Dietary variety and food group consumption in children consuming a cows’ milk exclusion diet

Kate Maslin¹,², Tara Dean¹,², Syed Hasan Arshad²,³ & Carina Venter¹,²

¹School of Health Sciences & Social Work, University of Portsmouth, Portsmouth, UK; ²David Hide Asthma and Allergy Research Centre, Isle of Wight, UK; ³University of Southampton, Southampton, UK

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Abstract

Background: Dietary variety is defined as the number of different foods or food groups consumed over a given reference period, the consensus being that dietary variety and dietary quality are positively correlated. Recently there has been considerable interest in the association between infant dietary variety and atopic disease.

Methods: This was a cross-sectional study of 8- to 27-month-old children from the Isle of Wight, UK, including two groups: a group of children consuming a cows’ milk exclusion (CME) diet and a control group of children consuming an unrestricted diet. Parents completed a validated food frequency questionnaire, from which dietary variety and consumption of food groups were calculated. Growth measurements were recorded.

Results: A total of 126 participants of mean age 13.0 months were recruited. In addition to the expected differences in dairy and soya consumption, the CME group consumed sweet foods 1.6 times less frequently, non-water drinks seven times less frequently (p < 0.05) and ready-made baby foods 15 times more frequently (p < 0.01) than the control group. Overall dietary variety was significantly lower in the CME group (p < 0.01) as was variety of meat and sweet foods consumed. There was a greater concern with healthy eating in the CME group (p < 0.05).

Conclusions: Children consuming an exclusion diet for cows’ milk allergy have an overall less varied diet, including a less varied consumption of meat and sweet foods. Efforts should be made to ensure exclusion diets are as varied as possible to optimize nutritional intake.

‘Dietary variety’, synonymous with ‘dietary diversity’ or ‘food diversity’, is defined as the number of different foods or food groups consumed over a given reference period. In theory, consumption of a varied diet should reduce the risk of developing a deficiency or excess of any particular nutrient. Therefore, the consensus is that dietary variety and dietary quality are positively correlated (1). Additionally, a varied diet may protect from allergies. It is hypothesized that exposure of the infant gut to different food antigens might influence the development of immune tolerance (2). Two notable publications investigating the diversity of the infant diet and risk of later allergy using prospective birth cohort data have recently been published (2, 3).

Unfortunately, neither of these two studies differentiated between homemade and commercially produced infant foods. This is important as there is debate whether commercially produced infant food increases or decreases infant food variety (4, 5). Of note, data from a birth cohort from the United Kingdom (UK) suggests that an infant diet high in fruit, vegetables and home prepared foods, with only occasional use of commercially produced infant food, is associated with less food allergy at age 2 years (6, 7). However, the authors did not rule out ‘reverse causation’, that increased consumption of home prepared foods occurs as a result of food allergy (i.e. being unable to access allergen free ready-made baby food), rather than the cause of the food allergy.

In recent years, it has become more common to analyse childhood dietary intakes according to patterns of food or food groups, rather than analysis of specific nutrients separately (8–10). Although several studies have investigated the...
nutritional consequences of children consuming both single and multiple food exclusion diets with broadly similar results (11–14), to date no published research has specifically investigated dietary variety in children consuming an exclusion diet for food allergy. It appears logical that children prescribed an exclusion diet will have a less varied diet as they are limiting a whole food or food group. Paradoxically, it may be that parents of children consuming exclusion diets are forced to widen their normal food patterns to include alternative foods and recipes, potentially resulting in a broader variety of foods consumed. Therefore, the aim of this study was to investigate this matter, given the recent literature regarding dietary variety and atopic disease.

Methods
Study design
This was a cross-sectional study of 8- to 27-month-old children from the Isle of Wight, UK. This study included two groups: an experimental group, composed of children consuming a cows’ milk exclusion (CME) diet and a control group of children consuming an unrestricted diet. Children were eligible for inclusion in the experimental group if they were currently consuming a hypo-allergenic formula and/or a CME diet, had consumed this diet in the first year of life for a period of 3 months or longer and/or if they were excluding other foods (e.g. egg or soya).

