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Short Communication

Dietary patterns of school-age children in Scotland: association with socio-economic indicators, physical activity and obesity

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The Survey of Sugar Intake among Children in Scotland was carried out in May to September 2006. The present study aimed to identify dietary patterns in school-aged children from the survey and investigate associations with socio-economic factors, obesity and physical activity. Habitual diet was assessed using the Scottish Collaborative Group FFQ. Height and weight were measured by trained fieldworkers. A total of 1233 FFQ were available for analysis. Dietary patterns were identified by age (5–11 and 12–17 years) and sex using principal components analysis. Associations between factor scores and socio-economic status, education level of the main food provider, physical activity levels and BMI category (based on UK 1990 charts) were examined. Three dietary patterns were identified in each age and sex group. 'Healthier' patterns loading highly for fruit and vegetables were significantly associated with higher socio-economic status and higher education levels of the main food provider whereas more 'unhealthy' patterns ('snacks' and 'puddings') were associated with lower socio-economic status and lower education levels of the main food provider. There was no consistent association between dietary patterns and BMI group or time spent in physical activity. However, inactivity (screen time) was inversely associated with 'healthier' patterns in all age and sex groups and positively associated with 'puddings' and 'snacks' in girls aged 5–11 years. Clear dietary patterns can be identified in school-age children in Scotland, which are consistently related to socio-economic factors and inactivity. This has implications for targeting health promotion at subgroups in terms of lifestyle changes required.

Dietary patterns: Principal components analysis: Children: Inactivity: Overweight

Traditionally research on diet and health has focused on intakes of individual nutrients and/or foods or food groups. However, diet is complex and intake of individual nutrients or foods is not independent of intakes of other nutrients or foods. More recently a number of statistical methods have been used to identify patterns of dietary behaviour. The most popular of these is principal components analysis (PCA)[1], a data-driven method which identifies foods that are frequently eaten together by aggregating items based on the degree to which the amounts consumed are correlated with one another. The aim of PCA is to identify groups of food that account for the largest amount of variation in overall diet between individuals. This method has been mainly used in studies of diet in adult populations but has also been used previously to explore dietary patterns in British, Spanish, Australian, Korean and Finnish children[2–11].

In 2005, the Food Standards Agency Scotland commissioned the 'Survey of Sugar Intake among Children in Scotland'[12] to provide information on the diet of children in Scotland, with a particular focus on the intake of non-milk extrinsic sugars and sugar-containing foods. The aims of the present study were to identify dietary patterns in school-age children from the survey and investigate associations with socio-economic factors, physical activity and obesity.

Methods

A named sample of 2800 Scottish children aged between 3 and 16 years on 1 May 2006 was drawn from eighty post-code sectors across Scotland using the Department of Work and Pensions Child Benefit records. Only one child per household was selected. After exclusions and an initial opt-out period, a FFQ (see below) was sent to the remaining sample

Abbreviations: ALSPAC, Avon Longitudinal Study of Pregnancy and Childhood; PCA, principal components analysis; SIMD, Scottish Index of Multiple Deprivation.

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of 2352 children, of whom a further sixty-five opted out and the address was found to be incorrect for forty-two. Completed FFQ were collected by trained fieldworkers when they conducted a face-to-face interview in which information on sociodemographic factors and physical activity levels was collected and the child's height and weight measured. A total of 1700 interviews were carried out between May and September 2006 and 1512 FFQ were returned, giving a combined response rate of 66 %.

The survey used two new versions of the Scottish Collaborative Group FFQ, which has been widely used in epidemiological studies in Scotland (http://www.foodfrequency.org.uk). Version C2 for children aged 3–11 years was designed for completion by a parent or guardian with help from the child and version C3 for young people aged 12–17 years for completion by the young person with help from their parent or guardian. Version C2 lists 140 foods or drinks with a measure defined for each item. Version C3 includes an additional six items covering intake of coffee and alcoholic drinks.

Socio-economic status was assessed using the 2006 Scottish Index of Multiple Deprivation (SIMD) based on postcode[13]. Data were analysed according to fifths of the distribution (quintiles). Respondents in the first quintile live in one of the 20 % least deprived areas in Scotland while those in the fifth quintile live in one of the 20 % most deprived areas in Scotland. Data were also analysed by quintiles of equivalised income (a measure of household income adjusted for the number of individuals living in the household) and education level of the main food provider (based on the highest level of recognised qualifications).

The questions on physical activity were the same as those used in the 1998 and 2003 Scottish Health Surveys[14–15]. Information was collected on the number of days and the time spent each day on the four different types of physical activity thought to account for the largest part of children's total physical activity (sport/exercise, active play, walking and housework/gardening) over the previous 7 d. The physical activity questions did not include any activity undertaken as part of the school curriculum. There was no lower time limit for the inclusion of sport/exercise or active play but only episodes of housework/gardening which lasted for at least 15 min and walks of at least 5 min duration were included.

As a measure of physical inactivity, children were asked about the average number of hours spent sitting in front of a television or computer screen (other than at school) on an average week day and on an average weekend day.

BMI was calculated from measured height and weight. Respondents were classified using UK 1990 reference data[16] as neither overweight nor obese (BMI $<$ 85th centile (z-score $< 1{\cdot}04$)), overweight (BMI $\geq$ 85th centile and $<$95th centile (z-score $\geq 1{\cdot}04$ and $<1{\cdot}64$)) and obese (BMI $\geq$ 95th centile (z-score $\geq 1{\cdot}64$)).

The study did not require the approval of a National Health Service research ethics committee but was carried out in accordance with the research governance and quality-assurance policies of the Scottish Centre for Social Research and the Institute of Applied Health Sciences at the University of Aberdeen (http://www.abdn.ac.uk/iahs/research-governance/governance.shtml). After an initial opt out, consent was implied by completion of the FFQ and written consent obtained for the interview and measurements.

Statistical analysis

In line with standard operating procedures for the Scottish Collaborative Group FFQ, questionnaires with more than ten missed lines were excluded from analysis (n 51 (3 %)). Respondents with extreme values of total energy intake below the 2·5th centile or above the 97·5th centile for age group (3–7, 8–11 or 12–17 years) were also excluded from the analysis (n 70). Analysis of dietary patterns was carried out for school-age children; therefore children aged 3–4 years were excluded. After exclusion of outliers, incomplete questionnaires and 3- to 4-year-old children, 1233 FFQ were available for analysis.

Statistical analysis was carried out using SPSS (version 15.0; SPSS Inc., Chicago, IL, USA)[17]. Data were weighted so that the estimates generated from the responding sample more accurately reflected the characteristics of the population of children aged 3–16 years on 1 May 2006 in Scotland. Weights were calculated to take account of selection probabilities and non-response bias and then combined to create a calibration weight which was applied in analyses. Further details can be found in Appendix A of the survey report[12].

PCA was carried out separately by age group (5–11 and 12–17 years) and sex. The decision was made to explore the dietary patterns separately by age group due to the questionnaires differing slightly by age with an additional six items in the older children's questionnaire and some differences in portion sizes for certain foods. In addition, dietary patterns were explored separately by sex within each age group due to an *a priori* assumption that patterns may be different between the sexes.

The weight (g/d) consumed for each item on the FFQ was calculated by multiplying the frequency of consumption by the portion weight. Missing lines were recoded as 0 g/d for children with $\leq$ ten missing lines.

In order to minimise the number of subjective decisions in determining the dietary patterns and retain the full detail of the diet as assessed by the FFQ we chose to retain the majority of items as they appeared on the FFQ. Food items consumed by $<$5 % of the sample were excluded (soya milk for all respondents and some alcoholic beverages and Marmite for 12- to 17-year-olds). PCA was carried out using the weight (g/d) of all remaining food items; 139 food items for 5- to 11-year-olds and 141 items for 12- to 17-year-olds. The number of components was selected primarily by examination of scree plots[18], but the interpretability of the components was also considered. Where the number of components to choose was unclear from the scree plot, the effect of removing or adding components on the content of the components and therefore ease of interpretation was assessed. Rotation was carried out using Varimax orthogonal rotation[19]. Factor loadings $<-0{\cdot}3$ and $>0{\cdot}3$ were used to define the patterns. The factor scores for each component for each child were used in subsequent analyses.

