Tracking a Dietary Pattern Associated with Increased Adiposity in Childhood and Adolescence

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Objective: Understanding dietary tracking may help to inform interventions to improve dietary intakes and health outcomes. This study investigated how a dietary pattern (DP) associated with increased adiposity in childhood tracked from 7 to 13 years of age, in the Avon Longitudinal Study of Parents and Children (ALSPAC).

Design and Methods: Three-day food diaries were collected at 7, 10 and 13 years. Reduced rank regression was used to score respondents for an energy-dense, high fat, low fiber DP at each age. Tracking coefficients were estimated for the DP and its key foods using data from 7,027 children.

Results: The DP tracking coefficient was 0.48 (95% CI: 0.44-0.52) for boys and 0.38 (95% CI: 0.35-0.41) for girls. Of 10 key food groups, fruit, vegetables, high fiber bread, high fiber breakfast cereals and full fat milk intakes exhibited the strongest tracking, particularly among low consumers. Lower maternal education and greater prepregnancy maternal BMI predicted higher DP \( z \) scores and lower fruit and vegetable intakes.

Conclusions: A dietary pattern associated with increased adiposity tracks moderately from 7 to 13 years of age in this large UK cohort. Specific groups of families may require additional support to foster lifelong healthy dietary habits in their children.

Introduction

An understanding of the stability or tracking of dietary intake is crucial for formulating policy and interventions to improve nutrition-related health outcomes such as obesity. Strong dietary tracking signifies maintenance of a similar level of dietary intake over time whereas, poor dietary tracking indicates a susceptibility to alter dietary intake over time. Knowledge of dietary tracking over the life course may assist in identifying which dietary intakes are maintained more (or less) consistently over time and therefore, their potential susceptibility to intervention, as well as identification of key times for intervention. This is especially relevant to dietary intakes linked to health outcomes.

Early childhood and adolescence are critical times for physical development as well as changes in psycho-social environments. Yet, relatively few studies have examined the tracking of dietary intake during the transition from childhood to adolescence (1-5). Dietary patterns may be more informative for investigating diet-disease relationships than individual foods or nutrients, as they consider total dietary intake and the colinearity between many foods and nutrients, as well as the potentially synergistic effects of foods and nutrients (6). Only two studies to date have examined how empirically derived dietary patterns track during childhood (1,7).

We previously identified an energy-dense, high fat, low fiber dietary pattern prospectively associated with increased and excess adiposity during childhood and adolescence in the UK Avon Longitudinal Study of Parents and Children (ALSPAC) (8). The current article examines how scores for this dietary pattern and intakes of its key foods tracked between 7 and 13 years of age in the ALSPAC cohort. As maternal education and maternal overweight have been linked with both offspring dietary intakes (9,10) and weight status (11) we also hypothesized that low maternal education and greater maternal prepregnancy BMI would be positively associated with stronger tracking and higher scores for the energy-dense, high fat, low fiber dietary pattern, between 7 and 13 years of age.

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Methods

Data were from children and parents participating in the Avon Longitudinal Study of Parents and Children (ALSPAC). Full details of the study have been reported elsewhere (12-14). In brief, ALSPAC commenced with the recruitment of 14,541 pregnant women residing in Avon, England, with an expected delivery date between April 1991 and December 1992. The total sample of children consisted of 14,610 live births and 14,536 were alive at 1 year. A range of health data have been collected from the women, their partners and children, at regular intervals thereafter, via mailed questionnaires and clinic visits at Bristol University (13). Parents provided written consent for their child to participate in the study. Ethical approval for the study was obtained from the ALSPAC Law and Ethics Committee and the Local Research Ethics Committees.

