Tracking diet variety in childhood and its association with eating behaviours related to appetite: the Generation XXI birth cohort.

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Abbreviations

HDVI, Healthy Diet Variety Index;

1. Introduction

Eating behaviour patterns acquired during childhood and adolescence are likely to track into adulthood (1, 2). Diet tracking might be represented by the maintenance of eating habits, nutrient intake or food intake over time. Poor eating habits established in early life are likely to remain stable, therefore establishing healthy eating habits early on is essential. Dietary tracking has been demonstrated in adults and between adolescence and adulthood period, while few studies have tracked diet during childhood (3). It has been shown that the introduction of a variety of foods as early as the beginning of the complementary feeding, positively influences the variety of the diet later on (4, 5). Variety of the free food choices between 2 and 3 years has been associated with the variety of food consumed up to the age of 22 years (6). Several paediatric diet quality indices, including assessment of the food variety, have been administered in both developed and developing countries and studied in relation to health-related outcomes (7). However, the tracking of the overall food variety throughout childhood, using the same validated instrument, is lacking in the literature.

An earlier study has proposed that other aspects of eating behaviour, such those related to appetite, also track throughout childhood (8). The authors highlighted that some changes in the magnitude of appetitive traits can, however, occur as the result of interaction with child's food environment (9, 10). One aspect previously explored was the decrease of food fussiness behaviour with an increase of diet variety offered to children (9, 10).

Recommendations (11) to increase the diet variety in order to achieve a higher quality diet are included in most European national dietary guidelines, including Portugal (12). The term 'diet variety' indicates the number of different foods or food groups consumed over a given reference period. Increasing the variety of nutrient-dense foods, within and across food groups, is thought to ensure adequate intake of essential nutrients and to improve health outcomes (13-17). The World Health Organization (WHO) recommends the consumption of a varied diet originated mainly from plants, rather than animals (11). Eating a variety of foods is crucial to achieving optimal nutritional status and complete coverage of essential nutrients. It is also a key factor to tackle chronic micronutrient deficiencies, also known as hidden hunger (18).

A greater variety of healthy foods has been also associated with a lower prevalence of overweight or obesity (19). However, intake of a variety of less healthy foods, such as energy-dense foods, has been positively associated with adiposity (19). It is not known whether exposure to a higher food variety environment might stimulate appetite and increase food consumption, leading to excess energy intake and an unhealthy body weight gain. Short-term controlled feeding studies consistently show that the variety of food offered during a meal increases energy intake, and limiting variety across days tends to reduce food consumption (20, 21). The stimulating effect of a high diet variety on appetite might be attributable to lower sensory-specific satiation for multiple components of a meal, to delayed satiation or by making the eating occasion more enjoyable (21). These short-term studies are limited by the tendency to offer highly palatable, energy-dense foods. When low energy-dense foods are offered, for example, fruits and vegetables (FV), the variety effect seems to stimulate intake in both children (22) and adults (23).

The majority of previous studies have investigated the effects of food variety on appetite using short-term controlled feeding studies, however, to date no published research has investigated the association in children between tracking of diet variety and eating behaviours related to appetite, using a prospective approach. Therefore, we aimed to prospectively assess the effect of changes in diet variety from 4 to 7 years on eating behaviours related to appetite at 7 years of age.

2. Material and methods

2.1. Study design and participants

Participants were from the population-based birth cohort Generation XXI, assembled in the five-level III public maternity units in the Porto Metropolitan Area (Northern Portugal), during 2005/2006 (24). At enrolment, these maternity units were responsible for 91.6% of the deliveries in the whole catchment population. Of the invited mothers, 91.4% accepted to participate at baseline (n=8647 children). Data on demographic and social conditions, lifestyles, medical history and anthropometrics were collected by trained interviewers within 72 hr after delivery. When the children were 4 and 7 years of age, an evaluation of the entire cohort occurred, achieving a participation rate of 86% and 81%, respectively. In baseline and follow-up evaluations, information was collected in face-to-face interviews, and for those families that were not able to participate in-person, the evaluation was performed by telephone using a shorter version of the questionnaire (20% and 15% at 4 and 7 years of age, respectively).

The present analysis included 4748 children with complete data using a food frequency questionnaire (FFQ) (25) at 4 and 7 years of age, and complete information on the Children's Eating Behaviour Questionnaire (CEBQ) (26), at 7 years of age. We excluded twins (n=183) and children with congenital anomalies or diseases that might influence dietary intake (cerebral palsy, celiac disease, food allergy, food intolerance, and phenylketonuria; n=28), resulting in a sample of 4537 children. Comparing the children included in the analysis with the remaining cohort, we found no statistical differences regarding sex children. However, mothers of children included in the study at baseline were slightly older (mean (SD): 29.8 (5.25) vs. 28.1 (5.82) years, p<0.001) and more educated (mean (SD): 11.2 (4.27) vs. 9.6 (4.10) years, p<0.001). The prevalence of obesity in our sample was also higher (68% vs. 67%, p=0.009)

2.2. Data collection

2.2.1. Dietary intake

The children's dietary intake was evaluated through an FFQ that queried frequency of intake for 35 and 38 food items at 4 and 7 years of age, respectively, that was previously tested. As previously described (25), for each food item, parents or another caregiver were asked how many times on average his/her child had consumed that food during the previous 6 months.