Tests of association were carried out using the Complex Samples option in SPSS to take account of sample design and response weighting variables. Associations between factor scores and SIMD quintile, income quintile and education level of the main food provider were assessed using Complex Samples general linear model (ANOVA) for individual associations and Complex Samples general linear

Table 1. Dietary patterns (variance explained) for boys and girls by age group

5- to 11-year-olds		12- to 17-year-olds	
Boys (*n* 381)	Girls (*n* 340)	Boys (*n* 250)	Girls (*n* 262)
Fruit and vegetables (5·3 %)	Fruit and vegetables (5·2 %)	Vegetables (6·2 %)	Puddings (5·1 %)
Snacks (3·3 %)	Puddings (4·4 %)	Puddings (4·7 %)	Fruit (5·0 %)
Fish and sauce (3·0 %)	Snacks (3·4 %)	Starchy food and drinks (3·5 %)	Vegetables (5·0 %)

model (analysis of covariance) when adjusting for each other, looking at the linear trend across the groups. The associations between factor scores and physical activity and BMI classification were assessed using Complex Samples general linear model (analysis of covariance) adjusting for age at interview and SIMD, again looking at the linear trend across the groups.

Results

PCA identified three dietary patterns in each age and sex group (Table 1 and Appendix 1). The three patterns accounted for 11·6 and 13·0 % of the variance, respectively, in boys and girls aged 5–11 years, and 14·4 and 15·1 % of the variance, respectively, in boys and girls aged 12–17 years.

The first component accounted for 5·1–6·2 % of the variance in the separate groups; for girls aged 12–17 years each of the three factors accounted for approximately the same amount of variance (5 %), whereas in the other groups the second and third factors accounted for progressively less of the variance.

The components were assigned labels based on the foods with high loadings within that component. For boys and girls aged 5–11 years and boys aged 12–17 years the first component was characterised by high intakes of 'healthier' foods such as fruit and vegetables; however, for girls aged 12–17 years the first component was characterised by high intakes of more 'unhealthy' foods such as puddings.

For most of the groups at least one of the other two patterns identified was a more 'unhealthy' 'snacks' or 'puddings' pattern. For 5- to 11-year-old boys a third 'fish and sauce' pattern was identified and for 12- to 17-year-old boys a third pattern loading highly for 'starchy food and drinks' was identified.

For boys and girls aged 5–11 years and boys aged 12–17 years fruit and vegetables loaded highly within the same component (component 1), although for 12- to 17-year-old boys there was a predominance of vegetables; however, for girls aged 12–17 years fruit and vegetables loaded highly in separate components (components 2 and 3, respectively).

Association between dietary patterns and socio-economic indicators

Table 2 shows the relationship between the dietary components and SIMD by age and sex group.

In boys and girls aged 5–11 years the 'fruit and vegetables' component was associated with lower levels of deprivation and the 'snacks' component was associated with higher levels of deprivation. In girls aged 5–11 years the 'puddings' component was also associated with higher levels of deprivation. In boys and girls aged 12–17 years the 'vegetables' component was associated with lower levels of deprivation and the 'puddings' component was associated with higher levels of deprivation.

An almost identical relationship was found between the dietary patterns and quintiles of household income (data not shown), with income positively associated with the 'fruit and vegetables' component in 5- to 11-year-olds (P for linear trend 0·008 boys and 0·014 girls) and the 'vegetables' component in 12- to 17-year-olds (P for linear trend $<0·001$ boys and 0·008 girls) and inversely associated with the 'puddings' component in girls of both ages and 12- to 17-year-old boys (P for linear trend 0·002 5- to 11-year-old girls, $<0·001$ 12- to 17-year-old girls and 0·001 12- to 17-year-old boys) and the 'snacks' component in 5- to 11-year-old boys (P for linear trend $<0·001$).

Again a similar relationship was found with education level of the main food provider (Table 3). The 'fruit and vegetables' pattern in 5- to 11-year-old girls and the 'vegetables' pattern in 12- to 17-year-olds were most likely to be followed by children whose main food provider was educated to degree level. In contrast, the 'snacks' and 'puddings' patterns were most likely to be followed by children whose main food provider had no qualification.

The 'fish and sauce' component in 5- to 11-year-old boys, the 'starchy food and drinks' component in 12- to 17-year-old boys and the 'fruit' component in 12- to 17-year-old girls showed no significant association with any of the socio-economic indicators.

In order to assess any independent associations, all three socio-economic indicators were entered into the same model (data not shown). In younger children aged 5–11 years the education level of the main food provider seemed to be the socio-economic indicator most associated with dietary patterns after adjustment for the other indicators. It remained significantly related to the 'fruit and vegetables' patterns in boys and girls (P for linear trend 0·001 boys and 0·013 girls) and the 'snacks' and 'puddings' patterns in girls (P for linear trend 0·020 and 0·027, respectively). However, household income was significantly related to the 'snacks' pattern in boys (P for linear trend 0·025) and SIMD to the 'snacks' pattern in girls (P for linear trend 0·012). In older children aged 12–17 years, however, household income was the only indicator which remained significant after adjustment for the other indicators, with the 'vegetables' component in 12- to 17-year-old boys (P for linear trend 0·003) and the 'puddings' component in 12- to 17-year-old boys and girls (P for linear trend 0·024 boys and 0·041 girls) remaining significantly associated with income.

Table 2. Factor scores for components by quintile of Scottish Index of Multiple Deprivation

(Mean values and 95 % confidence intervals)

	Scottish Index of Multiple Deprivation quintile										
	1st (least deprived)		2nd		3rd		4th		5th (most deprived)		
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	*P**
5- to 11-year-olds											
Boys											
Subjects (*n*)	83		70		83		82		60		
'Fruit and vegetables'	0·24	−0·10, 0·57	−0·03	−0·22, 0·17	0·15	−0·05, 0·35	−0·04	−0·02, 0·15	−0·39	−0·58, −0·20	0·003
'Snacks'	−0·32	−0·54, −0·10	−0·10	−0·41, 0·20	−0·09	−0·28, 0·09	0·09	−0·12, 0·29	0·49	0·17, 0·82	<0·001
'Fish and sauce'	0·01	−0·28, 0·29	−0·03	−0·20, 0·15	0·14	−0·08, 0·37	−0·16	−0·39, 0·06	0·02	−0·16, 0·20	0·726
Girls											
Subjects (*n*)	81		60		62		67		66		
'Fruit and vegetables'	0·29	0·06, 0·53	0·12	−0·15, 0·39	−0·09	−0·32, 0·14	−0·16	−0·32, 0·00	−0·15	−0·39, 0·09	0·003
'Puddings'	−0·17	−0·37, 0·03	−0·11	−0·29, 0·07	0·03	−0·32, 0·37	0·00	−0·22, 0·22	0·25	−0·01, 0·52	0·011
'Snacks'	−0·17	−0·40, 0·07	−0·02	−0·24, 0·19	−0·42	−0·72, −0·13	0·13	−0·08, 0·35	0·40	0·14, 0·66	0·003
12- to 17-year-olds											
Boys											
Subjects (*n*)	59		53		40		47		44		
'Vegetables'	0·50	0·05, 0·94	0·02	−0·19, 0·24	0·02	−0·32, 0·36	−0·38	−0·63, −0·13	−0·20	−0·47, 0·07	0·002
'Puddings'	−0·22	−0·55, 0·11	−0·13	−0·34, 0·07	−0·05	−0·29, 0·18	0·31	−0·12, 0·74	0·15	−0·13, 0·43	0·017
'Starchy food and drinks'	0·09	−0·27, 0·44	−0·11	−0·45, 0·22	−0·25	−0·40, −0·09	0·10	−0·16, 0·36	0·05	−0·38, 0·48	0·813
Girls											
Subjects (*n*)	55		67		44		41		52		
'Puddings'	−0·23	−0·49, 0·03	−0·15	−0·32, 0·02	−0·05	−0·30, 0·21	−0·03	−0·30, 0·24	0·45	0·03, 0·87	0·007
'Fruit'	0·14	−0·14, 0·41	−0·01	−0·20, 0·17	0·02	−0·23, 0·27	0·27	−0·24, 0·78	−0·37	−0·47, −0·27	0·062
'Vegetables'	0·21	−0·02, 0·45	0·16	−0·01, 0·33	−0·01	−0·23, 0·22	−0·04	−0·58, 0·50	−0·34	−0·49, −0·19	0·004

* *P* value for linear association.

