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The quality of girls' diets declines and tracks across middle childhood

Michelle L Mannino¹, Yoonna Lee², Diane C Mitchell³, Helen Smiciklas-Wright⁴ and Leann L Birch^{*5}

Address: ¹Department of Human Development and Family Studies, The Pennsylvania State University, S-110 South Henderson, University Park, PA 16802, USA, ²Department of Food and Nutrition, Seoul National University, Shilim-dong, San 56-1, Kwanak-gu, Seoul, Korea, ³Department of Nutritional Sciences, The Pennsylvania State University, 5 Henderson Building, University Park, PA 16802, USA, ⁴Department of Nutritional Sciences, The Pennsylvania State University, 5 Henderson Building, University Park, PA 16802, USA and ⁵Distinguished Professor, Department of Human Development and Family Studies, The Pennsylvania State University, 105N White Building, University Park, PA 16802, USA

Email: Michelle L Mannino - mlt115@psu.edu; Yoonna Lee - yoonnalee@hotmail.com; Diane C Mitchell - dcm1@psu.edu; Helen Smiciklas-Wright - hsw@psu.edu; Leann L Birch* - llb15@psu.edu

* Corresponding author

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Abstract

Background: Food group intakes by US children are below recommendations and micronutrient inadequacies have been reported. There are few longitudinal data that focus on developmental changes in food and nutrient intake from early to middle childhood. We examined changes in nutrient and food group intakes over time and the tracking of intakes across middle childhood in a longitudinal sample of girls.

Methods: Three multiple-pass 24-hour diet recalls were conducted in a sample of 181 non-Hispanic White girls at ages 5, 7, and 9 years. Food and nutrient data were averaged across 3 days. Analyses of time effects were conducted using repeated measures analysis of variance and tracking of intakes was assessed via rank analysis.

Results: We found significant decreases in nutrient densities (intakes per 1000 kcal) of vitamins C and D, calcium, phosphorus, magnesium and zinc at age 9. Girls maintained their relative quartile positions for these micronutrients from ages 5–9. Analysis of food group data showed similar trends. At age 9, significantly fewer girls were meeting the recommendations for dairy, fruit and vegetable servings than at age 5 and girls also tended to remain in their respective quartiles over time, especially for fruit and dairy intakes.

Conclusions: These results highlight the importance of developing healthy eating practices during early childhood when caretakers have considerable control over children's food intake.

Background

There is strong evidence indicating that diet influences the risk for several major diseases including cardiovascular disease, hypertension, certain cancers, non-insulin dependent diabetes, and obesity [1,2]. Further, it has been

reported that many chronic diseases begin in childhood [3-7] and that dietary modifications in childhood could delay the onset of many chronic diseases [8,9].

Recent studies suggest that many children have diets that do not meet current recommendations for foods or nutrients. Several studies [10,11] report that 1% or fewer of children meet all of the recommendations for food group intake according to the recommendations of the Food Guide Pyramid (FGP) [12]. The FGP is a graphic representation of the USDA Dietary Guidelines for Americans, which were developed for use by all Americans aged 2 years and over to promote health and reduce the risk of chronic disease. Among children, intakes of fruits, vegetables and dairy are of particular concern. In a recent study, only 5%, 20%, and 9% of children met the FGP recommendations for fruit, vegetables, and dairy, respectively [10]. Nutrient intake inadequacies have also been reported for children. Using the new Dietary Reference Intakes (DRIs), which are sets of nutrient-based reference values that were formulated to reduce the risk of chronic diseases and prevent nutrient deficiencies [13-18], a recent study reported that the risk of inadequacy for vitamin E, folate, phosphorus and magnesium was substantial among children aged 6–18 years. In addition, intakes of calcium were below the recommendations for the majority of these children [19].

Much of the data on children's dietary intakes is based on national food consumption survey data [20]. The surveys are cross-sectional; however, longitudinal data are needed to provide evidence of changes in intake over time. It is currently not known whether the quality of children's diets changes or whether eating patterns and dietary quality remain relatively stable during middle childhood.

While data on developmental trends in diet quality during middle childhood are lacking, there is evidence that diet quality declines as children move from middle childhood into adolescence. Longitudinal data indicate that consumption of fruits, vegetables and milk declines from middle childhood into early adolescence [21] and cross-sectional data indicate further declines in fruit and vegetable intakes during adolescence [22,23]. In addition, the prevalence of nutrient inadequacies has been found to be increased during adolescence [19].