Dietary assessment

The current analysis utilizes dietary data collected at follow ups that took place when study children were ~7, 10 and 13 years of age. At each of these ages, the children were requested to complete a 3-day unweighed food diary over 2-week days and 1-weekend day. Parents completed the diary on behalf of the child at 7 years of age. At 10 and 13 years of age, the children completed the diary with input from an adult as required, and these diaries were later checked and queried with a nutritionist. All completed food diaries were coded into one of five ordinal categories (in decreasing order): University degree, A level (academic examination passed at 18 years), O level (academic examination passed at 16 years), vocational (non-academic training or apprenticeship) and CSE (Certificate of Secondary Education, non-academic study to 16 years).

We have previously described an “energy-dense, high fat, low fiber” dietary pattern identified using reduced rank regression (RRR) in this cohort, in detail (8). This dietary pattern, or pattern in food intake, explained the maximum variation in three dietary response variables hypothesized to be related with obesity risk: (1) dietary energy density, (2) the proportion of total energy from fat (%EF), and (3) dietary fiber density. Separate exploratory RRR analyses were conducted at 7, 10, and 13 years of age (17), modeling 45 food groups intakes as predictor variables and energy density, %EF and fiber density as response variables. This identified an almost identical dietary pattern at all ages positively correlated with dietary energy density and %EF and negatively correlated with dietary fiber density. This energy-dense, high fat, low fiber dietary pattern was characterized mostly by low intakes of fruit, vegetables and high fiber breakfast cereals and high intakes of confectionery, crisps, low fiber bread, cakes and biscuits (Table 1); full details are published elsewhere (8).

Each subject received a z score quantifying the degree to which their reported dietary intake reflected the energy dense, high fat, low fiber dietary pattern at 7, 10, and 13 years of age (where data available). To track z scores for exactly the same dietary pattern from 7 to 13 years of age, an applied dietary pattern z score was calculated at 10 and 13 years using the scoring coefficients produced by the 7 years RRR analysis. This allowed a z score for the dietary pattern identified at 7 years of age to be calculated at 10 and 13 years of age, and to more accurately track z scores for the same dietary pattern.

Covariates

Information on maternal prepregnancy BMI and maternal education was available from questionnaires completed by the study child’s mother at 32 week’s gestation. Mothers were classified as overweight or obese if their BMI was ≥25 kg m\(^{-2}\). Maternal education level (reflecting the mother’s highest educational achievement) was coded into one of five ordinal categories (in decreasing order): University degree, A level (academic examination passed at 18 years), O level (academic examination passed at 16 years), vocational (non-academic training or apprenticeship) and CSE (Certificate of Secondary Education, non-academic study to 16 years).

Statistical analyses

Tracking was defined as how consistently individuals maintained their position or z score in the study population distribution during

| TABLE 1 | Five highest and lowest factor loadings for the energy-dense, high fat, low fiber dietary pattern |
|---------|----------------------------------------------------------------------------------|
| 7 y     | 10 y                                | 13 y                                |
| Five highest factor loadings | Five lowest factor loadings |
| Chocolate, confectionery | 0.23 | Chocolate, confectionery | 0.25 |
| Bread, low fiber | 0.20 | Bread, confectionery | 0.21 |
| Cakes, biscuits | 0.19 | Bread, low fiber | 0.20 |
| Potato crisps | 0.18 | Potato crisps | 0.21 |
| Milk, full fat | 0.14 | Processed meats | 0.16 |
| Fruit, fresh | −0.48 | Fruit, fresh | −0.43 |
| Vegetables, raw or boiled | −0.41 | Vegetables, raw or boiled | −0.42 |
| Breakfast cereal, high fiber | −0.26 | Legumes | −0.24 |
| Potato, boiled | −0.21 | Potato, boiled | −0.22 |
| Bread, high fiber | −0.21 | Breakfast cereal, high fiber | −0.20 |
Dietary Pattern Tracking in Childhood and Adolescence