For each food item, the selected frequency response option (4 times or more per day, 2–3 times per day, 1 time per day, 5–6 times per week, 2–4 times per week, 1 time per week, 1–3 times per month\once a month, or never) was converted into daily frequency (e.g. 5–6 times per week was converted into a mean of 5.5 times per week, meaning 5.5/7d = 0.78 times per day). Five food groups were defined: starchy foods (3 original food items: rice, pasta, potatoes, bread and semi-sweet type biscuits); fruits (only one food item); vegetables (3 original food items: vegetable soup and vegetable on plate); meat, fish and alternatives (5 original food items: meat, sausage, ham, fish and eggs); and dairy products (5 original food items at 4y and 4 food items at 7y: yoghurt, cheese and milk).

In a subsample of 2482 children at 4 years and 3511 at 7 years, FFQ data was compared with 3-day food diaries. For food groups eaten more often, fair-to-moderate agreement was obtained. Significant positive intraclass correlation coefficients (ICC) were found for vegetable soup

[(ICC = 0.54, 95%CI: 0.51; 0.56) at 4 years and (ICC = 0.54, 95%CI: 0.52; 0.56) at 7 years], fruit [(ICC = 0.42, 95%CI: 0.39; 0.45) at 4 years and (ICC = 0.46, 95%CI: 0.43; 0.48) at 7 years], milk [(ICC = 0.46, 95%CI: 0.43; 0.49) at 4 years and (ICC = 0.50, 95%CI: 0.47; 0.52) at 7 years], yoghurt [(ICC = 0.48, 95%CI: 0.45; 0.51) at 4 years and (ICC = 0.49, 95%CI: 0.47; 0.52) at 7 years], sweets [(ICC = 0.23, 95%CI: 0.19; 0.26) at 4 years and (ICC = 0.22, 95%CI: 0.19; 0.25) at 7 years] and salty snacks [(ICC = 0.19, 95%CI: 0.16; 0.23) at 4 years and (ICC = 0.10, 95%CI: 0.07; 0.13) at 7 years].

2.2.2. Diet Variety Index

A healthy diet variety index (HDVI) (27), based on the Food Variety Index for Toddlers by Cox et al, (28) was calculated at 4 and 7 years using data from the FFQ. This was done by considering variety within and among the five food groups previously described, and considering the number of servings recommended in the food plate model healthy eating guidelines promoted by the U.S. Department of Agriculture (29). As indorsed by Cox et al, (28) truncations were applied in the next steps to ensure variety in intake both within and between food groups. As recommended in the original index (28), a higher variety of a particular food item or food groups could not compensate a low intake of other food item or food groups. First, within each food groups (except FV) the contribution of a particular food item was truncated at 33%. Foods within a food group, which were similar (e.g. yoghurt without sugar and sweetened yoghurt at 4 years) were grouped together and counted as a single food, so they did not contribute more than 33% of the total. Due to the relatively limited number of questions of the FFQ, it was not possible to assess variety of FV. For these items, the index instead reflects whether or not the children ate the recommended number of servings. The number of servings for each food group was completed after the groupings and truncations were applied. Food group scores were calculated by dividing the total number of servings by the recommended number of servings per day, for each food group. The following recommended number of servings was used: starchy foods = 7, fruit = 2, vegetables = 3, meat, fish and alternatives = 2 and dairy foods = 3. Then, a second truncation was applied to ensure variety between the food groups. Each food group score was truncated at 1 point (e.g. if a child ate 3 different types of meat, fish and alternatives daily when this was divided by 2 it gave a potential score of 1·5 points which was then truncated to 1 point). This meant that a high intake of one food group could not compensate for a low intake of another food group. The final HDVI was the sum of the five food group scores and the maximum score was 5, representing a higher diet variety and adequacy.

2.2.3. *Children's eating behaviours*

Appetitive traits were assessed using a Portuguese version of the Children's Eating Behaviour Questionnaire – CEBQ, originally developed by Wardle et al (26) which had been previously translated and tested, and shown to have good psychometric properties in 7-year-old Portuguese children (30). This questionnaire is a parental report (94% of the questionnaires were answered by mothers) constructed to assess eight subdimensions of eating behaviours in children: 'Food Responsiveness' (FR), 'Enjoyment of Food' (EF), Emotional Overeating' (EOE) and 'Desire to Drink' (DD) as 'food-approach' appetitive traits, and 'Satiety Responsiveness' (SR), 'Slowness in Eating' (SE), 'Emotional Undereating' (EUE) and 'Food Fussiness' (FF) as 'food-avoidant' appetitive traits. This 35-item instrument is rated on a 5-point Likert scale ("never", "seldom", "sometimes", "often" and "always"), scored 1 to 5. Each of the eight subscales contained 3 to 6 items. The items 3 (SR), 4 (SE), 10 (FF), 16 (FF) and 32 (FF) were reverse-scored items. In individuals with missing data for less than 50% of the items, missing data (around 3%) were handled by imputation, replacing the average of the remaining questions within each subdimension.