Children were excluded from the study if they had any medical condition requiring a special diet (e.g. diabetes, cystic fibrosis). This applied to both CME and control groups.

Recruitment took place between July 2013 and December 2014. Participants eligible for the experimental group were identified via routine allergy clinics. Diagnosis of CMA and indication for an exclusion diet was conducted via positive clinical history, skin prick testing and/or improvement in symptoms with dietary exclusion and recurrence of symptoms with reintroduction of cows’ milk. The clinic from which participants were recruited followed the diagnostic pathway in the Milk Allergy in Primary Care guidelines (15). Due to resources, children did not undergo formal physician-supervised oral food challenges.

The control group was recruited from health visitor clinics in the same locality. Ethical approval was obtained from Berkshire NHS Ethics Committee. All parents completed a consent form.

Data collection
Information was collected on social demographics, family history of allergy, symptoms, infant feeding, healthy eating and growth. Dietary variety was measured using a Food Frequency Questionnaire (FFQ), as per the methodology of Emond et al. (16). A validated FFQ for this age group was adapted (17), by adding substitute foods that are typically eaten in a CME diet. The FFQ consisted of a list of 76 food and drinks, divided into subcategories of non-water drinks, ready-made baby foods, cereal based foods, dairy/egg, soya/substitute foods, meat fish and vegetarian substitute foods, fruits, vegetables and sweet/miscellaneous foods. The frequency of consumption over the previous 28 days of each food and drink was recorded. There was a free text option to document additional items consumed. The parent was also asked the type and volume of infant formula, cows’ milk or milk substitute the child drank per day and/or the approximate duration of breastfeeds per 24 hours.

Data analysis
Diet variety score (DVS) was calculated as the number of times ‘never’ is selected on the frequency option for each food. The DVS% for each category was calculated as a percentage of the items in each food category that had never been eaten. Therefore, a higher DVS and DVS% indicate a less varied diet. A power calculation for a two-tailed outcome at 80% power indicated that 104 participants were required. Data were analysed using SPSS software (IBM, version 20 Armonk, NY, USA). Descriptive statistics and frequencies were calculated. Differences between the CME and control groups were compared using Mann–Whitney U or $\chi^2$ tests. Analysis of covariance (ANCOVA) was calculated to control for the effect of age. A significance level of p < 0.05 was set for all analyses.

Results
Description of sample
One hundred and 26 participants were recruited, 66 in the CME group and 60 in the control group. Within the CME group, of the 89 participants who met the inclusion criteria, 20 did not return the questionnaires (22.5%), one did not wish to take part (1.1%) and two participants were excluded due to other medical conditions (2.2%), indicating an overall response rate of 74.2%. In the control group, no parents who were approached refused to take part; however, two (3.2%) did not have time to complete the questionnaire at the time and did not return it.

Demographic characteristics are detailed in Table 1. Participants in the CME group were younger than those in the control group (p = 0.02) and had higher levels of maternal food allergy.

Infant feeding and dietary exclusion
Details of participants’ infant feeding and symptoms have previously been reported (18). At the time of data collection, all participants in the CME group were consuming an exclusion diet for cows’ milk allergy and all participants in the control group were consuming an unrestricted diet. In brief, 13.5% of participants were being breastfed at the time of data collection. In the CME group, the most commonly used hypo-allergenic formula was amino acid formula (45.5%). The majority of the CME group was excluding cows’ milk only, whilst 28.8% were excluding another food allergen in addition to cows’ milk, usually egg. The median volume of cows’ milk/cows’ milk substitute consumed per day was 480mls (range 0–1080mls). Parents of the CME group were more concerned with healthy eating than the control group (p < 0.01).
Table 1 Demographic characteristics of all participants and by group