There is also some evidence that children's diets track over time (i.e. that individuals maintain their respective rank for a specific food or nutrient over time). Several researchers have reported that children's macronutrient intakes show moderate to substantial tracking. In one study macronutrient tracking was apparent as early as age 2 [24] while other studies provide evidence for macronutrient tracking from about age 4 to age 8 [25,26]. Data on the tracking of micronutrient and food group intakes in young children, however, are limited or nonexistent. In one study, fruit and vegetable intakes were found to have low to moderate tracking over two years of elementary

school [27], however other food groups and micronutrients have not been investigated in children.

The purpose of this study is to examine the developmental changes in nutrient and food group intakes, using longitudinal data from a sample of girls aged 5 to 9. Specifically, this research investigates the quality of children's diets, how this changes over time and whether or not food group and nutrient intakes track during middle childhood.

Methods

Participants

Participants were from central Pennsylvania and were part of a longitudinal study of the health and development of young girls. Eligibility criteria for girls' participation at the time of recruitment included living with both biological parents, the absence of severe food allergies, chronic medical problems, or dietary restrictions affecting food intake. Families were recruited for participation in the study through flyers and newspaper advertisements that described the study's focus as girls' nutrition, early experience, and development. In addition, families with age-eligible female children within a 5-county radius received mailings and follow-up phone calls (Metromail Inc.). The study protocol was reviewed and approved by the Pennsylvania State University Institutional Review Board. Parents provided written consent for their daughters' participation in the study.

At entry into the study, participants included 197 5-year old girls (mean age 5.4 ± 0.4) and their parents, of whom 192 families were reassessed 2 years later when girls were 7-years old (mean age 7.3 ± 0.3). A third assessment with 183 families was done 2 years later, 4 years after the initial assessment, when girls were 9-years old (mean age 9.3 ± 0.3). Reasons for family attrition included: moved out of the area (6 families), unable to locate family for follow-up visit (3 families), no longer interested in participating (3 families), failure to attend scheduled visit (1 family), and failure to complete data collection protocol (1 family). Families received \$200 at the completion of each wave of data collection (i.e. at ages 5, 7 and 9). In addition, girls completed a variety of crafts, and received a t-shirt and other small items (stickers, erasers) during each wave of data collection.

On average, parents were in their mid 30s at the time of recruitment (mothers 35.4 ± 4.8 years; fathers 37.4 ± 5.4). Approximately equal numbers of families reported incomes in the following ranges \$20,000–\$35,000, \$35,000–\$50,000, and above \$50,000 when girls were 5. The percentage of families reporting incomes greater than \$50,000 increased to 47% when girls were 7 and then to 57% at age 9. Parents were well-educated; mothers mean

education was 15 ± 2 years (range = 12–20) and fathers was 15 ± 3 years (range = 12–20). Trained researchers measured parents' height (in triplicate to the nearest 0.1 cm) and weight (triplicate to the nearest 0.1 kg) at each wave of data collection. Parents were on average slightly overweight at the first time of measurement with a mean body mass index score (BMI, weight (kg)/height (m²)) of 26 for mothers, and 28 for fathers. Parent's weight status increased slightly at each time point.

Girls' weight status

Height and weight measurements for determining BMI were obtained by a trained staff member. The girls were dressed in light clothing and were measured without shoes. Height was measured in triplicate to the nearest 0.1 cm with a stadiometer (Shorr Productions, Olney, MD). Weight was measured in triplicate to the nearest 0.1 kg with an electronic scale (Seca Corp, Birmingham, United Kingdom). Because BMI is age and sex specific, girls' BMI percentiles were calculated using recent growth charts from the Centers for Disease Control [28]. Overweight among girls was scored as a dichotomous variable, with the 85th percentile for age- and sex-specific reference data as the cutoff point.

Dietary intake

Girls' energy, macronutrient, and micronutrient intakes were measured using three 24-hour recalls at each of the three assessments. Recalls were conducted with mothers and their daughters by trained staff at the Pennsylvania State University's Diet Assessment Center. The computer-assisted Nutrition Data System (NDS, Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN) was used for data collection and analysis. When the girls were 5 years old, we used NDS Version 2.91, Nutrient database version 26, food database 11a, release date 1996. Nutrient Data System for Research (NDS-R) was used when the girls were 7 and 9 years old. At age 7, we used version 4.01_30, release date 2000 and at age 9, we used version 4.02_31 release date 2001. Randomly selected days (two weekdays and 1 weekend day) were used to collect dietary data over a two-week period during the summer and fall months. Food portion posters (2D Food Portion Visual, Nutrition Consulting Enterprises, Framingham, Ma) were used to assist in the estimation of food amounts. Nutrient data were averaged across 3 days to obtain an estimate of energy and nutrient intakes. Nutrient intakes estimates were based on foods consumed and do not include intake from supplements. The percent of energy consumed from fat, carbohydrate and protein were compared to the Acceptable Macronutrient Distribution Ranges (AMDR) for these macronutrients [18].