2.2.4. Covariates

Problematic eating behaviours were also assessed at 4 years of age by caregiver report. Caregivers were asked about any perceived eating problem observed in their child. The following questions were included in the final model as potential confounders: "my child does not eat enough", "my child eats very slowly" and "my child eats too much". Caregivers reported if any of these behaviours happened in the last year and their level of concern (very concerned, somewhat concerned, no concern). These variables were used as proxies of the subdimensions of the CEBQ at 4 years of age. Significant differences were found between different levels of parental concern with children's eating behaviours and scores of the CEBQ subdimensions at 7 years of age (Supplemental Table 1). For example, children with a higher score in 'Enjoyment of Food' and 'Food Responsiveness' were the ones with a higher level of parental concern in "my child eats too much"

(9%). Parents that were more concerned with “not eating enough” (35%) had children with higher scores in ‘Satiety Responsiveness’, ’Slowness in Eating’ and ‘Food Fussiness,’ but lower scores in ‘Food Responsiveness’ and ‘Enjoyment of food’ ($p<0.001$, Supplemental Table 1).

Other child and maternal characteristics that may confound the association between diet variety and appetitive traits were also considered. The maternal education was evaluated, at 4-year-old evaluation, as the number of completed school years; the maternal age was obtained as the difference between the date of birth and the date of the 4-year interview. Breastfeeding duration (expressed or directly from the breast) was recorded in weeks, and a variable was defined as any breastfeeding duration (recorded as never or less than 16 weeks, between 16 and 20 weeks and more than 20 weeks). The practice of physical exercise (defined as regular physical exercise) was collected at 4 years of age as a qualitative variable (non-practitioners vs. practitioners). Daily screen time was calculated as the daily minutes spent in front of a screen (television, computer or game devices) during both week and weekend days, and categorized into less than 120 minutes and 120 minutes or more per day. At 7 years of age, timing of complementary feeding and first food eaten by the infant (cereals porridge (56.9%), fruit (5.2%), vegetable soup (36.6%) or other (1.2%)), was recorded and re-categorized as ’vegetable soup’ vs. ‘cereals porridge/fruit/other’. The vegetable soup was separated from the other categories due to the beneficial effect previously described in children having vegetables as the first food, in appetite and acceptance of new foods (9, 28)

In both evaluations, children’s anthropometric measurements were performed by a team of experienced examiners, according to standard procedures. Weight was measured in underwear and without shoes using a digital scale and was recorded to the nearest 0.1kg. Height was measured as the distance from the top of the head to the bottom of the feet without shoes, using a fixed stadiometer to the nearest 0.1cm. Children’s body mass index (BMI) was classified according to age- and sex-specific BMI standard z-scores developed by WHO (31).

2.3. Statistical analysis

Mean (standard deviation) and frequency differences were compared through Student’s t-test and chi-square test, respectively. The tracking of behaviours was estimated in different ways, each assessing a specific aspect of tracking. First, tertiles for the score of the HDVI were calculated at 4 and 7 years of age. The proportion of stability was assessed as the proportion of children who remained in the same tertile at both ages divided by the total number of children. If chance alone determined the tertile at age 7, one third would be expected to be placed in the same tertile; a value higher than 0.33 suggests that children do not stay in the same tertile completely by chance. A predictive value for remaining in the highest tertile was calculated as the proportion of children in the highest tertile at 4 years of age who remained in the highest tertile at 7 years, divided by the children in the highest tertile at 4 who had moved to other tertiles at 7 years. A value higher than 1 suggests more children remained than changed. Confidence intervals were calculated for the predictive value. For testing the overall tracking, the ICC was applied. Guidelines for interpreting ICC statistics suggest that values between 0.81 - 1.00 indicate almost perfect agreement, 0.61 - 0.80 substantial agreement, 0.41 - 0.60 moderate agreement, 0.21 - 0.40 fair agreement, and values less than 0.21 indicate a poor or slight agreement (32).

The effect size for the HDVI was calculated by dividing the mean change in the score (between 4 and 7 years of age) by the standard deviation (SD) of the initial mean score (at 4 years). Cohen classified effect sizes as small (d = 0.2), medium (d = 0.5), and large (d >= 0.8) (33). Furthermore, tertiles of HDVI score were transformed as following: ‘maintain: high’, for children who were at 2nd or 3rd tertile in both ages, ‘maintain: low’, for children who were at 1st tertile at both ages, ‘increase’, for children whose scores changed to a higher tertile (e.g. 1st tertile to 2nd or 2nd to 3rd) and ‘decrease’, for children whose scores fell to a lower tertile (e.g. 3rd tertile to 1st or 3rd to 2nd).