Tracking analyses were conducted separately for boys and girls. Food intakes were categorized into tertiles rather than quartiles. As there were fewer consumers of full fat milk by 7 years of age remained low consumers of these foods. The majority of children (57–75%) who were low consumers of these foods positively loaded onto the dietary pattern, there was some evidence that low consumers of processed meats and crisps at 7 years, remained low consumers at 13 years. Among those who maintained a high consumption of these foods. The tracking coefficient ranges from 0 to 1, with 1 indicating perfect tracking and 0 indicating no tracking. There are no universally accepted cutoffs to classify good or poor tracking, as the magnitude of the tracking coefficient can depend on the length of follow up and measurement error in the variable being tracked (19). However, it is possible to contrast tracking coefficients observed within the same study, and we considered tracking coefficients ≥0.40 to indicate “moderate” tracking. These GEE models were used as they can handle data from more than two time points, utilize all available data points, as well as account for repeated measurements on the same individuals being correlated and the different lengths of time between measurements. An exchangeable correlation structure was used and all models were adjusted for age at first dietary pattern measurement. The GEE models were run using PROC GENMOD in SAS v9.1.3.

A similar GEE model was applied to estimate tracking coefficients for key food group intakes. Only those food groups in the top five and bottom five factor loadings for the energy-dense, high fat, low fiber dietary pattern were examined (Table 1) as these explained over 80% of the variation in DP scores (8). To account for varying ages at each follow up, food group intakes were firstly adjusted for total energy intake (food group intake (g)/total energy intake (kJ)). Energy-adjusted food intakes were then standardized to z scores to estimate standardized tracking coefficients. Maternal education and maternal prepregnancy BMI were included as covariates in the GEE models to examine their influence on the tracking coefficients and to quantify their prospective associations with later dietary pattern z scores and food group intake z scores. Dietary misreporting was included in the models (as a categorical variable) as a potential predictor of dietary tracking.

A secondary analysis was conducted to enable comparisons with other studies that have not reported tracking coefficients. Dietary pattern and food group z scores were firstly categorized into quartiles. Tracking was then examined simply as the proportion of individuals in the highest or lowest quartiles at 7 years of age who maintained their quartile position at 13 years of age (maintenance of extreme quartiles). This enabled differences in tracking between high and low consumers to be identified. As there were fewer consumers of full fat milk, high fiber breakfast cereal, high fiber bread and legumes, these food intakes were categorized into tertiles rather than quartiles.

Tracking analyses were conducted separately for boys and girls. Only those respondents who completed a food diary on at least two follow ups were included in the analyses.

Results

A total of 7,078 participants (3,506 boys and 3,572 girls) provided dietary data from at least two follow ups and were considered for these analyses. Of the 6,202 in this sample who provided dietary data at 7 years of age, 5,949 had dietary data at 10 years of age and 4,986 had dietary data at 13 years of age. A total of 4,733 had dietary data at all three ages and 876 had dietary data at 10 and 13 years of age only. Participants included in this analysis were slightly more likely to be white and have higher levels of maternal education compared with the remainder of the cohort, who either did not complete or completed only one food diary; maternal prepregnancy BMI status did not differ (Supporting Information Table S1). Mean intakes of the ten key food groups at each follow up are shown in Table 2.

Tracking coefficients

The tracking coefficient for the energy-dense, high fat, low fiber dietary pattern was 0.48 (95% CI, 0.44-0.52) for boys and 0.38 (95% CI, 0.35-0.41) for girls (Table 3). Tracking coefficients for the food group intakes were generally lower, ranging from 0.14 to 0.40 (Table 3). Tracking was consistently higher among boys, particularly for the dietary pattern and intakes of full fat milk, cakes and biscuits, and high fiber breakfast cereal. After full fat milk, the strongest tracking for both boys and girls was for fresh fruit (0.35 and 0.31, respectively) and vegetables (0.31 and 0.28, respectively).