The mean number of servings consumed from each of the main food groups of the USDA Food Guide Pyramid was

calculated from the 24-hour recall data using methodology previously described [29]. To do this, the gram weights of all foods consumed were summed, including those contained in mixed dishes. Mixed dishes were disaggregated into the corresponding ingredient gram weights and the ingredient gram weights were summed into single whole food weights that were assigned to food groups according to the Food Guide Pyramid. The number of servings was calculated from gram weights of whole foods consumed and were primarily based on serving sizes as defined by the Food Guide Pyramid.

Statistical analysis

Girls' weight status and dietary intake data were analyzed using SAS (version 8.02, Cary NC) and a p-value of $p < 0.05$ was considered significant in all analyses. Complete data were obtained from 181 girls at each time point. Analyses of time effects (i.e. changes in weight status and dietary intake at ages 5, 7 and 9) were conducted using repeated measures analysis of variance. Pairwise comparisons of significant effects were computed using contrast statements. Because the contrast statements are equivalent to multiple t-tests, a Bonferroni correction was used to control the overall error rate at $p < 0.05$ (i.e. individual contrasts were considered significant at $p < 0.0167$). McNemar's chi-square test was used to analyze change in prevalence over time. The McNemar's test is a variation of the chi-square test that is appropriate for paired data.

Tracking of nutrient and food group intakes was assessed using two methods. First, subjects were divided into quartiles by baseline intakes of nutrients and food groups at age 5 and mean values for these variables were calculated at ages 7 and 9. These mean values were plotted to determine whether or not subjects remained in their respective quartiles over time. If tracking occurs the lines for each quartile remain generally parallel and do not intersect. Second, nutrient and food group data were divided into year-specific quartiles and cross-tabulated to determine the percent who remained in the highest or lowest quartiles at subsequent years. If no tracking occurs, one would expect those in a given baseline quartile to be evenly distributed across quartiles at later years. Thus if no tracking occurs approximately 25% of those in the highest quartile at age 5 would be in highest quartile at age 9 (or approximately 50% in the highest two quartiles). Chi-squared goodness-of-fit tests were used to determine if observed rates of agreement differed from rates expected by chance.

Results

Weight status

Girls' height, weight, body mass index (BMI), and BMI-for-age percentiles are presented in Table 1. At ages 5 and 7, the mean BMI for girls in this sample was at the 60th percentile. By age 9, BMI increased significantly to the 65th

Table 1: Height, Weight and BMI Measures ^a

	Age 5	Age 7	Age 9
Height (cm)	111.3 ± 4.7 ‡	123.8 ± 5.4 ^δ	136.0 ± 6.2 ^ψ
Weight (kg)	19.8 ± 3.1 ‡	25.7 ± 5.2 ^δ	34.5 ± 8.4 ^ψ
BMI (kg/m ²)	15.9 ± 1.6 ‡	16.6 ± 2.5 ^δ	18.5 ± 3.4 ^ψ
BMI-for-age percentile ^b	60.1 ± 26.9 ‡	59.2 ± 27.7 ‡	64.5 ± 27.2 ^δ
Percent Overweight ^c	20	21	31*

^a Mean ± SD; values with different symbols are significantly different at $p < 0.0001$. ^b BMI-for-age percentiles were calculated using growth charts from the CDC [28]. ^c Overweight is defined as a BMI-for-age percentile $\geq 85\%$ * Significant increase in prevalence from age 5 to age 9 ($p < 0.001$)