Associations between tracking behaviour (maintain: high; maintain: low; increase; and decrease - exposure) and appetitive subdimensions of the CEBQ (outcome) were evaluated through linear regression models – regression coefficients and respective 95% confidence intervals [β̃, 95%CI]. Two regression models were presented, one crude model and the other model adjusted for maternal age, maternal education (in years) and child’s BMI at 4 years (adjusted model). Other potential confounders, such as parental concerns of problematic eating behaviours at 4 years, breastfeeding duration, the practice of physical exercise, daily screen time and the first food eaten, were tested and included in the adjusted model if statistically significant for the model. An interaction of the child’s sex in these associations was studied by including an interaction term in the final models, but no significant interaction was found; thus, results are reported for all children.

The software used was the Statistical Package for the Social Sciences (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.). Significance was established a priori at 0.05.

2.4. Ethical consideration

The project Generation XXI was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects/patients were approved by the Ethical Committee of the São João Hospital/ the University of Porto Medical School. The project was approved by the Portuguese Authority of Data Protection. Parents or legal guardians of each participant received an explanation on the purposes and design of the study and gave written informed consent at baseline and follow-up evaluations.

3. Results

3.1. Participants characteristics

Table 1 presents characteristics of children and their mothers by age and sex. The sample in this study had 49% of girls. No significant differences were found for the maternal level of education and age, between girls and boys. At both ages, there were no significant differences between the groups, regarding HDVI score. At 4 years, a higher prevalence of overweight and obesity was observed among girls, in comparison with boys ($p=0.027$). At 7 years, there were no statistical differences for BMI between girls and boys ($p=0.167$). However, when comparing between the two periods of time, the HDVI score decreased from 4 to 7 years (mean (SD): 4.01 (0.52) and 3.60 (0.35), respectively, $p<0.001$), with a large effect size (0.8). The HDVI score at 4 years ranged from 1.45 to 4.99 and at 7 years from 1.27 to 4.95 (from a possible maximum of 5). From 4 to 7 years of age, for each food group that contributes to the HDVI, a statistically significant ($p<0.001$) decrease was observed in the frequency of consumption per day. Compared to girls, boys had a higher frequency of intake of starch in both ages. At 7 years, boys had a higher intake of foods from the dairy category than girls [(mean (SD): 2.08 (0.61) vs. 2.03 (0.63), $p=0.010$].

3.2. Diet variety tracking

Figure 1 shows the proportion of children by tertiles of HDVI score at 4 and 7 years of age. More than half of the children that were in the lowest tertile of HDVI score at 4 years remained in the lowest tertile at 7 years. The same trend was observed for the highest tertile. In a subsample with dietary intake evaluated by 3-day food diaries at 4 (n=1984) and 7 years of age (n=2779), energy intake, macronutrients and fiber intake were compared across HDVI tertiles. The energy intake increased across tertiles of diet variety in both ages [1st tertile vs. 3rd tertile: at 4 years, mean (SD) = 1567 (297.4) kcal vs. 1682 (291.4) kcal, $p<0.001$; at 7 years, 1792 (364.3) kcal vs. 1842 (314.7) kcal, $p=0.06$]. Children with a high diet variety, compared to children in the lowest tertile of variety (3rd vs 1st tertile of intake) had a significantly higher intake of fiber at 4 years [mean (SD) = 14 (3.6) g vs. mean (SD) = 12 (3.7) g, $p<0.001$] and at 7 years [mean (SD) = 16 (4.0) g, vs. mean (SD) = 13 (4.0) g, $p<0.001$]. On the other hand, in both ages, children with the lowest diet variety had a higher intake of total fat, including saturated fat.

Table 2 presents the tracking values for the HDVI score and for each food group included. Overall, the HDVI showed a stability of 48% and a positive predictive value (1.13, 95%CI: 1.02; 1.25). Regarding the food groups, the 'fruit and vegetables' group had the highest stability value (0.52) and the highest predictive value (1.30; 95%CI: 1.18, 1.44). The agreement was moderate for this food group (ICC = 0.464, 95%CI: 0.388; 0.529). All the other food groups had stability values higher than 0.33, but negative predictive values. They all had a fair agreement with the exception of meat, fish and alternatives that showed only slight tracking.

3.3. Diet variety and eating behaviours related to appetite

The mean scores in the CEBQ subdimensions at 7 years ranged from 1.8 (SD = 0.64) for 'Emotional Overeating' to 3.0 (SD = 0.80) for 'Enjoyment of Food' (Supplemental Table 1).