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Table 3. Factor scores for components by education level of the main food provider
(Mean values and 95 % confidence intervals)

	Education level of main food provider										
	Degree		Vocational qualification		Higher grade		Standard grade		Other or no qualification		
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	*P**
5- to 11-year-olds											
Boys											
Subjects (*n*)	100		129		19		84		43		
'Fruit and vegetables'	0·37	0·11, 0·63	−0·11	−0·29, 0·07	−0·09	−0·36, 0·17	−0·22	−0·36, −0·08	−0·05	−0·47, 0·36	0·051
'Snacks'	−0·40	−0·59, −0·21	−0·03	−0·18, 0·13	0·08	−0·35, 0·51	0·30	0·07, 0·52	0·31	−0·08, 0·70	<0·001
'Fish and sauce'	0·15	−0·08, 0·37	0·09	−0·09, 0·28	−0·33	−0·67, 0·01	−0·28	−0·44, −0·11	0·01	−0·35, 0·37	0·183
Girls											
Subjects (*n*)	100		114		23		56		41		
'Fruit and vegetables'	0·28	0·05, 0·50	0·05	−0·16, 0·25	−0·03	−0·42, 0·35	−0·30	−0·51, −0·09	−0·30	−0·61, 0·01	0·001
'Puddings'	−0·22	−0·34, −0·10	0·00	−0·20, 0·19	−0·40	−0·64, −0·17	0·07	−0·20, 0·34	0·58	0·06, 1·10	0·004
'Snacks'	−0·26	−0·44, −0·07	0·05	−0·22, 0·32	0·17	−0·19, 0·53	0·09	−0·07, 0·26	0·20	−0·10, 0·49	0·014
12- to 17-year-olds											
Boys											
Subjects (*n*)	72		67		21		37		40		
'Vegetables'	0·58	0·23, 0·94	−0·24	−0·43, −0·04	−0·27	−0·54, 0·00	−0·33	−0·67, 0·01	−0·10	−0·37, 0·17	0·005
'Puddings'	−0·24	−0·52, 0·05	−0·08	−0·24, 0·09	−0·19	−0·35, −0·03	0·13	−0·12, 0·37	0·49	−0·03, 1·02	0·006
'Starchy food and drinks'	0·03	−0·30, 0·37	0·09	−0·21, 0·39	−0·22	−0·56, 0·12	−0·10	−0·29, 0·08	−0·10	−0·38, 0·18	0·320
Girls											
Subjects (*n*)	63		79		20		47		39		
'Puddings'	−0·39	−0·54, −0·23	0·08	−0·15, 0·32	−0·05	−0·39, 0·29	−0·05	−0·25, 0·15	0·43	−0·12, 0·98	0·017
'Fruit'	0·09	−0·10, 0·29	−0·08	−0·29, 0·13	−0·26	−0·44, −0·08	0·02	−0·38, 0·42	0·02	−0·27, 0·32	0·923
'Vegetables'	0·22	−0·06, 0·49	0·15	−0·12, 0·42	−0·10	−0·32, 0·11	−0·20	−0·46, 0·05	−0·28	−0·50, −0·06	0·001

* *P* value for linear association.

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Association between dietary patterns and physical activity and inactivity

Time spent in physical activity was positively related to the 'snacks' component for boys and girls aged 5–11 years, i.e. scores for these patterns were higher in children who spent longer in physical activity and also positively related to the 'fruit and vegetables' component for girls aged 5–11 years (Table 4).

Table 5 shows the relationship between the dietary components and time spent sitting at a screen. In all age and sex groups, components loading highly for fruit and/or vegetables were inversely associated with time spent in front of a screen. In girls aged 5–11 years the 'puddings' and 'snacks' components were positively associated with more time spent in front of a screen.

Association between dietary patterns and overweight and obesity

The only significant association between BMI group and dietary patterns was found in boys aged 5–11 years, in whom there was a significant linear association between 'snacks' and BMI group, with the lowest factor score in obese children, i.e. obese children ate less of the snack foods associated with this component (*P* for linear trend 0·047). There was also a significant linear association between 'fish and sauce' and BMI group, with the highest factor score in obese children (*P* for linear trend 0·023).

Discussion

For most of the age and sex groups, one 'healthy' dietary pattern characterised by high intakes of foods such as fruit and vegetables was identified and this was usually the first pattern explaining the greatest variance. At least one of the other two patterns identified was a more 'unhealthy' 'snacks' or 'puddings' pattern consisting mainly of high-fat and/or high-sugar energy-dense foods. For younger boys a third 'fish and sauce' pattern was identified and for older boys a third 'starchy food and drinks' pattern was identified.

Older girls (aged 12–17 years) differed from the other groups with respect to the dietary patterns identified in that the first component was a more 'unhealthy' pattern loading highly for puddings, although the percentage variance explained did not differ much from the second and third components. Each of the three factors in older girls accounted for approximately the same amount of variance (5 %), whereas for the other groups the first component accounted for 5·2–6·2 % of the variance, with the other components accounting for less. Also for older girls fruit and vegetables loaded highly in separate components, whereas for the other groups fruit and vegetables loaded highly within the same component, although for 12- to 17-year-old boys there was a predominance of vegetables.

The three dietary patterns identified for each age and sex group only accounted for 12–15 % of the variance; however, the low variance explained is not unique to the present study, as dietary patterns derived using PCA generally tend to account for only a small amount of the total variance of diet in a dataset[1]. Therefore, results should be interpreted with caution, as other patterns exist within the data which may individually explain less of the variance but jointly account for a substantial proportion of the variation between individuals. The variance explained in the present study was very slightly lower than that of three factors identified at 4, 7 and 9 years of age in the ALSPAC Study children (17·7 % at 4 years, 18·1 % at 7 years and 19·2 % at 9 years)[4] and three factors identified in an Australian study of 12- to 18-year-olds which accounted for 21·7 % of the variance[7]. However, this is most probably due to the larger number of food items used in the PCA in the present study, as it has been shown that with more items the lower the proportion of variance explained; however, prior grouping of foods may attenuate relationships between derived patterns and outcome variables[20]. As we chose not to pre-group the foods before analysis there were approximately 140 input variables, whereas the Australian study had eighty-six items[7] and the ALSPAC Study approximately forty[4].

The dietary patterns found by the ALSPAC Study at age 4, 7 and 9 years of age were 'processed' (originally named 'junk'), 'health conscious' and 'traditional'[4]. At age 3 years a fourth 'snacks' pattern was found[2]. The foods that made up the 'processed' pattern are similar to those in the 'snacks' and 'puddings' patterns in the present study. The 'traditional' pattern contained meat, poultry, potato and vegetables whilst the 'health conscious' pattern loaded highly for fruit, vegetables, fish, pasta and rice at ages 3, 4 and 7 and inversely with meats at 9 years. The three dietary patterns identified in the Australian study of 12- to 18-year-olds were a 'fruit, salad, cereals and fish' pattern, a 'high fat and sugar' pattern and a 'vegetables' pattern[7]. The results from these two studies and the present one suggest that intake of vegetables may be highly correlated with the intake of fruit in younger children but not necessarily in older children.

The present study found significant relationships between dietary patterns and socio-economic indicators. In general, 'healthier' dietary patterns ('fruit and vegetables') were associated with lower levels of deprivation, higher incomes and higher education levels of the main food provider whereas more 'unhealthy' dietary patterns ('snacks' and 'puddings') showed the opposite association. It should be noted, however, that although there were clear associations between dietary patterns and socio-economic status, the survey did not find as clear an association between socio-economic status and nutrient intakes, with a small increase in non-milk extrinsic sugars intake with increasing deprivation measured by SIMD and no difference in total fat or SFA intakes[12] which is also consistent with data from other surveys[21].

In older girls, where fruit and vegetables loaded highly in separate components, socio-economic factors were related to 'vegetables' but not 'fruit', suggesting that intake of vegetables may be more influenced by socio-economic factors than intake of fruit. Very few other studies have investigated fruit and vegetables separately and most other studies of dietary patterns have found that fruit and vegetables aggregate together in the same component, similar to most of the subgroups in the present study. However, the results from the main analysis of the survey looking at individual food groups showed a stronger socio-economic gradient for vegetables than fruit in these children[12].