Maintenance of extreme quartile position

A total of 4,986 individuals (2,460 boys, 2,526 girls) provided dietary data at 7 and 13 years of age. Figure 3 shows the proportion of respondents who maintained their ranking in either the highest or lowest quartile of dietary pattern z scores and food group intakes between 7 and 13 years of age. For simplicity, Figure 1 shows results for boys and girls combined, as there were few gender differences, with the exception of the dietary pattern. Among girls, tracking for the dietary pattern was stronger among low scorers (43%) compared with high scorers (32%), whereas among boys, there was little difference between high (45%) and low scorers (41%).

Overall, there was fair to strong tracking of food group intakes; 30–77% of subjects maintained their position in an extreme quartile during follow up, more than the 25% expected to remain in the same quartile by chance (Figure 1). Almost 80% of children who were low consumers of full fat milk by 7 years of age remained low consumers at 13 years. The proportions of children maintaining a low consumption of fresh fruit, high fiber breakfast cereals, high fiber bread, potato (boiled) and legumes was considerably greater than those who maintained a high consumption of these foods. The majority of children (57–75%) who were low consumers of these foods at 7 years, remained low consumers at 13 years. Among those foods positively loaded onto the dietary pattern, there was some evidence that low consumers of processed meats and crisps at 7 years of age were less likely to alter their intake level than high consumers.

Maternal education and prepregnancy BMI

Adjustment for maternal education, prepregnancy BMI and dietary misreporting made little difference to the GEE tracking coefficients (not shown).
However, maternal education level was a predictor of later dietary pattern scores. A lower maternal education level was associated with higher scores for the energy-dense, high fat, low fiber dietary pattern in boys and girls (P value for trend < 0.0001). For example, among boys, each decreasing level of maternal education was associated with a dietary pattern score in later years that was on average, 0.11 SD units greater (95% CI, 0.08-0.15, P < 0.0001) than those with the highest level of maternal education (Figure 2). As such, boys in the lowest maternal education group had a dietary pattern z score that was 0.45 SD units (95% CI, 0.30-0.61) greater on average, than those in the highest maternal education group.

A lower level of maternal education predicted greater z scores for later intakes of nearly all foods positively loaded onto the energy-dense, high fat, low fiber dietary pattern; confectionery and chocolate, low fiber bread, crisps, full fat milk, and processed meat (Figure 2). Conversely, lower intakes of foods negatively loaded onto the dietary pattern, including fresh fruit, vegetables, high fiber breakfast cereals and high fiber bread, were observed with each decreasing level of maternal education (Figure 2). For example, among girls, for each decreasing level of maternal education, fresh fruit intake (energy-adjusted z score) was lower on average by 0.10 SD units (95% CI, 0.08-0.13, P < 0.001) (Figure 2). As such, girls in the lowest maternal education group would be expected to have an average z score for fruit intake that was 0.37 SD units (95% CI, 0.26-0.47) lower than those in the highest maternal education group.

Approximately 17% of study children’s mothers were overweight or obese according to their prepregnancy BMI. Maternal prepregnancy BMI was a predictor of later dietary pattern z score and food group Z-scores. A lower maternal prepregnancy BMI was associated with lower dietary pattern z scores. For example, among boys, each decreasing level of maternal prepregnancy BMI was associated with a dietary pattern score in later years that was on average, 0.17 SD units lower (95% CI, 0.14-0.20, P < 0.0001) than those with the highest level of maternal education (Figure 2). As such, boys in the lowest maternal prepregnancy BMI group had a dietary pattern z score that was 0.34 SD units (95% CI, 0.26-0.40) lower on average, than those in the highest maternal prepregnancy BMI group.