Associations between levels of tracking of the HDVI (exposure) and eating behaviours related to appetite at 7 years (outcome) are shown in table 3. Parental concerns for problematic behaviours were used at 4 years as a proxy of appetitive traits. and were tested in the final model as potential confounders.

In the adjusted models, increasing diet variety from 4 to 7 years, in comparison with maintaining a low variety, was inversely associated with the 'Desire to Drink' (β= -0.090, 95%CI: -

0.174; -0.006) and ‘Satiety Responsiveness’ (β= -0.119, 95%CI: -0.184; -0.054) subdimensions, and positively with the ‘Enjoyment of Food’ (β = 0.098, 95%CI: 0.023; 0.172) and ‘Emotional Overeating’ (β = 0.073, 95%CI: 0.006; 0.139). Increase or maintain a high diet variety, in comparison with maintaining a low variety, were associated with lower scores in the ‘Food Fussiness’. No effect of changes in HDVI score from 4 to 7 years was observed on ‘Food Responsiveness’, ‘Slowness in Eating‘, and ‘Emotional Undereating‘.

4. Discussion

To our knowledge, this is the first study assessing the tracking of diet variety from preschool to school age and its association with individual differences in appetitive traits. It is important to know which children will benefit most from practical and targeted interventions to promote healthy diets in early life. The results of this study show that diet variety is somewhat stable throughout childhood. A higher varied diet, namely through a higher consumption of fruit and vegetables, predicted a fair to moderate tracking during childhood. There is also room for improvement of eating habits since a low tracking was found for the ‘starch’ and ‘meat, fish and alternatives’ food groups.

A previous review regarding dietary patterns from childhood to adolescence described a weak to moderate tracking throughout childhood, and between childhood and adolescence periods (34). In a similar birth cohort study (ALSPAC) in the UK, dietary patterns were obtained through early to mid-childhood and stability was assessed. Similar dietary patterns were obtained at 4 and 7 years of age with correlations around 0.60 (3). A previous study among Brazilian children, and using approximately the same age span, described some level of tracking for diet quality, including diet variety (35). In the present study, although a certain level of tracking was observed from 4 to 7 years, there was a general trend for a decrease in diet variety over time. Further research is warranted to test whether this trend for a decrease in diet variety extends into late childhood. This will be possible to answer with data from Generation XXI, from subsequent follow-up evaluations. Our results are in agreement with previous research, thus early food variety is a predictor of later food variety in childhood but also there is an observed decrease in overall food variety, including fruit and vegetable variety (36). At both ages, almost none of the children reached the recommended score of 5 for the variety of healthy foods. In our sample, although a decrease of consumption of the ‘fruit and vegetables’ group was described, a higher tracking was observed for this group. However, taking into consideration that we only evaluated recommended eating per day and not fruit and vegetables variety, the tracking might be easier to achieve that using the other food group's variety. Recently, a greater variety of fruit and vegetables was associated with a better overall diet quality in a nationally representative sample of US preschool children (37). In another European prospective population-based cohort study (38), analyzing tracking of food intake from 1 to 7 years of age, fair to moderate tracking was also described for intake of fruit and vegetables. Young children seems to benefit from being exposed consistently to a variety of healthy foods, including fruit and vegetables. In particular, the use of different strategies such as repeated exposure to unfamiliar foods, offering tangible rewards or modifying recipes to improve visual appeal are known to improve intake of healthy foods (39-41).

Diet variety can be evaluated in different ways and there is a lack of consistency in a validated method (7). We used an index based on FFQ, previously tested in children from European birth cohorts, including the Generation XXI (27, 42). In association with health outcomes, such as obesity, the use of the FFQ is recommended as the most appropriate tool to measure long-term diet variety (43). The comparison between nutrient intake evaluated by food diaries and HDVI tertiles showed a better macronutrient intake profile in children with higher diet variety in both ages.

The effect of diet variety on appetite, mainly related to satiety, has been explored in previous studies. Several authors described a positive effect of offering different types of foods on food intake (20, 21, 44-46). For instance, previous studies described that both adults and children ate significantly more vegetables when presented with two or more vegetables, than just one (44, 45). Increasing variety within a meal has been effective in increasing energy intake in older adults with a poor appetite, in a cross-over trial study (47). Exposure to different types of food might prevent the onset of sensory-specific satiety, that is defined as the decline in pleasure derived from consuming a known type of food in comparison to exposure to a new flavour or food (48). This effect might be also attributed to habituation, as exposure to different types of foods might retard the habituation process (49). The variety effect in appetite has been demonstrated in both humans and animals (50, 51). For example, in a previous work, researchers showed that food variety could change the rate of habituation in children involved in a food-seeking task (49). In a previous randomized 8-week behavioural weight loss intervention, limiting energy-dense food group variety across several days produced long-term sensory-specific satiety and monotony (52).