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Table 4. Factor scores for components by time spent in physical activity
(Mean values and 95 % confidence intervals)

	Time spent in physical activity per week (h)										
	<7 h		≥7 h to <14 h		≥14 h to <21 h		≥21 h to <28 h		≥28 h		
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	*P**
5- to 11-year-olds											
Boys											
Subjects (*n*)	21		75		94		96		90		
'Fruit and vegetables'	−0·11	−0·42, 0·20	−0·13	−0·29, 0·03	0·16	−0·13, 0·46	−0·12	−0·24, 0·00	0·02	−0·12, 0·16	0·488
'Snacks'	−0·17	−0·44, 0·10	−0·12	−0·33, 0·09	−0·06	−0·30, 0·18	0·04	−0·14, 0·22	0·22	−0·01, 0·45	0·021
'Fish and sauce'	0·32	−0·26, 0·90	−0·02	−0·23, 0·19	−0·19	−0·39, 0·01	0·04	−0·21, 0·29	0·07	−0·13, 0·27	0·458
Girls											
Subjects (*n*)	23		101		81		62		68		
'Fruit and vegetables'	−0·43	−0·75, −0·12	−0·02	−0·20, 0·45	0·03	−0·20, 0·26	−0·05	−0·31, 0·20	0·26	0·00, 0·53	0·003
'Puddings'	0·65	0·21, 1·09	−0·05	−0·21, 0·12	−0·27	−0·42, −0·12	−0·03	−0·31, 0·25	0·14	−0·15, 0·42	0·076
'Snacks'	−0·16	−0·46, 0·14	−0·17	−0·34, 0·00	−0·03	−0·22, 0·16	0·10	−0·16, 0·36	0·27	0·02, 0·51	0·011
12- to 17-year-olds											
Boys											
Subjects (*n*)	36		56		51		45		57		
'Vegetables'	0·06	−0·25, 0·37	−0·32	−0·50, −0·14	0·16	−0·16, 0·49	0·08	−0·27, 0·43	0·09	−0·13, 0·31	0·241
'Puddings'	0·04	−0·34, 0·43	0·03	−0·23, 0·28	0·14	−0·13, 0·40	−0·26	−0·51, 0·00	0·09	−0·20, 0·38	0·708
'Starchy food and drinks'	−0·30	−0·52, −0·08	0·19	−0·17, 0·56	−0·02	−0·25, 0·20	−0·25	−0·66, 0·16	0·11	−0·13, 0·36	0·390
Girls											
Subjects (*n*)	85		65		48		38		30		
'Puddings'	0·05	−0·22, 0·33	−0·17	−0·34, 0·00	−0·15	−0·36, 0·07	0·34	−0·08, 0·76	0·03	−0·39, 0·45	0·382
'Fruit'	−0·21	−0·33, −0·10	−0·08	−0·29, 0·12	0·33	−0·15, 0·81	0·15	−0·17, 0·46	0·11	−0·28, 0·51	0·084
'Vegetables'	−0·06	−0·24, 0·13	−0·08	−0·31, 0·15	−0·10	−0·32, 0·13	0·31	−0·15, 0·78	0·04	−0·23, 0·31	0·119

* *P* value for linear association.

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Table 5. Factor scores for components by time spent sitting at a screen
(Mean values and 95 % confidence intervals)

	Time spent sitting at a screen on an average day (h)										
	< 1 h		≥ 1 h to < 2 h		≥ 2 h to < 3 h		≥ 3 h to < 4 h		≥ 4 h		
	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	*P**
5- to 11-year-olds											
Boys											
Subjects (*n*)	66		149		110		37		14		
'Fruit and vegetables'	0·29	−0·08, 0·67	−0·02	−0·20, 0·15	−0·15	−0·30, −0·01	−0·03	−0·33, 0·27	−0·12	−0·37, 0·13	0·035
'Snacks'	−0·15	−0·36, 0·06	0·01	−0·17, 0·20	0·05	−0·13, 0·24	0·11	−0·26, 0·48	0·19	−0·34, 0·72	0·232
'Fish and sauce'	0·06	−0·18, 0·30	−0·06	−0·23, 0·10	0·03	−0·16, 0·22	0·22	−0·20, 0·65	−0·47	−0·99, 0·05	0·207
Girls											
Subjects (*n*)	74		147		83		25		5		
'Fruit and vegetables'	0·29	0·03, 0·55	0·10	−0·05, 0·26	−0·24	−0·46, −0·02	−0·53	−0·87, −0·20	−0·35	−0·98, 0·27	0·009
'Puddings'	−0·08	−0·33, 0·16	0·03	−0·15, 0·20	0·01	−0·18, 0·21	−0·03	−0·35, 0·29	0·58	0·06, 1·09	0·042
'Snacks'	−0·07	−0·37, 0·23	0·00	−0·15, 0·15	−0·10	−0·34, 0·14	0·15	−0·13, 0·44	1·00	0·42, 1·57	0·001
12- to 17-year-olds											
Boys											
Subjects (*n*)	21		56		81		53		31		
'Vegetables'	0·49	0·15, 0·82	0·03	−0·18, 0·24	0·04	−0·22, 0·29	−0·01	−0·28, 0·25	−0·37	−0·63, −0·11	< 0·001
'Puddings'	0·02	−0·52, 0·57	0·00	−0·28, 0·29	0·01	−0·14, 0·15	−0·15	−0·47, 0·17	0·24	−0·11, 0·60	0·628
'Starchy food and drinks'	−0·18	−0·47, 0·11	−0·08	−0·35, 0·19	0·02	−0·20, 0·24	0·16	−0·30, 0·62	−0·19	−0·40, 0·02	0·532
Girls											
Subjects (*n*)	38		82		73		33		33		
'Puddings'	−0·27	−0·62, 0·08	−0·03	−0·24, 0·18	0·05	−0·19, 0·29	0·30	−0·31, 0·91	−0·04	−0·34, 0·26	0·134
'Fruit'	0·25	−0·12, 0·61	0·00	−0·15, 0·15	0·20	−0·16, 0·57	−0·34	−0·53, −0·15	−0·27	−0·57, 0·02	0·003
'Vegetables'	0·36	−0·18, 0·91	0·19	−0·02, 0·40	−0·12	−0·35, 0·10	−0·18	−0·37, 0·02	−0·38	−0·58, −0·18	0·003

* *P* value for linear association.

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Other studies have found similar associations between dietary patterns in children and socio-economic factors. The ALSPAC Study[2–3] found that their 'junk' (renamed 'processed') pattern was related to socially disadvantaged households (council housing, financial difficulties, lower levels of maternal education), whereas their 'healthy' component was associated with higher maternal education levels. A Spanish study of 2-to 24-year-olds found similar associations with maternal education levels[6]. Those children whose mother had a lower education level were more likely to have a 'snacky' pattern and less likely to have a 'healthy' pattern. However, the Australian study of 12- to 18-year-olds failed to find an association between the three dietary patterns identified in their sample and socio-economic indicators[7].

In younger children education level of the main food provider seemed to be the socio-economic indicator most associated with dietary patterns after adjustment for the other indicators; however, in older children household income was the only indicator which remained significant after adjustment for the other socio-economic indicators. It is conceivable that as children age and become more independent and make more of their own food choices the amount of money available to them may become more of an issue and perhaps their own education level becomes more important than that of a parent. Most other studies have considered only one age group, focusing either on younger or older children and often considering different socio-economic indicators separately; therefore it is difficult to compare these findings. However, as highlighted earlier, the ALSPAC Study[2–3] found that maternal education levels in particular were associated with dietary patterns in children up to 7 years of age and the enKid Study found that maternal education levels were associated with dietary patterns in 2- to 24-year-olds in Spain[6].

The present study found significant linear relationships between dietary patterns and physical activity and inactivity, with associations being more consistent with inactivity. 'Healthier' dietary patterns were consistently associated with less time spent in front of a screen for all age and sex groups whereas more 'unhealthy' dietary patterns were associated with more time spent in front of a screen for girls aged 5–11 years. However, time spent in physical activity was positively related to the 'snacks' component in 5- to 11-year-olds of both sexes and the 'fruit and vegetables' component in 5- to 11-year-old girls.