### TABLE 2 Mean dietary intakes at 7, 10 and 13 years of age

|                      | 7 y         | 10 y       | 13 y        |
|----------------------|-------------|------------|-------------|
| n                    | 7285        | 7471       | 6106        |
| Z-score for energy-dense, high fat, low fiber dietary pattern | -0.84 (3.91) | -0.92 (4.27) | -0.78 (4.78) |
| Total energy intake (MJ)| (2.52, 14.33) | (2.14, 15.5) | (2.22, 23.9) |
| Dietary energy density (kJ g⁻¹) | 8.8 (1.5) | 8.8 (1.6) | 8.5 (1.7) |
| (4, 17.8) | (4.3, 16.9) | (2.8, 17.8) |
| Dietary fiber density (g MJ⁻¹) | 1.5 (0.4) | 1.5 (0.4) | 1.6 (0.5) |
| (0, 3.9) | (0.4, 4.3) | (0.2, 5.5) |
| Energy from fat (%) | 35.5 (4.4) | 35.6 (4.8) | 34.8 (5.8) |
| (15.4, 56.3) | (10.3, 55.6) | (8.9, 60.1) |
| Chocolate, confectionery (g day⁻¹) | 26 (21) | 31 (28) | 26 (33) |
| (0, 170) | (0, 284) | (0, 954) |
| Bread, low fiber (g day⁻¹) | 59 (40) | 63 (48) | 61 (56) |
| (0, 375) | (0, 410) | (0, 453) |
| Cakes, biscuits (g day⁻¹) | 49 (34) | 46 (37) | 44 (45) |
| (0, 324) | (0, 280) | (0, 455) |
| Potato crisps (g day⁻¹) | 18 (14) | 20 (17) | 17 (19) |
| (0, 100) | (0, 164) | (0, 429) |
| Milk, full fat (g day⁻¹) | 139 (183) | 79 (146) | 65 (151) |
| (0, 1389) | (0, 1343) | (0, 2387) |
| Processed meats (g day⁻¹) | 24 (25) | 29 (31) | 31 (37) |
| (0, 261) | (0, 358) | (0, 424) |
| Fresh fruit (g day⁻¹) | 78 (77) | 66 (75) | 74 (92) |
| (0, 828) | (0, 645) | (0, 1150) |
| Vegetables, raw or boiled (g day⁻¹) | 49 (41) | 59 (54) | 70 (65) |
| (0, 432) | (0, 535) | (0, 520) |
| Breakfast cereals, high fiber (g day⁻¹) | 16 (24) | 14 (24) | 19 (32) |
| (0, 255) | (0, 382) | (0, 400) |
| Potato, boiled (g day⁻¹) | 30 (35) | 33 (45) | 38 (55) |
| (0, 275) | (0, 353) | (0, 400) |
| Bread, high fiber (g day⁻¹) | 12 (24) | 13 (27) | 24 (28) |
| (0, 239) | (0, 316) | (0, 352) |
| Legumes (g day⁻¹) | 17 (29) | 21 (42) | 20 (44) |
| (0, 400) | (0, 523) | (0, 450) |

Figures shown are mean (SD) and (ranges).
### TABLE 3: Tracking coefficients for the dietary pattern and food group z scores from 7 to 13 years of age

|                                | Boys Tracking Coeff\(^a\) | 95% CI     | Girls Tracking Coeff\(^a\) | 95% CI     |
|--------------------------------|----------------------------|------------|----------------------------|------------|
| **Energy-dense, high fat,      | 0.48                       | 0.44-0.52  | 0.38                       | 0.35-0.41  |
| low fiber dietary pattern      |                            |            |                            |            |
| **Food groups positively loaded onto the dietary pattern** |                          |            |                            |            |
| Confectionery, chocolate       | 0.18                       | 0.14-0.21  | 0.14                       | 0.11-0.17  |
| Bread, low fiber               | 0.22                       | 0.19-0.25  | 0.17                       | 0.14-0.20  |
| Cakes, biscuits                | 0.22                       | 0.19-0.25  | 0.15                       | 0.12-0.18  |
| Potato crisps                  | 0.23                       | 0.20-0.26  | 0.23                       | 0.20-0.25  |
| Milk, full fat                 | 0.40                       | 0.36-0.45  | 0.31                       | 0.27-0.34  |
| Processed meat                 | 0.15                       | 0.12-0.18  | 0.14                       | 0.11-0.18  |
| **Food groups negatively loaded onto the dietary pattern** |                          |            |                            |            |
| Fresh fruit                    | 0.35                       | 0.32-0.39  | 0.31                       | 0.28-0.35  |
| Vegetables, raw or boiled      | 0.31                       | 0.28-0.35  | 0.28                       | 0.25-0.31  |
| Breakfast cereal, high fiber   | 0.21                       | 0.17-0.26  | 0.14                       | 0.10-0.17  |
| Potato, boiled                 | 0.15                       | 0.11-0.19  | 0.14                       | 0.10-0.18  |
| Bread, high fiber              | 0.23                       | 0.20-0.27  | 0.22                       | 0.19-0.26  |
| Legumes                        | 0.21                       | 0.16-0.26  | 0.15                       | 0.11-0.18  |