Our study hypothesised a long-term influence of diet variety on appetitive traits of children. Overall, different levels of tracking of diet variety were associated with eating behaviours related to appetite at 7 years of age. Maintaining a high diet variety in childhood was inversely associated with problematic behaviours such as being a fussy eater. Children with a higher dietary variety also had a higher general interest in food although a lower desire to have drinks, and lower satiety responsiveness, than those with a low dietary variety. A lack of interest in food, including fussy eating, is being described as a common problem among children (53). Increasing variety of healthy food could be a strategy to decrease eating problems among children. Previous research suggests that following a less healthy dietary pattern early in life increases the risk of disordered eating behaviours later in childhood (54).

Strengths of this study are the longitudinal design based on a large population-based birth cohort, and the use of the same method to describe tracking of diet variety across childhood. We also analyzed the prospective association between tracking of diet variety and appetitive traits, overcoming the limitations of cross-sectional studies. However, we evaluated children's eating behaviours only at 7 years and we could not exclude a bidirectional association between diet variety and eating behaviours. It was previously described a bidirectional relationship between children's fussy behaviour and parents feeding practices (55). The authors also suggested an increase of variety of foods offered to increase food acceptance, decreasing fussiness behaviour (55). Parental concerns for problematic behaviours were used at 4 years as a proxy of previously eating behaviours.

Additional limitations of this study will be discussed. Our diet variety index was based on data of a short FFQ, which did not allow measuring variety of fruit and vegetable. A previous systematic review (7) studied different diet indices in paediatric age, including those used to evaluate variety in diet related to health outcomes. The majority of FFQ used to create the several diet variety indices had less than 60 food items, with some studies using FFQ with less than 20 food items (7). Adding more questions to the FFQ would help increase the accuracy of our diet variety index; however, that would increase the burden of response among caregivers, which could result in more losses to follow-up or more errors in the responses. Even with the short FFQ, we were capable to find tracking in the diet variety and its associations with eating behaviours related to appetite. Eating behaviours were assessed subjectively through the CEBQ, based on caregivers' report; however, the CEBQ subdimensions have shown a good internal reliability in this population (30) and good correspondence with objective measures in previous studies (56). Children's dietary intake was also based on reported by parents or caregiver who might not be aware of all the foods eaten by the child. Comparing FFQ with 3-day food diaries, a fair to moderate agreement was obtained for those food items eaten more often. The trend for an overall decrease in diet variety could be explained by the effect of the regression to the mean, which is a statistical phenomenon that can happen when repeated measurements are made on the same participant over time (57). We quantified the regression to the mean effect in our sample, assuming the 3rd tertile of diet variety as the cut-off point. We found an estimated regression to the mean effect for the diet variety (0.19) much lower than the mean difference found in our sample (-0.41, 95% CI:-0.39; 0.43). These data indicate that a decrease in diet variety from 4 to 7 years of age cannot be completely explained by this statistical phenomenon.

5. Conclusions

Children with a higher diet variety were less fussy, had a lower desire to drink and had a higher general interest in food. Although these eating behaviours related to appetite track throughout childhood, they can nevertheless be managed using strategies, such as having a variety of healthy foods consistently available at home and persisting with the provision of variety over time. Diet variety seems to decrease with age in childhood; these findings enhance the need of implementing effective strategies to increase the consumption of a variety of healthy foods, including fruit and vegetables, from early life.

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Potential conflict of interest and source of funding

The authors declare no conflicts of interest.

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Figure legends

Figure 1 - Proportion of children by tertiles of healthy diet variety index (HDVI) at 4 and 7 years (y) of age.

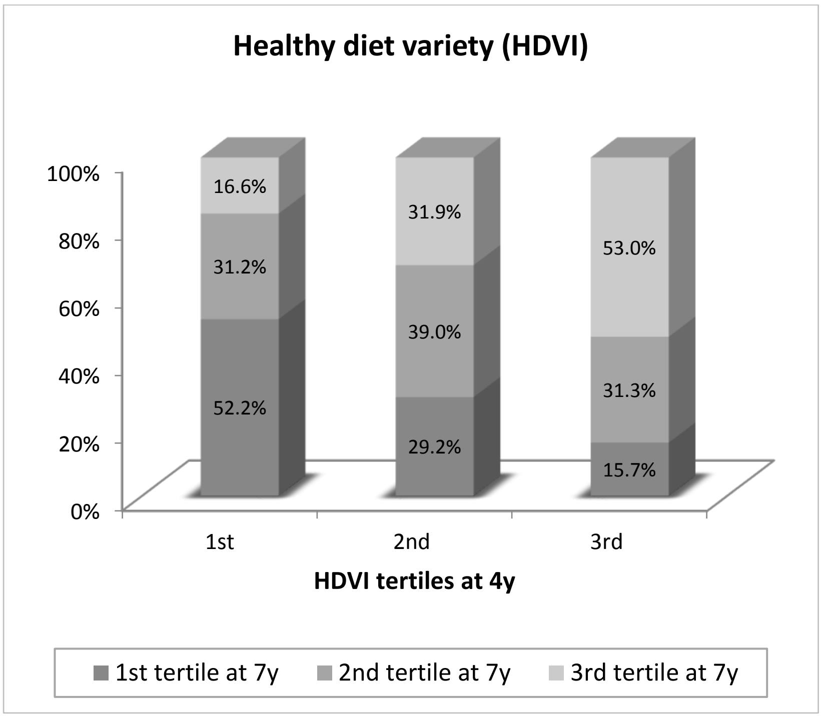
Table Legends

Table 1. Sample characteristics by age and sex.