Few studies have examined associations between dietary patterns identified by PCA and physical activity. The Spanish study of 2- to 24-year-olds[6] found that their 'snacky' pattern was positively associated with time spent watching television in all ages and their 'healthy' pattern inversely associated with time spent watching television in 2- to 13-year-olds. Similar to the present study, the Australian study of adolescents[7] failed to find a consistent association between dietary patterns and physical activity in 15- to 18-year-olds, with only their 'high fat and sugar' pattern being associated with higher levels of physical activity. In general, other studies have concentrated on the relationship between diet and inactivity (usually measured by television viewing), with few looking at the relationship with physical activity. More 'unhealthy' diets have been found to be associated with greater time spent watching television[22–25].

There was little association between dietary patterns and overweight and obesity. The only significant relationships were in boys aged 5–11 years, with the lowest intake of 'snacks' and the highest intake of 'fish and sauce' in obese children. The few other studies that have looked at dietary patterns identified by PCA in relation to obesity in children have also failed to find significant associations[5–7] apart from one which found a positive association between an 'animal foods' pattern and overweight in Korean preschool children[9]. Another study utilising cluster analysis also failed to find a significant association between dietary patterns and BMI in German children[26]. The lack of an association between diet and BMI could be due to the fact that the data are cross-sectional. The results could be influenced by dieting and/or under-reporting, particularly in the overweight and obese children, but as no information was collected on dieting behaviour and no adjustment of the data has been made for possible under-reporting, the results should be interpreted with caution. However, in general there is a lack of consistent association between diet and BMI in children in the literature[27–28].

There are several strengths and limitations of PCA which are discussed in detail by other authors[1,29]. One of its main limitations is that it involves several subjective decisions, in particular choosing the number of components to retain and naming them and, also, grouping of foods if researchers choose to do so. As mentioned earlier, in order to minimise the number of subjective decisions we chose not to pre-group the foods before analysis. However, PCA requires a large sample size due to the fact that the analysis is based on a correlation matrix of the variables, and correlations usually need a large sample size before they stabilize. It has been suggested that a sample size of 200 is fair and 300 is good[30], but it has also been suggested that the ratio of sample size to the number of variables is important, with anything from two to ten subjects per variable being recommended[31]. The sample sizes for the various age and sex groups in the present study ranged from 250 to 381, meaning that they were fair to good by the first definition; however, as there were approximately 140 items on the FFQ this would need 280–1400 subjects to fulfill the second criteria for sample size. The minimum number of 280 was achieved in the younger age groups but not quite in the older children. Pre-grouping the foods may have meant that some of these new groups would have contributed more to components than individual items; however, it would not be clear which of the foods within these new groupings were most important.

The main advantage of PCA is that it combines information across the diet based on food intakes, taking into account the complexity of the diet and revealing underlying food consumption patterns, meaning that it may be more relevant to dietary choices than analyses based on individual foods and/or nutrients.

There are two main approaches to dietary patterns, either a hypothesis-driven *a priori* approach, or an empirical *a posteriori* approach[1,29,32]. In the hypothesis-driven *a priori* approach, the diet is given a score based on the degree to which it conforms to dietary recommendations such as the Healthy Eating Index[33], the Diet Quality Index[34] or the Mediterranean Diet Score[35] and this score is used as an exposure variable. The score does not reflect overall diet, but rather specific aspects of it that are thought to represent a healthy diet. This method, however, is limited by current knowledge of diet–disease relationships and the choice of which foods and/or nutrients to include in the score and what cut-off points to apply. The empirical approach relies entirely on data, and patterns are derived using statistical techniques. PCA is the most popular of these approaches but cluster analysis is also commonly used. Cluster analysis differs from PCA in that it aggregates individuals into mutually exclusive subgroups or clusters with similar diets rather than grouping foods that are consumed together. Individuals can only belong to one cluster; therefore, there can be a risk of misclassification which does not exist for PCA. Further analysis such as comparing profiles across clusters is required to interpret these patterns, whereas in PCA the patterns are directly interpretable. A more recent addition to dietary pattern methodology is reduced rank regression[36]. This is of most use when studying diet–disease relationships, as it takes account of biological pathways by identifying patterns associated with biomarkers of disease. It is therefore considered a combination of *a priori* and *a posteriori* methods. However, it requires information on disease biomarkers.

Using PCA to generate dietary patterns shows which foods tend to be eaten together, and relating these patterns to other factors such as demographics, lifestyle and health helps to tailor and set priorities for health promotion and also to better understand the role of diet in relation to disease risk.

In conclusion, distinct dietary patterns could be identified in school-age children, which differed slightly between age and sex groups. The predominant dietary pattern seemed to be a ‘healthy’ one containing vegetables, in combination with fruit for the younger children. This pattern was consistently associated with higher socio-economic status (less deprivation, higher income and higher education level of the main food provider) and less time spent in inactivity. Although clear associations were found between dietary patterns and socio-economic factors, it should be noted that this does not necessarily translate into large differences in nutrient intakes between socio-economic groups; therefore analyses of dietary patterns should be combined with analyses of nutrients, as studying either one alone could be misleading. This may have important implications for targeting health promotion messages at subgroups in terms of changes required to current food intakes. Clear associations between ‘unhealthy’ dietary patterns and inactivity were found but there were no consistent associations between dietary patterns and physical activity except for the suggestion in younger children that more unhealthy ‘snacks’ patterns were positively associated with physical activity. This suggests that ‘healthy’ lifestyle factors do not necessarily cluster together in the same children but ‘unhealthy’ ones do tend to cluster together. This also has implications for health promotion strategies in children which should focus on ‘healthy’ lifestyles including both diet and physical activity messages.

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The authors state that there are no conflicts of interest.

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Appendix 1. Factor loadings for principal components analysis

Table A1. Components for 5- to 11-year-olds

	Boys (*n* 381)			Girls (*n* 340)		
Component and % variance… Food item	Fruit and vegetables (5·3)	Snacks (3·3)	Fish and sauce (3·0)	Fruit and vegetables (5·2)	Puddings (4·4)	Snacks (3·4)
Unsweetened cereals	0·036	0·021	−0·041	0·237	0·056	−0·081
Sweetened cereals	−0·049	0·172	−0·161	−0·119	0·142	0·196
Ready Brek or porridge	0·294	−0·002	−0·026	0·258	0·007	−0·131
Muesli	0·062	−0·083	0·083	0·171	−0·056	−0·132
White bread or rolls	−0·124	0·402*	−0·092	−0·137	0·067	0·343*
Brown or granary bread or rolls	0·102	−0·253	0·099	0·147	−0·013	−0·093
Wholemeal bread or rolls	0·269	−0·217	−0·056	0·090	−0·077	−0·146
Croissants, garlic bread or Aberdeen rolls	−0·041	0·109	0·185	−0·005	0·051	0·059
Pitta, naan, tortilla, bagel, etc	0·462*	0·047	−0·042	0·310*	0·039	−0·121
Full-fat cows' milk	0·127	0·101	0·135	−0·024	0·161	−0·116
Semi-skimmed cows' milk	0·124	−0·065	−0·037	0·157	−0·094	0·101
Skimmed cows' milk	−0·036	−0·113	0·016	0·015	−0·019	−0·039
Flavoured milk	−0·075	0·089	0·057	0·064	0·214	0·193
Drinking yogurts	−0·062	−0·114	0·039	0·117	0·130	−0·065
Flavoured yogurts	0·041	−0·029	0·160	0·119	0·006	0·233
Fromage frais	0·137	0·011	−0·308*	−0·022	−0·053	0·106
Natural, low-fat or low-energy yogurt	0·197	−0·142	−0·050	0·126	0·093	−0·141
Cream	0·129	−0·048	0·167	0·247	0·143	−0·100
Full-fat cream cheese	0·152	−0·004	0·119	0·099	0·090	0·006
Cheddar cheese	0·157	0·033	0·084	0·116	−0·090	0·180
Edam, cheese spreads	0·013	0·026	−0·057	0·065	0·161	0·241
Low-fat cheese	0·085	0·081	0·213	0·151	0·169	0·021
Eggs	0·108	0·236	0·350*	0·188	0·137	0·197
Meat burgers or mince	−0·017	0·347*	0·163	0·002	0·249	0·364*
Meat sauce	−0·068	0·267	0·339*	0·293	0·309*	0·242
Frankfurters	−0·059	0·224	0·040	−0·017	0·250	0·158
Sausages	−0·158	0·365*	0·109	−0·097	0·201	0·314*
Bacon or gammon	−0·021	0·299	0·170	0·162	0·283	0·233
Cold ham or turkey	0·005	0·274	0·019	0·037	−0·065	0·412*
Salami, etc	0·014	−0·009	0·008	0·157	0·018	−0·004
Stewed, fried or grilled meat	0·177	0·267	0·295	0·257	0·177	0·203
Chicken nuggets	−0·114	0·182	−0·194	−0·226	0·332*	0·154