|                          | All (N = 126) | CME group (n = 66) | Control group (n = 60) |
|--------------------------|---------------|--------------------|------------------------|
| Age (months) median      | 13.0 (8-27)   | 12.37* (8-25)      | 15.0* (8-27)           |
| Male (%)                 | 67 (53.2)     | 34 (51.5)          | 33 (55.0)              |
| Maternal age (years) mean| 29.3 (SD 6.5) | 29.8 (SD 6.38)     | 28.6 (SD 6.62)         |
| Median number of siblings (minimum-maximum) | 1 (0-5) | 0 (0-3) | 0.5 (0-5) |
| White British (%)        | 118 (93.6)    | 61 (92.5)          | 57 (95.0)              |
| Median BMI centile % (minimum-maximum) | 65.3 (2.6-99.5) | 67.4 (2.6-99.5) | 54.9 (8.2-97.1) |
| Maternal education        |               |                    |                        |
| None (%)                 | 1 (0.8)       | 0 (0.0)            | 1 (1.7)                |
| GCSE/A-level equivalent (%) | 80 (63.4)   | 41 (62.1)         | 39 (65.0)              |
| Graduate/Postgraduate (%) | 41 (32.6)    | 23 (34.9)         | 18 (30.0)              |
| Not stated (%)           | 4 (3.2)       | 2 (3.0)           | 2 (3.3)                |
| Paternal education       |               |                    |                        |
| None (%)                 | 3 (2.4)       | 2 (3.0)           | 1 (1.7)                |
| GCSE/A-level equivalent (%) | 82 (65.1)   | 43 (65.2)         | 39 (65.0)              |
| Graduate/Postgraduate (%) | 31 (24.6)    | 15 (22.7)         | 16 (26.7)              |
| Not stated (%)           | 10 (7.9)      | 6 (9.1)           | 4 (6.6)                |
| Family history of food allergy |             |                    |                        |
| Maternal (%)             | 32 (25.6)     | 24 (36.4)*         | 8 (13.3)*              |
| Paternal (%)             | 12 (9.5)      | 9 (13.6)          | 3 (5.0)                |
| Sibling (%)              | 18 (14.3)     | 14 (21.2)         | 4 (6.6)                |
| Median birth weight in kg (minimum-maximum) | 3.43 (1.55-4.67) | 3.48 (2.08-4.67) | 3.34 (1.55-4.53) |
| Median weight in kg (minimum-maximum) | 9.9 (7.43-14.90) | 9.9 (7.59-14.9) | 10.1 (7.43-14.9) |
| Median length/height in cm (minimum-maximum) | 76.0 (68-90.4) | 76.0 (69.0-90.4) | 76.0 (68.0-88.0) |
| Median weight centile % (minimum-maximum) | 62.2 (5.6-137.0) | 65.9 (5.6-137.0) | 52.2 (8.1-98.2) |
| Median length/height centile % (minimum-maximum) | 66.9 (3.9-110.0) | 67.8 (3.9-100) | 30.8 (11-110) |
| Median BMI in kg/m² (minimum-maximum) | 17.0 (14-20.6) | 17.1 (14-20.6) | 17.0 (14.3-19.0) |
| Median BMI centile % (minimum-maximum) | 65.3 (2.6-99.5) | 67.4 (2.6-99.5) | 54.9 (8.2-97.1) |

BMI: Body Mass Index.
*Difference between CME and control group significant p < 0.05 using a Mann-Whitney U test.

Food frequency questionnaire results

Frequency of food group consumption

The most frequently consumed food groups overall were cereals, fruit and vegetables. Differences in consumption of different food categories between the CME and control groups are shown in Fig. 1. As expected, the CME group consumed dairy/egg foods less frequently and soya/substitute products more frequently than the control group (p < 0.01). They also consumed sweet foods 1.6 times and non-water drinks (including baby juice and tea) seven times less frequently (p < 0.05), but consumed ready-made baby foods 15 times more frequently (p < 0.01) than the control group. ANCOVA indicated that these differences persisted whilst controlling for age (p < 0.01). There was no difference in the frequency of consumption of fruit, vegetables, fish, meat or cereals between groups.