Table 2. Tracking values from 4 to 7 years of age of the healthy diet variety index (HDVI) and food groups.

Table 3. Associations between levels of tracking of the healthy diet variety index (HDVI) and eating behaviours related to appetite at 7 years of age.

Supplemental Table 1. Mean differences of subdimensions of the Children Eating Behaviour Questionnaire (CEBQ) by the parental level of concern of problematic eating behaviours at 4 years.



Healthy diet variety (HDVI)
100%
80%
60%
40%
20%
0%
16.6%
31.2%
52.2%
31.9%
39.0%
29.2%
53.0%
31.3%
15.7%
1st
2nd
3rd
HDVI tertiles at 4y
1st tertile at 7y
2nd tertile at 7y
3rd tertile at 7y

Figure 1

Table 1. Sample characteristics by age and sex.

	4 years				7 years			
	all	Girls	Boys	p-value	all	Girls	Boys	p-value
Maternal level of education at 4y (years), mean (SD)	11.4 (4.22)	11.4 (4.24)	11.4 (4.21)	0.320[a]	--	--	--	--
Maternal age at 4y (years), mean (SD)	34.2 (5.22)	34.2 (5.32)	34.1 (5.15)	0.065[a]	--	--	--	--
Body Mass Index, n (%)								
Normal/Thinness	3029 (68.3)	1454 (66.6)	1575 (70.0)	0.027[b]	2754 (63.1)	1375 (61.9)	1481(64.2)	0.167[b]
Overweight	966 (21.8)	493 (22.6)	473 (21.0)		940 (21.5)	504 (22.7)	472 (20.5)	
Obese	438 (9.9)	237 (10.9)	201 (8.9)		669 (15.3)	344 (15.5)	353 (15.3)	
Fruit & Vegetables, (frequency/day), mean (SD)	5.09 (1.739)	5.12 (1.739)	5.08 (1.740)	0.355[a]	4.54 (1.648)**	4.54 (1.641)	4.53 (1.656)	0.732[a]
Starch, (frequency/day), mean (SD)	5.04 (1.114)	5.00 (1.145)	5.07 (1.141)	0.037[a]	4.62 (1.100)**	4.54 (1.127)	4.69 (1.068)	<0.001[a]
Dairy, (frequency/day), mean (SD)	2.31 (0.480)	2.31 (0.485)	2.31 (0.475)	0.706[a]	2.05 (0.618)**	2.03 (0.628)	2.08 (0.607)	0.010[a]
Meat, fish and alternatives, (frequency/day), mean (SD)	1.80 (0.320)	1.81 (0.324)	1.80 (0.316)	0.317[a]	1.42 (0.241)**	1.42 (0.241)	1.41 (0.242)	0.396[a]
HDVI score, mean (SD)	4.01 (0.521)	4.02(0.519)	4.01(0.522)	0.745[a]	3.60 (0.352)**	3.58(0.601)	3.61 (0.58)	0.122[a]
HDVI stability								
Maintain: low (n=781)	3.34 (0.375)	3.34 (0.378)	3.34 (0.373)	0.881[b]	2.83 (0.396)	2.81 (0.400)	2.86 (0.391)	0.117[b]
Maintain: high (n=1397)	4.36 (0.291)	4.36 (0.294)	4.36 (0.288)	0.805[b]	3.99 (0.348)	4.00 (0.344)	4.00 (0.352)	0.531[b]
Increase (n=1202)	3.73 (0.396)	3.72 (0.400)	3.74 (0.400)	0.593[b]	3.97 (0.319)	3.97 (0.317)	3.97 (0.323)	0.792[b]
Decrease (n=1157)	4.34 (0.267)	4.33 (0.265)	4.34 (0.269)	0.580[b]	3.26 (0.428)	3.23 (0.439)	3.29 (0.415)	0.014[b]

a Student's t-test: comparisons between the sexes, for continuous variables. **Paired t-test: comparisons between ages (p<0.001).
b Chi-square: comparisons between the sexes, for categorical variables.

Table 2. Tracking values from 4 to 7 years of age of the healthy diet variety index (HDVI) and food groups.