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Table A1. *Continued*

Component and % variance... Food item	Boys (n 381)			Girls (n 340)		
	Fruit and vegetables (5·3)	Snacks (3·3)	Fish and sauce (3·0)	Fruit and vegetables (5·2)	Puddings (4·4)	Snacks (3·4)
Other chicken or turkey	0·131	0·174	0·223	0·197	0·037	0·164
Meat or chicken pies, pasties, sausage roll	−0·174	0·246	0·098	−0·154	0·369*	0·270
Fish fingers	−0·020	−0·038	−0·028	−0·098	0·341*	−0·054
Fish cakes or fish pie	0·100	0·017	0·243	0·132	0·341*	−0·009
Grilled or poached white fish	0·162	0·015	0·320*	0·397*	0·105	−0·047
Fried or battered white fish or scampi	−0·003	0·033	0·165	0·112	0·269	−0·068
Grilled oily fish	0·178	−0·043	0·412*	0·346*	0·161	−0·102
Fried oily fish	0·069	−0·002	0·289	0·055	0·248	−0·092
Smoked oily fish	0·089	−0·182	0·318*	0·089	0·076	−0·117
Tuna	0·260	0·043	0·280	0·237	0·041	0·110
Tinned salmon, sardines, mackerel, pilchards	0·174	−0·044	0·171	0·321*	0·128	−0·005
Prawns	0·425*	−0·015	0·075	0·337*	0·243	−0·062
Boiled, mashed or baked potatoes	0·320*	0·212	0·037	0·101	0·078	0·241
Potato croquettes or waffles	−0·093	0·205	−0·130	−0·114	0·215	0·221
Roast or fried potatoes	−0·110	0·135	0·355*	0·130	0·176	0·266
Oven chips	−0·233	0·259	0·120	−0·052	0·155	0·256
Home-cooked chips	−0·014	0·150	−0·023	−0·136	0·368*	0·045
Bought chips	−0·199	0·286	−0·096	−0·221	0·231	−0·319*
Pasta or couscous	0·165	−0·159	0·312*	0·317*	−0·030	0·085
Rice	0·302*	−0·022	0·156	0·425*	−0·001	−0·031
Noodles	0·028	0·231	0·131	−0·130	0·367*	−0·186
Pizza	−0·177	0·204	0·010	−0·116	0·390*	−0·030
Quiche	0·123	0·008	0·312*	0·085	0·434*	−0·025
Quorn, soya or tofu	0·166	−0·266	0·126	0·068	0·006	−0·305*
Nut roast, nut burgers or vegetable burgers	0·083	−0·255	0·169	0·006	0·138	−0·150
Baked beans	0·040	0·144	0·003	−0·034	0·343*	0·108
Other beans or lentils	0·213	−0·096	0·140	0·224	0·217	−0·148
Canned or dried soup	0·025	0·334*	0·149	−0·070	0·320*	0·143
Home-made soup	0·353*	0·065	0·098	0·338*	0·083	−0·164
Bottled sauces (for example, ketchup)	−0·097	0·231	−0·058	−0·016	0·128	0·381*
Tomato sauce	0·004	0·112	0·356*	0·334*	0·212	0·191
Other sauce	0·085	0·053	0·476*	0·159	0·105	0·062
Gravy	−0·052	0·332*	0·301*	0·171	0·152	0·246
Mayonnaise or salad cream	0·013	−0·020	0·143	0·253	0·126	0·061
Mixed vegetable dishes	0·385*	−0·016	0·277	0·244	0·157	−0·120
Peas or green beans	0·348*	−0·077	0·249	0·412*	0·122	0·129
Sweetcorn	0·409*	0·050	0·158	0·457*	0·099	0·031
Broccoli	0·742*	−0·086	0·037	0·559*	−0·038	0·006
Cabbage	0·637*	0·091	0·037	0·508*	0·190	−0·051
Spinach	0·529*	−0·058	0·045	0·468*	0·063	−0·280
Other green vegetables	0·566*	−0·086	0·194	0·565*	0·093	−0·349*
Cauliflower, swede or turnip	0·663*	0·044	0·008	0·504*	0·086	−0·009
Raw carrots	0·580*	0·049	−0·084	0·514*	−0·030	−0·104
Cooked carrots	0·413*	−0·013	0·241	0·540*	0·158	0·009
Onions	0·487*	−0·074	0·211	0·503*	0·015	−0·135
Tomatoes	0·555*	−0·014	−0·053	0·277	−0·091	−0·114
Peppers	0·408*	−0·064	0·058	0·437*	−0·048	−0·159
Other salad vegetables	0·551*	−0·055	0·016	0·407*	−0·063	−0·142
Coleslaw	0·051	0·184	0·209	0·190	0·241	−0·152
Potato salad	−0·047	0·057	0·307*	−0·110	0·241	−0·399*
Fresh fruit salad	0·194	−0·031	0·086	0·276	−0·100	0·080
Tinned fruit	0·220	0·156	0·219	0·171	0·077	0·262
Apples	0·411*	−0·066	−0·019	0·387*	−0·183	0·037
Oranges	0·480*	0·091	−0·006	0·439*	−0·117	0·111
Bananas	0·411*	−0·040	0·041	0·378*	−0·127	−0·009
Grapes, melon, pear	0·324*	−0·064	0·146	0·368*	−0·187	0·222
Kiwi	0·435*	0·045	0·078	0·401*	−0·076	0·030
Other fruit	0·502*	0·004	0·010	0·389*	−0·149	0·142
Dried fruit	0·192	−0·222	0·101	0·258	−0·053	−0·118
Pure apple juice	0·191	−0·098	0·059	0·059	−0·015	−0·090
Other pure fruit juice	0·205	−0·015	0·146	0·197	−0·015	−0·121
High-juice fruit drinks	0·029	0·088	0·058	−0·068	0·140	0·196
Regular fruit juice drinks	−0·040	0·154	−0·169	−0·128	0·029	0·249
Other fruit-flavoured drinks including flavoured water	0·004	0·203	−0·035	−0·036	−0·022	0·246
Blackcurrant diluting juice	0·010	0·049	−0·207	0·091	0·098	0·113
No-added-sugar blackcurrant diluting juice	−0·040	0·219	−0·240	0·028	−0·024	0·277