Significant differences in frequency of consumption of foods were found between participants during the first year of life compared to older children. To investigate this further, the group was stratified according to age. No difference was found in the consumption of ready-made baby food between the two groups in participants aged under one year; however, in older children, the CME group consumed ready-made baby food significantly more frequently compared with those in the control group (p < 0.01). Similarly, in terms of sweet/miscellaneous foods, there was no difference in consumption between the two groups of infant under one year of age; however, over one year of age, the control group consumed significantly more than the CME group (p < 0.01). Differences in consumption of dairy/egg products and soya/substitute foods persisted between groups across both age groups (p < 0.01).

Variety of food group consumption

The DVS for food categories is shown in Fig. 2. There was no difference in DVS according to gender. Participants aged above one year had more varied diets overall (p < 0.01). The DVS for all foods was significantly higher in the CME group (p < 0.01) than the control group. ANCOVA indicated that these differences persisted whilst controlling for age (p < 0.01). The DVS for ready-made baby food was significantly lower in the CME group than the control group (p < 0.01) (i.e. the CME group consume a greater variety of ready-made baby food than those in the control group). The DVS% in the dairy/egg/substitute category (p < 0.01), meat (p < 0.01) and sweet/miscellaneous (p < 0.01) food groups were significantly higher in the CME group than
the control group (i.e. the control group consume a greater variety of these food groups than the CME group).

Association with anthropometric measurements
BMI centile was moderately inversely correlated with DVS% for all foods (rho = 0.305, p < 0.01), indicating that children with a more varied diet overall had a higher BMI. BMI centile was also positively correlated with frequency of soya (rho = 0.304), meat (rho = 0.294) and fruit consumption (rho = 0.336) (p < 0.05).

Discussion
This study set out to measure the dietary variety and food group consumption of a group of children consuming an exclusion diet for cows’ milk allergy. Overall, the CME group
was found to have a significantly less varied diet than the control group. This was the case whether dairy/egg/soya substitutes were included or excluded from the calculation. Amongst food subcategories, the CME group had a less varied intake of dairy/egg, meat and sweet/miscellaneous foods and a greater variety in the ready-made baby food category. In addition, it does not appear that children consuming CME diets are fed a greater variety of other food categories (e.g. fruit, vegetables, or starchy carbohydrates) to compensate for the restriction of dairy products. However, the CME group also had some dietary practices that were more favourable than the control group, such as consumption of less baby juice and tea, which is a positive finding from a healthy eating perspective.

Whilst it may be expected that the CME group have a less varied diet overall and a less varied intake of the dairy/egg foods, the lower variety in the meat and sweet/miscellaneous categories are of more interest. It is perhaps an indication that parents are over-restricting the diets of children with CMA, or it may be a reflection of the ubiquity of milk in processed foods. For example, lower consumption of the sweet/miscellaneous foods category is likely attributed to the fact that some of these foods contain milk powder (e.g. biscuit), or possibly due to the higher concern with healthy eating the CME group had. Looking at beverages, the ‘healthy eating’ aspect may also explain the less frequent consumption of non-water drinks (e.g. tea, baby juice) in the CME group, which may be due to the dietetic advice the CME group received as part of routine clinical care and a greater awareness of food ingredients. This is in disagreement with the theory that children with a restricted diet develop a strong preference to calorie-dense ‘safe’ foods resulting in increased juice consumption (19).

There were significant differences in both the frequency and variety of consumption of ready-made baby foods between groups. The CME group ate ready-made baby foods significantly more often than the control group and ate a greater variety of ready-made baby foods than the control group. In total, these foods were eaten 15 times more frequently in participants aged above one year in the CME than the control group. This is important as several international studies have reported that ready-made baby food is of inferior nutritional quality to home-made baby food (20–23). In addition, food safety requirements lead to a negligible microbiota content (24). However, consumption of ready-made baby food is increasing, with qualitative research indicating it is perceived by some mothers as potentially ‘safer’ and composed of superior ingredients (25). On a practical level, it is perceived as more convenient and portable (26); therefore, it may be that infants with CME are fed these foods as it is difficult to source guaranteed cows’ milk free meals and snacks when eating away from the home. Previous research has reported that a ‘healthier eating’ dietary pattern, higher in fruit, vegetables and home-made foods, and lower in commercial baby foods was associated with a reduced prevalence of food allergy (6, 7). The authors reported that this pattern may have a protective effect on the development of food allergy, rather than be a result of having a food allergy. Although the data generated from the present study is cross-sectional and causation cannot be inferred, it is likely that increased consumption of ready-made baby food is occurring as a result of the CME diet. This could be explained by the fact that there is now a greater availability of milk free baby foods on sale than before.