\(^a\)GEE adjusted for age at first measurement and time between measurements, all \(P\) value <0.0001 (\(H_0: \beta = 0\)).

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**FIGURE 1**: Proportions remaining in the same extreme quartile of consumption levels at 7 and 13 years of age. Plotted values are proportions of respondents who maintained their ranking in either the lowest (light-diagonal) or highest (dark) quartile at 7 and 13 years of age. Tertiles replace quartiles for full fat milk, high fiber breakfast cereal, high fiber bread and legumes. Results are for boys and girls combined.
intakes, albeit to a lesser extent than maternal education (Figure 3). A one unit higher prepregnancy BMI was associated with later dietary pattern $z$ scores that were greater on average by 0.015 SD units (95% CI, 0.004-0.025, $P = 0.005$) in girls and 0.010 SD units (95% CI 0.004-0.024, $P = 0.006$) in boys (Figure 3). More markedly, maternal prepregnancy overweight or obesity was associated with later dietary pattern $z$ scores that were on average, 0.11 SD units (95% CI, 0.02-0.20, $P = 0.02$) higher in boys and 0.08 SD units (95% CI, 0.01-0.18, $P = 0.08$) higher in girls (not shown). A greater prepregnancy BMI predicted higher intakes of low fiber bread, crisps (girls only), processed meat and lower intakes of fresh fruit, vegetables, high fiber bread (girls only) and unexpectedly, cakes and biscuits (Figure 3). Dietary misreporting was not an important predictor of dietary pattern scores or food group intakes.

Discussion

This analysis of a large pregnancy cohort demonstrates that a dietary pattern longitudinally associated with increased adiposity in childhood and adolescence tracks moderately between 7 and 13 years of age. The individual food groups important to this dietary pattern showed varying but generally lower degrees of tracking. This suggests that, although intakes of individual food groups may be less stable, children and adolescents may maintain a similar profile of dietary energy density, fiber density and energy from fat that can contribute to obesity risk (8).

The differences in tracking among food groups indicate that some food intakes are less stable than others. The stronger tracking coefficients for fruit, vegetables and high fiber bread suggest that early interventions to increase intakes of these foods would be anticipated to have a lasting effect on dietary habits into adolescence. In this study with no specific dietary interventions, it is also notable that children who were low consumers of fruit, high fiber breakfast cereals and high fiber bread at 7 years of age were likely to remain low consumers in adolescence. This suggests that unhealthy dietary habits may be more amenable to intervention throughout childhood and adolescence.

Maternal education was an important predictor of dietary intakes between 7 and 13 years of age. This corresponds with studies of maternal determinants of offspring diet (9) and suggests that mothers with lower levels of education may need extra support to encourage healthy intakes in their children.

The positive relationship between maternal prepregnancy BMI and the energy-dense, high fat, low fiber dietary pattern among children in this study supports the “environment hypothesis” for obesity development. Parents are important role models for children’s dietary intake, and there is considerable evidence that children’s eating behaviors, including food preferences, and levels of intake, are closely aligned with that of their parents (9).