Table A1. *Continued*

Component and % variance... Food item	Boys (*n* 381)			Girls (*n* 340)		
	Fruit and vegetables (5·3)	Snacks (3·3)	Fish and sauce (3·0)	Fruit and vegetables (5·2)	Puddings (4·4)	Snacks (3·4)
Orange, lemon, etc, diluting juice	0·064	0·199	0·025	0·049	0·126	0·036
No-added-sugar orange, lemon or other diluting juice	0·012	0·242	−0·046	−0·002	−0·124	0·272
Regular fizzy drinks	−0·060	0·374*	−0·152	−0·160	0·089	0·224
Low-energy fizzy drinks	−0·059	0·281	−0·049	−0·043	−0·064	0·259
Water	0·318*	−0·133	0·143	0·262	−0·127	−0·028
Smoothies	0·045	−0·025	0·067	0·459*	0·100	−0·222
Drinking chocolate	0·050	0·136	0·081	0·039	−0·006	0·011
Tea	−0·012	0·225	0·073	0·136	0·088	0·076
Sugar	−0·027	0·390*	−0·025	−0·011	0·308*	0·188
Jam, etc	0·287	0·109	−0·136	0·172	0·194	0·168
Peanut butter	0·012	−0·167	0·245	0·032	0·076	−0·102
Chocolate spread	−0·021	0·008	−0·200	0·002	0·153	0·140
Marmite	0·224	−0·083	0·023	0·091	−0·060	0·032
Butter or margarine	0·207	0·219	−0·070	−0·015	−0·050	0·256
Regular crisps	−0·054	0·460*	−0·281	−0·154	−0·109	0·275
Reduced-fat crisps	0·031	−0·070	0·141	0·032	−0·036	−0·028
Other savoury snacks	−0·017	0·335*	−0·051	−0·044	0·079	0·373*
Nuts	0·054	−0·036	0·143	0·185	0·136	−0·077
Savoury biscuits, crackers and breadsticks	0·194	0·025	0·023	0·097	0·083	0·061
Plain biscuits	0·034	0·276	−0·003	0·029	0·106	0·100
Fancy biscuits	−0·067	0·306*	−0·115	−0·088	0·249	0·224
Chocolate biscuits	−0·139	0·326*	−0·253	−0·015	0·146	0·404*
Cereal bars or flapjacks	0·030	0·079	0·087	0·184	0·040	0·008
Scones or pancakes	−0·010	0·123	0·075	0·022	0·219	0·175
Doughnuts or muffins	−0·056	0·130	0·136	0·019	0·304*	0·198
Fruit cake or malt loaf	0·051	−0·095	0·229	0·165	0·316*	−0·086
Plain cakes	0·069	0·101	0·197	0·050	0·480*	0·036
Cakes with icing	0·019	0·146	0·160	−0·043	0·525*	0·092
Cream cakes or gateaux	−0·047	0·205	0·178	0·085	0·598*	0·055
Mousse	−0·041	0·103	0·269	−0·033	0·346*	0·121
Jelly	0·093	0·338*	0·059	−0·001	0·182	0·062
Milk puddings	0·042	0·159	0·123	0·162	0·563*	0·060
Sponge puddings	0·093	0·237	0·223	0·113	0·601*	0·032
Fruit tarts, crumbles or pies	0·211	0·166	0·353*	0·145	0·597*	−0·011
Custard	0·013	0·261	0·126	−0·024	0·478*	−0·003
Cheesecake	0·030	0·191	0·042	0·146	0·482*	0·001
Boiled, chewy sweets or chocolate sweets	−0·092	0·409*	−0·098	−0·077	0·051	0·375*
Chocolate bars	−0·061	0·324*	−0·238	−0·111	−0·017	0·293
Wrapped ice creams	−0·026	0·101	0·076	0·127	0·123	0·361*
Other ice cream	−0·005	0·259	0·093	−0·053	0·128	0·325*
Iced lollies	−0·019	0·351*	−0·085	0·030	0·061	0·428*

* Factor loadings $< -0·3$ and $> 0·3$.

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Table A2. Components for 12- to 17-year-olds

Component and % variance... Food item	Boys (n 250) Vegetables (6·2)	Boys (n 250) Puddings (4·7)	Boys (n 250) Starchy food and drinks (3·5)	Girls (n 262) Puddings (5·1)	Girls (n 262) Fruit (5·0)	Girls (n 262) Vegetables (5·0)
Unsweetened cereals	−0·007	0·053	−0·034	−0·047	0·047	0·102
Sweetened cereals	−0·061	0·037	0·172	0·049	−0·030	0·069
Ready Brek or porridge	0·127	0·047	−0·086	−0·053	0·242	0·113
Muesli	0·217	−0·030	−0·020	−0·043	0·031	0·209
White bread or rolls	−0·193	−0·004	0·182	0·053	−0·173	−0·017
Brown or granary bread or rolls	0·167	0·006	−0·051	−0·099	0·064	0·456*
Wholemeal bread or rolls	0·264	0·064	−0·204	−0·139	0·040	0·177
Croissants, garlic bread or Aberdeen rolls	0·032	0·176	0·043	0·143	0·120	0·033
Pitta, naan, tortilla, bagel, etc	0·268	−0·141	0·446*	0·061	0·080	0·104
Full-fat cows' milk	−0·084	0·287	−0·091	0·116	−0·117	−0·007
Semi-skimmed cows' milk	0·039	−0·128	0·121	−0·074	0·039	0·231
Skimmed cows' milk	0·191	0·075	0·016	0·036	0·136	0·084
Flavoured milk	−0·012	0·278	−0·051	0·232	−0·013	−0·067
Drinking yogurts	0·086	0·025	−0·053	0·035	0·088	0·038
Flavoured yogurts	0·089	0·133	−0·205	0·150	0·154	0·118
Fromage frais	−0·030	0·190	0·085	0·130	0·014	0·024
Natural, low-fat or low-energy yogurt	0·172	0·017	0·168	−0·082	0·214	0·134
Cream	0·228	0·147	0·080	0·116	0·003	0·021
Full-fat cream cheese	0·116	0·151	0·038	0·232	0·059	0·077
Cheddar cheese	−0·059	0·104	−0·045	0·034	0·062	0·054
Edam, cheese spreads	0·054	0·132	−0·130	0·097	−0·031	0·017
Low-fat cheese	0·074	0·223	0·057	0·040	0·035	0·156
Eggs	0·056	0·262	0·083	0·212	0·143	0·088
Meat burgers or mince	−0·050	0·106	0·263	0·276	0·078	0·198
Meat sauce	0·145	0·075	0·258	0·202	0·068	0·251
Frankfurters	−0·033	0·112	0·100	0·121	−0·087	0·026
Sausages	−0·209	0·255	0·365*	0·351*	−0·029	−0·059
Bacon or gammon	−0·107	0·152	0·211	0·636*	−0·021	−0·047
Cold ham or turkey	−0·098	−0·060	0·340*	0·061	−0·047	0·257
Salami, etc	0·028	0·061	0·101	−0·079	0·005	0·050
Stewed, fried or grilled meat	0·200	0·024	0·230	0·169	0·075	0·170
Chicken nuggets	−0·199	0·325*	0·202	0·258	−0·012	−0·100
Other chicken or turkey	0·113	−0·119	0·291	0·256	0·055	0·234
Meat or chicken pies, pasties, sausage roll	−0·069	0·181	0·339*	0·325*	−0·023	0·158
Fish fingers	−0·026	0·301*	0·093	0·166	−0·042	0·513*
Fish cakes or fish pie	0·207	0·320*	0·229	0·150	−0·065	0·018
Grilled or poached white fish	0·366*	0·116	0·094	−0·041	0·201	0·242
Fried or battered white fish or scampi	0·261	0·258	0·098	0·047	0·118	0·225
Grilled oily fish	0·321*	0·190	0·060	0·276	0·270	0·130
Fried oily fish	0·306*	0·282	0·057	0·224	0·259	0·152
Smoked oily fish	0·330*	−0·037	0·318*	−0·055	0·076	0·185
Tuna	0·127	−0·013	0·190	0·120	0·375*	0·102
Tinned salmon, sardines, mackerel, pilchards	0·323*	0·128	0·104	0·148	0·058	0·195
Prawns	0·093	0·035	0·266	−0·105	0·213	0·159
Boiled, mashed or baked potatoes	0·049	−0·048	0·442*	−0·024	0·031	0·257
Potato croquettes or waffles	0·049	0·297	0·224	0·131	0·057	−0·095
Roast or fried potatoes	0·230	−0·025	0·508*	0·295	0·127	0·049
Oven chips	−0·213	0·235	0·270	0·189	−0·110	−0·019
Home-cooked chips	−0·012	0·206	−0·088	0·245	−0·186	−0·131
Bought chips	−0·208	0·271	0·072	0·431*	−0·125	−0·106
Pasta or couscous	0·230	−0·143	0·456*	−0·019	0·052	0·393*
Rice	0·315*	−0·139	0·361*	0·090	0·236	0·225
Noodles	−0·111	0·014	0·004	0·262	−0·013	0·002
Pizza	−0·187	0·273	0·375*	0·426*	−0·040	0·069
Quiche	0·248	0·133	−0·065	0·053	0·048	0·311*
Quorn, soya or tofu	0·048	0·104	−0·132	−0·134	−0·003	0·164
Nut roast, nut burgers or vegetable burgers	0·310*	0·417*	−0·089	−0·129	0·102	0·105
Baked beans	−0·006	0·069	0·209	0·470*	0·123	0·016
Other beans or lentils	0·412*	0·298	−0·005	−0·079	0·179	0·229
Canned or dried soup	−0·023	0·270	−0·015	0·327*	0·106	0·060
Home-made soup	0·225	0·182	0·001	0·168	0·419*	0·118
Bottled sauces (for example, ketchup)	−0·068	0·172	0·068	0·096	−0·071	0·082
Tomato sauce	0·184	0·036	0·230	0·038	0·274	0·261
Other sauce	0·203	0·202	0·317*	0·086	0·044	0·249
Gravy	0·094	0·006	0·224	0·314*	−0·131	0·240
Mayonnaise or salad cream	0·108	−0·096	0·310*	−0·001	0·071	0·190
Mixed vegetable dishes	0·621*	0·111	0·131	0·060	0·210	0·586*