Table 2: Mean Intakes of Energy, Energy-yielding Nutrients and Cholesterol

	National Data ^a		Intake ^b	
	6–9 yr	Age 5	Age 7	Age 9
Energy (kcal)	1768	1524.4 ± 337.3 ‡	1704.9 ± 347.6 ^δ	1821.8 ± 344.6 ^ψ
Fat (g)	64.2	51.8 ± 14.8 ‡	59.6 ± 16.9 ^δ	65.4 ± 17.6 ^ψ
Fat (% of energy)	32.4	30.3 ± 4.9 ‡	31.1 ± 4.9 ‡ ^δ	31.8 ± 4.6 ^δ
Carbohydrate (g)	243.1	218.8 ± 51.4 ‡	242.2 ± 51.9 ^δ	253.6 ± 51.4 ^ψ
Carbohydrate (% of energy)	55.2	57.6 ± 5.8 ‡	57.0 ± 5.6 ‡ ^δ	56.0 ± 5.8 ^δ
Protein (g)	60.9	52.7 ± 14.8 ‡	57.1 ± 14.2 ^δ	61.9 ± 14.5 ^ψ
Protein (% of energy)	13.9	13.9 ± 2.6 ‡	13.6 ± 2.4 ‡	13.8 ± 2.5 ‡
Saturated Fat (g)	23.6	19.4 ± 6.6 ‡	22.2 ± 7.4 ^δ	24.1 ± 7.5 ^ψ
Saturated Fat (% of energy)	11.9	11.3 ± 2.4 ‡	11.5 ± 2.5 ‡	11.7 ± 2.3 ‡
Sucrose (g)	N/A	47.2 ± 17.6 ‡	53.1 ± 20.8 ^δ	55.2 ± 21.1 ^δ
Sucrose (% of energy)	N/A	12.4 ± 3.8 ‡	12.3 ± 3.7 ‡	12.1 ± 3.8 ‡
Cholesterol (mg)	190	157.6 ± 83.6 ‡	166.5 ± 82.4 ‡	186.1 ± 88.7 ^δ
Dietary Fiber (g)	12.1	10.5 ± 3.9 ‡	11.2 ± 4.4 ^δ	12.2 ± 3.8 ^ψ

^a USDA Food and Nutrient Intakes by Children; data shown is for females aged 6–9 years [20]. ^b Mean ± SD; values with different symbols are significantly different at $p < 0.0001$, except for % of energy from fat, % of energy from carbohydrate, and cholesterol which are significantly different at $p < 0.01$

percentile ($p < 0.0001$). At ages 5 and 7, approximately 20% of the sample was classified as overweight; by age 9 this increased significantly to 31% of the sample ($p < 0.001$).

Energy and nutrient intakes

Girls' mean daily energy intake increased by 297 kcal from age 5 to 9 (Table 2). Consistent with the increase in energy intake was an increase in the gram amounts of fat, carbohydrate and protein consumed ($p < 0.0001$). Expressing each macronutrient as a percentage of energy showed that protein intakes remained stable over time, however, from 5 to 9 girls consumed significantly less energy from carbohydrate and more from fat ($p < 0.01$). At all time points more than 90% of girls were within the Acceptable Macronutrient Distribution Ranges (AMDR) for carbohydrate and protein, however only 70% were within the AMDR for fat. At age 5, 16% of the girls consumed more than

35% of energy from fat. This increased significantly such that by age 9, 25% of the girls were consuming $>35\%$ of energy from fat ($p < 0.01$). At all time points less than 4% of the girls were consuming less than 20% of energy from fat. The gram amounts of saturated fat and sucrose consumed increased ($p < 0.0001$), but these were not increased when calculated as percentages of energy (Table 2). Dietary fiber intakes increased significantly ($p < 0.0001$) but remained low at all time points (Table 2). At ages 5 and 7, only one girl in this sample met the Adequate Intake (AI) value for fiber and at age 9, no one met the AI for fiber. Finally, cholesterol intakes were significantly increased at age 9 ($p < 0.001$) (Table 2).

Table 3 presents the age-appropriate dietary recommendations as well as the mean intakes from our sample. Most vitamin and mineral intakes were increased with age, which corresponds with the increase in energy intake.

Table 3: Dietary Recommendations and Mean Intakes of Selected Vitamins and Minerals