To our knowledge, only two studies have examined how empirically derived dietary patterns track in young people and both focused on...
the maintenance of extreme quartiles. The Cardiovascular Risk in Young Finns Study reported how two dietary patterns tracked 6 and 21 years after baseline in 1,768 children aged 3–18 years. The dietary patterns were identified using principal components analysis (PCA); one pattern containing “traditional Finnish,” the other “health conscious” foods. Both patterns exhibited similar degrees of tracking however, fewer subjects (~25–42%) maintained the same extreme quartiles than the present study (1). The HEALTH-KIDS study tracked three dietary patterns derived using factor analysis and selected food intakes over 1 year in 181 low-income African-American adolescents (7). A “Western” dietary pattern showed stronger tracking than an “Eastern” or “Dairy” dietary pattern. Similar to our study, tracking was greater among low consumers of fruits and vegetables. However, both studies compared scores for dietary patterns identified using exploratory pattern analyses at each follow up, rather than calculating scores for the same pattern at each follow up. Although these patterns appeared qualitatively similar at different time points, there were some important differences. As such, these studies have not tracked exactly the same dietary pattern over time.

Two other studies have reported tracking coefficients for food intakes in young people using GEE. An Australian study of children aged 5-6 years and 10-12 years (296 in total) reported strong tracking coefficients for frequency of fruit consumption (0.73 to 0.89) and frequency of vegetable consumption (0.52 to 0.86), based on three dietary assessments over 5 years (2). These tracking coefficients are higher than those reported in the current study, however they are based on the frequency of consumption, not the amount of food consumed, reported by parents. The Amsterdam Growth and Health Study tracked dietary intakes measured six times between 12 and 36 years of age in 168 subjects. The tracking coefficients were 0.33 for fruit (95% CI, 0.25-0.41) and 0.27 for vegetable (95% CI, 0.19-0.36) intakes (20), which are comparable to those observed in the present study. However differences in the length of follow up need to be taken into consideration when making comparisons.

A number of other studies have attempted to track food and nutrient intakes from childhood to adolescence (3-5,21-23). Direct comparison of these studies is challenging, owing to widely varying sample sizes, number and length of follow ups, statistical methods, and dietary assessment methods. However, these studies suggest considerable potential for dietary change between childhood and adolescence (3-5,21-23).

The current study has several strengths. We tracked a dietary pattern known to be longitudinally associated with obesity, or an “obesogenic” dietary pattern (8). This is one of the first studies to track a dietary pattern identified using reduced rank regression. The availability of up to three dietary assessments over the course of childhood, starting from early school age up until mid-adolescence, covers more than one key developmental phase. The application of longitudinal models makes use of all available data. The use of 3-day food diaries provides detail on the types of foods consumed and depends less on dietary recall than other commonly used dietary assessment methods. However, residual error cannot be ruled out, and while we attempted to adjust for dietary misreporting, the degree of error may have increased with age, as the 7 years diaries...
were completed by the parents, while later diaries were mainly completed by the children. This tracking analysis included over 7,000 children, far more than in previous studies. Although approximately half of the original cohort could not be included in the analysis because of missing data, we adjusted for some of the differences between respondents included and not included in this analysis.

In conclusion, an energy-dense, high fat and low fiber dietary pattern that is longitudinally associated with increased adiposity (8), tracks moderately between 7 and 13 years of age in this cohort. Early interventions (before 7 years of age) to increase intakes of fruit, vegetables, high fiber bread and high fiber breakfast cereals, key components of this dietary pattern, would be anticipated to influence dietary habits into adolescence. Interventions to reduce low fiber bread, processed meat, cakes, biscuits, chocolate and confectionery are also warranted. While policies are needed to support healthy eating among all children, children whose mothers have a history of overweight or low levels of education may need the most support to make these changes.

