary patterns in infancy: the importance of maternal and family influences on feeding practice. *British Journal of Nutrition* **98**, 1029–1037.

World Health Organization (2001) *Report of the expert consultation on the optimal duration of exclusive breastfeeding*. Available at: http://www.who.int/nutrition/publications/optimal_duration_of_exc_bfeeding_report_eng.pdf

Ystrom E., Niegel S. & Vollrath M.E. (2009) The impact of maternal negative affectivity on dietary patterns of 18-month-old children in the Norwegian mother and child cohort study. *Maternal and Child Nutrition* **5**, 234–242.

Appendix 1. Combinations of food groups

Formula milk	Standard formula milk
	Follow-on formula milk
	Soya formula milk
	Hypoallergenic formula milk
Ready-prepared baby food	Baby rice
	Other baby cereal
	Rusks
	Meat-based baby food
	Vegetable-based baby food
	Fish-based baby food
	Fruit-based dessert baby food
	Dairy-based dessert baby food
Soup	Packet soup
	Tinned soup
Offal	Liver and pate
	Kidney
Fruit	Apple
	Other fruits
Raw vegetables	Raw carrot
	Other raw vegetables
Crisps	Crisps
	Other savoury snacks
Sweets	Mints
	Other sweets
Fizzy drinks	Cola
	Other fizzy drinks
Fruit juice	Apple juice
	Orange juice
	Blackcurrant juice
Tea/coffee	Tea
	Coffee
Flavoured milk	Chocolate flavoured milk
	Other flavoured milk

Supporting information

Additional Supporting Information may be found in the online version of this article:

Table S1. Unadjusted dietary pattern mean (SD) scores according to different feeding behaviours and difficulties at 2 years of age