Dietary variety in food allergic children has not been specifically investigated to date. One study was identified that measured ‘dietary monotony’ in an Italian study of mothers of food allergic children aged 0–16 years (27). Most of the participants claimed to have a ‘monotonous diet’. When asked about causes of the repetitive diet, the responses were: strict avoidance, low curiosity about food, a limited choice of food industry safe products and difficulties in making traditional recipes. Similar to this study’s findings, they also found an inverse association between child age and the repetitiveness of the diet. The authors hypothesized that this was due to children outgrowing some food allergies or that the diet becomes more varied as families become more accustomed to available food products. However, Polloni’s study was limited in that the questionnaire was not validated, there was no control group and no dietary data was reported. It may be that individuals who have a history of anaphylaxis consume more monotonous diets, due to stricter avoidance practices. However, we did not specifically explore this issue or present data on symptoms as this has previously been published elsewhere (18).

There is no universal criteria for choosing a dietary assessment method in children (28) and in infants it is complicated by the fact that their dietary habits can change rapidly and they typically may not eat all the food offered to them (29). However, a systematic review concluded that FFQs are an appropriate measure for this age group (30). Dietary variety has been shown to correlate strongly with dietary adequacy in toddlers (r = 0.74) (31); therefore, it provides a quick surrogate measure of the nutritional quality and balance of food groups, without the need to complete a food diary. A limitation of dietary variety and this study is that it focuses on nutritional adequacy and does not necessarily take into account excess consumption. It is possible to consume a limited number of nutrient dense foods and have a narrow dietary variety. Conversely it is possible to consume several different foods of low nutritional quality and have a high dietary variety (31). Despite these limitations, dietary variety has been shown to be an indicator of child growth (10), which we have also shown by reporting a moderate correlation with BMI centile.

The mean BMI centile in this study was in the normal range with no difference seen between the CME and the control group. Typically impaired growth in children with food allergy is thought to be related to dietary restrictions and/or the underlying pathophysiology of the allergic disorder (32). However, a recent study of patients with suspected food allergies from general paediatric practice reported that children under two years of age consuming CME diets did not experience weight impairment (33). This was attributed to prescribed hypo-allergenic infant formula providing adequate nutrition to compensate. The authors also identified that many typical toddler snack foods contain milk. Mehta et al.’s study is one of the few studies to also have been undertaken in a primary care population, and similar to this one the children
were following exclusion diets for physician-diagnosed food allergies, rather than challenge-proven food allergies, meaning the population is similar. It is also worth highlighting that participants in the CME group in the present study all had dietetic consultations, meaning they would have received individualized nutritional advice and growth monitoring at timely intervals, which has been shown to improve nutritional outcomes (12, 34).

Other limitations of this study are that the population was not very ethnically diverse and the exclusion group included both single and multiple exclusion diets. A recruitment bias may exist where those more interested in diet are more likely to take part, however, consecutive sampling was used to overcome this problem. Strengths of the study are that the groups were closely matched for demographic variables, except age, and validated questionnaires were used.

In conclusion, we have demonstrated that children consuming an exclusion diet for CMA have reduced dietary variety that is not limited to just dairy foods. There is a higher concern with healthy eating, a lower consumption of non-water drinks and sweet foods, alongside increased consumption of ready-made baby foods, particularly in children aged above one year. These findings are important as they emphasize the need to ensure exclusion diets are as varied as possible to optimize nutritional intake. Future research should address the dietary variety of older children consuming exclusion diets for other allergies.

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