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References

1. Mikkilä V, Räsänen L, Raitakari OT, et al. Consistent dietary patterns identified from childhood to adulthood: the Cardiovascular Risk in Young Finns Study. Br J Nutr 2005;93:923-931.
2. Pearson N, Salmon J, Campbell K, et al. Tracking of children’s body-mass index, television viewing and dietary intake over five-years. Prev Med 2011;53:268-270.
3. Patterson E, Wambberg J, Kearney J, et al. The tracking of dietary intakes of children and adolescents in Sweden over six years: the European Youth Heart Study. Int J Behav Nutr Phys Act 2009;6:91.
4. Zive MM, Berry CC, Sallis JF, et al. Tracking dietary intake in white and Mexican-American children from age 4 to 12 years. J Am Diet Assoc 2002;102:683-689.
5. Robson PJ, Gallagher AM, Livingstone MBE, et al. Tracking of nutrient intakes in adolescence: the experiences of the Young Hearts Project, Northern Ireland. Br J Nutr 2000;84:541-548.
6. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. Curr Opin Lipidol 2002;13:3-9.
7. Li J, Wang Y. Tracking of dietary intake patterns is associated with baseline characteristics of urban low-income African-American adolescents. J Nutr 2008;138:94-100.
8. Ambrosini GL, Emmett PM, Northstone K, et al. Identification of a dietary pattern prospectively associated with increased adiposity in childhood and adolescence. Int J Obes 2012;36:1299-1305.
9. Patrick H, Nicklas TA. A review of family and social determinants of children’s eating patterns and diet quality. J Am Coll Nutr 2005;24:83-92.
10. Hendrie GA, Coveyen J, Cox DN. Defining the complexity of childhood obesity and related behaviours within the family environment using structural equation modelling. Public Health Nutr 2012;15:48-57.
11. Reilly JJ, Armstrong J, Dorosty AR, et al. Early life risk factors for obesity in childhood: cohort study. Br Med J 2005;330:1357.
12. Golding J, Pembrey M, Jones J, et al. ALSPAC—the avon longitudinal study of parents and children. Paediatr Perinat Epidemiol 2001;15:74-87.
13. Boyd A, Golding J, Macleod J, et al. Cohort profile: the ‘children of the 90’s’—the index offspring of the Avon Longitudinal Study of Parents and Children. Int J Epidemiol 2013;42:111-127.
14. Fraser A, Macdonald-Wallis C, Tilling K, et al. Cohort profile: the avon longitudinal study of parents and children: ALSPAC mothers cohort. Int J Epidemiol 2013;42:97-110.
15. Johnson L, Mander AP, Jones LR, et al. Energy-dense, low-fiber, high-fat dietary pattern is associated with increased fatness in childhood. Am J Clin Nutr 2008;87:846-854.
16. Remnie KL, Coward A, Jebb SA. Estimating under-reporting of energy intake in dietary surveys using an individualised method. Br J Nutr 2007;97:1169-1176.
17. SAS Institute Incorporated. SAS for Windows. SAS Institute Incorporated: Cary, NC, USA, 2003.
18. Twisk JW. Applied Longitudinal Data Analysis for Epidemiology: A Practical Guide. Cambridge University Press: Cambridge, 2003.
19. Twisk JW. The problem of evaluating the magnitude of tracking coefficients. Eur J Epidemiol 2003;18:1025-1026.
20. te Velde SJ, Twisk JWR, Brug J. Tracking of fruit and vegetable consumption from adolescence into adulthood and its longitudinal association with overweight. Br J Nutr 2007;98:431-438.
21. Singer MR, Moore LL, Garrahie EJ, et al. The tracking of nutrient intake in young children: the Framingham Children’s Study. Am J Public Health 1995;85:1673-1677.
22. Wang Y, Bentley ME, Zhai F, et al. Tracking of dietary intake patterns of Chinese children from childhood to adolescence over a six-year follow-up period. J Nutr 2002;132:430-438.
23. Resnicow K, Smith M, Baranowski T, et al. A 2-year tracking of children’s fruit and vegetable intake. J Am Diet Assoc 1998;98:785-789.