	Stability*	Predictive value± (95% CI)	ICC (95% CI)
HDVI	0.48	1.13 (1.02,1.25)	0.337 (0.104,0.506)
Food groups			
Fruit & Vegetables	0.52	1.30 (1.18,1.44)	0.464 (0.388,0.529)
Starchy	0.40	0.95 (0.85,1.06)	0.209 (0.162,0.254)
Dairy	0.43	0.48 (0.42,0.55)	0.307 (0.214,0.387)
Meat, fish and alternatives	0.39	0.85 (0.77,0.94)	0.146 (-0.051,0.325)

CI, confidence interval;

*Proportion of children who remained in the same tertile 3 years later.

±Predictive value for remaining in the highest tertile.

Table 3. Associations between levels of tracking of the healthy diet variety index (HDVI) and eating behaviours related to appetite at 7 years of age.

	Desire to drink (DD)		**Enjoyment of Food (EF)**		**Satiety Responsiveness (SR)**		**Slowness in Eating (SE)**	
	Crude model $\hat{\beta}$ (95% CI)	Adjusted model[a] $\hat{\beta}$ (95% CI)	Crude model $\hat{\beta}$ (95% CI)	Adjusted model[b] $\hat{\beta}$ (95% CI)	Crude model $\hat{\beta}$ (95% CI)	Adjusted model[b] $\hat{\beta}$ (95% CI)	Crude model $\hat{\beta}$ (95% CI)	Adjusted model[b] $\hat{\beta}$ (95% CI)
HDVI stability (4 to 7y)								
Maintain: low	ref	ref	ref	ref	ref	ref	ref	ref
Maintain: high	**-0.108 (-0.180,-0.036)**	-0.105 (-0.230,0.020)	**0.188 (0.117,0.258)**	0.064 (-0.047,0.174)	**-0.185 (-0.245,-0.125)**	-0.074 (-0.170,0.022)	-0.076 (-0.153,0.000)	-0.017 (-0.139,0.104)
Increase	**-0.108 (-0.182,-0.034)**	**-0.090 (-0.174,-0.006)**	**0.174 (0.102,0.246)**	**0.098 (0.023,0.172)**	**-0.186 (-0.248,-0.124)**	**-0.119 (-0.184,-0.054)**	**-0.095 (-0.173,-0.016)**	-0.031 (-0.113,0.051)
Decrease	-0.019 (-0.094,0.055)	-0.058 (-0.186,0.069)	**0.173 (0.101,0.246)**	0.039 (-0.074,0.152)	**-0.148 (-0.210,-0.085)**	-0.040 (-0.238,0.058)	-0.058 (-0.137,0.021)	-0.007 (-0.131,0.118)

	Food responsiveness (FR)		**Food fussiness (FF)**		**Emotional Overeating (EOE)**		**Emotional Undereating (EUE)**	
	Crude model $\hat{\beta}$ (95% CI)	Adjusted model[b] $\hat{\beta}$ (95% CI)	Crude model $\hat{\beta}$ (95% CI)	Adjusted model[c] $\hat{\beta}$ (95% CI)	Crude model $\hat{\beta}$ (95% CI)	Adjusted model[d] $\hat{\beta}$ (95% CI)	Crude model $\hat{\beta}$ (95% CI)	Adjusted model[b] $\hat{\beta}$ (95% CI)
HDVI stability (4 to 7y)								
Maintain: low	ref	ref	ref	ref	ref	ref	ref	ref
Maintain: high	**0.074 (0.005,0.144)**	-0.020 (-0.129,0.089)	**-0.424 (-0.490,-0.358)**	**-0.138 (-0.253,-0.022)**	0.048 (-0.008,0.105)	0.072 (-0.028,0.172)	-0.016 (-0.083,0.050)	0.006 (-0.110,0.122)
Increase	**0.115 (0.044,0.187**	0.057 (-0.016,0.131)	**-0.325 (-0.392,-0.257)**	**-0.219 (-0.297,-0.141)**	**0.076 (0.019,0.134)**	**0.073 (0.006,0.139)**	-0.015 (-0.083,0.053)	0.007 (-0.071,0.085)
Decrease	**0.130 (0.058,0.202)**	0.028 (-0.083,0.140)	**-0.252 (-0.321,-0.184)**	0.055 (-0.063,0.173)	**0.073 (0.015,0.132)**	0.094 (-0.007,0.196)	-0.020 (-0.088,0.049)	0.018 (-0.101,0.136)

[a] Adjusted for HDVI, maternal age and years of education, children´s BMI, caloric intake and parental concern “eating too much” at 4 years.
[b] Adjusted for HDVI, maternal age and years of education, children´s BMI, caloric intake and parental concerns regarding problematic behaviours at 4 years.
[c] Adjusted for HDVI, maternal age and years of education, , children´s BMI, caloric intake, weaning first food, and parental concerns “not eating enough” and “eating too slow” at 4 years.
[d] Adjusted for HDVI, maternal age and years of education, children´s BMI, caloric intake, TV per day and parental concern “eating too much” at 4 years.