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Table A2. *Continued*

Component and % variance... Food item	Boys (*n* 250) Vegetables (6·2)	Boys (*n* 250) Puddings (4·7)	Boys (*n* 250) Starchy food and drinks (3·5)	Girls (*n* 262) Puddings (5·1)	Girls (*n* 262) Fruit (5·0)	Girls (*n* 262) Vegetables (5·0)
Peas or green beans	0·558*	−0·113	0·148	−0·040	0·076	0·479*
Sweetcorn	0·617*	0·016	0·174	0·108	0·053	0·561*
Broccoli	0·588*	−0·116	0·054	−0·032	0·132	0·687*
Cabbage	0·495*	0·142	−0·117	0·073	0·063	0·660*
Spinach	0·516*	0·143	−0·142	0·021	0·198	0·359*
Other green vegetables	0·547*	−0·053	−0·065	−0·116	0·388*	0·444*
Cauliflower, swede or turnip	0·447*	0·022	−0·045	0·098	0·077	0·666*
Raw carrots	0·630*	−0·099	0·223	−0·046	0·256	0·132
Cooked carrots	0·614*	−0·124	0·189	0·062	0·109	0·621*
Onions	0·535*	−0·075	0·097	−0·141	0·201	0·528*
Tomatoes	0·501*	−0·054	0·103	−0·051	0·098	0·500*
Peppers	0·562*	−0·059	0·130	−0·049	0·136	0·562*
Other salad vegetables	0·619*	−0·096	0·159	−0·136	0·425*	0·471*
Coleslaw	0·463*	0·246	0·105	0·336*	0·271	0·145
Potato salad	0·433*	0·258	−0·021	0·163	0·261	0·192
Fresh fruit salad	0·138	0·094	0·027	0·170	0·453*	−0·008
Tinned fruit	0·123	0·193	−0·029	0·163	0·674*	−0·165
Apples	0·200	0·001	−0·046	−0·023	0·725*	−0·021
Oranges	0·295	0·116	−0·003	0·003	0·770*	−0·107
Bananas	0·385*	0·052	0·010	−0·058	0·806*	−0·053
Grapes, melon, pear	0·206	0·035	0·049	−0·018	0·668*	0·057
Kiwi	0·302*	0·201	−0·018	0·030	0·757*	−0·063
Other fruit	0·339*	0·058	−0·064	−0·093	0·657*	0·045
Dried fruit	0·327*	−0·017	−0·108	−0·160	0·672*	0·046
Pure apple juice	0·340*	0·061	0·096	−0·157	0·151	0·032
Other pure fruit juice	0·201	0·018	0·143	−0·143	0·235	0·166
High-juice fruit drinks	0·118	0·257	0·131	0·104	0·034	−0·026
Regular fruit juice drinks	−0·022	0·260	0·040	0·080	0·032	−0·018
Other fruit-flavoured drinks including flavoured water	0·081	0·328*	0·052	0·063	0·128	0·140
Blackcurrant diluting juice	−0·004	0·211	0·310*	0·196	0·067	0·116
No-added-sugar blackcurrant diluting juice	−0·180	0·068	0·257	0·052	0·116	0·196
Orange, lemon, etc, diluting juice	−0·117	0·238	0·412*	0·195	0·119	0·120
No-added-sugar orange, lemon or other diluting juice	−0·190	0·199	0·356*	0·019	0·021	0·255
Regular fizzy drinks	−0·251	0·126	0·102	0·512*	−0·162	−0·208
Low-energy fizzy drinks	0·044	0·132	0·014	0·165	−0·086	0·028
Water	0·282	−0·097	0·170	−0·015	0·179	0·096
Smoothies	0·181	0·312*	0·085	0·012	0·209	0·098
Drinking chocolate	0·106	0·295	−0·098	0·261	0·128	0·099
Tea	−0·024	−0·037	0·056	−0·033	−0·042	0·066
Coffee	0·088	−0·056	−0·035	0·118	0·033	0·169
Alcopops	0·057	−0·043	0·490*	0·548*	−0·005	−0·133
Lager or beer†	0·024	−0·017	0·415*	–	–	–
Cider‡	–	–	–	0·027	−0·016	−0·059
Sugar	−0·233	0·076	0·128	0·472*	−0·063	0·020
Jam, etc	0·052	0·109	0·003	0·031	0·155	0·066
Peanut butter	0·125	−0·015	−0·052	0·078	0·326*	0·045
Chocolate spread	0·117	0·272	−0·034	0·219	0·039	−0·010
Butter or margarine	−0·165	0·035	0·232	0·114	−0·138	0·179
Regular crisps	−0·306*	0·182	0·250	0·357*	−0·182	−0·242
Reduced-fat crisps	−0·032	0·210	0·139	0·123	−0·014	0·153
Other savoury snacks	−0·176	0·306*	0·227	0·434*	0·001	−0·032
Nuts	0·240	0·426*	−0·125	−0·006	0·432*	0·150
Savoury biscuits, crackers and breadsticks	0·028	0·210	0·402*	0·101	0·160	0·104
Plain biscuits	−0·077	0·080	0·250	0·112	0·023	0·028
Fancy biscuits	0·015	0·213	0·115	0·222	0·006	0·029
Chocolate biscuits	−0·118	0·116	0·190	0·274	−0·071	−0·026
Cereal bars or flapjacks	0·156	0·079	0·315*	0·193	0·138	0·046
Scones or pancakes	0·049	0·223	−0·079	0·312*	0·031	0·166
Doughnuts or muffins	−0·038	0·317*	−0·010	0·473*	−0·087	0·123
Fruit cake or malt loaf	0·020	0·099	0·017	0·113	0·062	0·287
Plain cakes	0·161	0·415*	0·024	0·274	0·022	0·199
Cakes with icing	−0·022	0·263	0·118	0·272	−0·045	0·226
Cream cakes or gateaux	0·079	0·371*	0·115	0·616*	−0·022	0·110
Mousse	−0·061	0·262	0·069	0·055	−0·048	0·169

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Table A2. *Continued*

Component and % variance... Food item	Boys (n 250) Vegetables (6·2)	Boys (n 250) Puddings (4·7)	Boys (n 250) Starchy food and drinks (3·5)	Girls (n 262) Puddings (5·1)	Girls (n 262) Fruit (5·0)	Girls (n 262) Vegetables (5·0)
Jelly	0·048	0·473*	−0·055	0·134	0·043	0·119
Milk puddings	0·122	0·552*	−0·170	0·560*	0·206	−0·122
Sponge puddings	0·123	0·627*	0·064	0·193	0·087	0·155
Fruit tarts, crumbles or pies	0·324*	0·472*	−0·128	0·193	0·101	0·211
Custard	0·089	0·466*	−0·043	0·606*	0·087	−0·008
Cheesecake	0·167	0·405*	0·026	0·619*	0·008	0·019
Boiled, chewy sweets or chocolate sweets	−0·154	0·356*	0·186	0·321*	0·031	−0·025
Chocolate bars	−0·214	0·265	0·137	0·308*	−0·093	−0·040
Wrapped ice creams	−0·125	0·519*	0·063	0·379*	0·037	0·087
Other ice cream	−0·156	0·437*	0·112	0·279	0·044	−0·021
Iced lollies	−0·118	0·484*	−0·031	0·339*	0·045	−0·017

* Factor loadings $< -0·3$ and $> 0·3$.
† Consumed by < 5 % of girls.
‡ Consumed by < 5 % of boys.

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