	Recommendation ^a		National Data ^b	Intake ^c		
	4–8 yr	9–13 yr	6–9 yr	Age 5	Age 7	Age 9
Vitamin A (µg RAE)	400	600	796	630.6 ± 335.7 ‡	650.1 ± 247.7 ‡	696.7 ± 282.2 ‡
Vitamin C (mg)	25	45	96	76.6 ± 48.9 ‡	73.9 ± 39.2 ‡	73.7 ± 41.4 ‡
Vitamin E (mg)	7	11	6.2	5.4 ± 2.1 ‡	5.1 ± 1.9 ‡	6.1 ± 2.0 ^δ
Folate (µg)	200	300	249	185.7 ± 67.5 ‡	203.7 ± 67.1 ^δ	317.9 ± 89.7 ^ψ
Vitamin D (µg)	5.0	5.0	N/A	5.3 ± 2.6 ‡	5.3 ± 2.3 ‡	5.2 ± 2.6 ‡
Vitamin B6 (mg)	0.6	1.0	1.5	1.3 ± 0.4 ‡	1.4 ± 0.4 ^δ	1.5 ± 0.5 ^δ
Vitamin B12 (µg)	1.2	1.8	3.9	3.0 ± 2.0 ‡	3.2 ± 1.8 ‡ ^δ	3.9 ± 4.4 ^δ
Calcium (mg)	800	1300	850	832.6 ± 332.5 ‡	864.1 ± 295.9 ‡ ^δ	909.2 ± 302.9 ^δ
Phosphorus (mg)	500	1250	1106	992.6 ± 303.4 ‡	1055.1 ± 276.9 ^δ	1104.8 ± 281.4 ^ψ
Magnesium (mg)	130	240	215	193.0 ± 59.5 ‡	204.1 ± 55.0 ^δ	215.3 ± 51.8 ^ψ
Iron (mg)	10	8	13.6	10.7 ± 3.8 ‡	11.7 ± 3.6 ^δ	12.5 ± 3.8 ^ψ
Zinc (mg)	5	8	9.4	7.8 ± 2.5 ‡	8.6 ± 2.6 ^δ	8.9 ± 2.6 ^δ
Sodium (mg)	N/A	N/A	2764	2237.4 ± 667.3 ‡	2560.2 ± 662.7 ^δ	2768.6 ± 661.1 ^ψ

^a Recommendations based on the DRIs for children aged 4–8 and girls aged 9–13 [13-15,17]. All values listed for vitamin D and calcium; other nutrients listed as RDAs. ^b USDA Food and Nutrient Intakes by Children; data shown is for females aged 6–9 years [20]. Vitamin A is presented as the retinal equivalent (RE) value. ^c Mean ± SD; values with different symbols are significantly different at $p < 0.0001$, except for calcium at $p < 0.01$, and vitamin B12 at $p < 0.05$.

Table 4: Dietary Nutrient Density

	Nutrient Density ^{a,b}		
	Age 5	Age 7	Age 9
Vitamin A (µg RAE)	417.9 ± 228.6 ‡	389.3 ± 156.5 ‡	385.6 ± 150.8 ‡
Vitamin C (mg)	50.0 ± 29.2 ‡	43.5 ± 21.8 ^δ	40.5 ± 21.4 ^δ
Vitamin E (mg)	3.5 ± 1.2 ‡	3.0 ± 1.0 ^δ	3.3 ± 1.0 ‡
Folate (µg)	122.9 ± 38.4 ‡	121.3 ± 39.0 ‡	175.9 ± 43.0 ^δ
Vitamin D (µg)	3.5 ± 1.5 ‡	3.2 ± 1.3 ^δ	2.9 ± 1.5 ^ψ
Vitamin B6 (mg)	0.8 ± 0.2 ‡	0.8 ± 0.2 ‡	0.8 ± 0.3 ‡
Vitamin B12 (µg)	2.0 ± 1.4 ‡	1.9 ± 0.9 ‡	2.2 ± 2.5 ‡
Calcium (mg)	544.7 ± 179.5 ‡	513.1 ± 162.2 ^δ	503.3 ± 156.1 ^δ
Phosphorus (mg)	651.2 ± 140.2 ‡	624.5 ± 134.8 ^δ	610.3 ± 127.6 ^δ
Magnesium (mg)	126.2 ± 24.3 ‡	120.5 ± 24.2 ^δ	119.1 ± 23.2 ^δ
Iron (mg)	7.1 ± 2.2 ‡	6.9 ± 1.9 ‡	6.9 ± 1.8 ‡
Zinc (mg)	5.2 ± 1.4 ‡	5.1 ± 1.3 ‡ ^δ	4.9 ± 1.2 ^δ

^a Dietary densities are expressed as units per 1000 kcal. ^b Mean ± SD; values with different symbols are significantly different at $p < 0.0001$, except for phosphorus and magnesium at $p < 0.001$, calcium at $p < 0.01$, and zinc at $p < 0.05$.

However, by age 9, mean intakes of calcium, phosphorus, and magnesium fell below the recommended amounts and at all time points vitamin E intakes were well below the recommended levels. Sodium intakes increased significantly at each time point ($p < 0.0001$).

Table 4 presents the girls' vitamin and mineral intakes per 1000 kcal. Nutrient densities of vitamins C and D, calcium, phosphorus, magnesium and zinc significantly

decreased with age ($p < 0.05$). The nutrient density of folate increased ($p < 0.0001$) which is most likely due to an increase in folate fortification of the food supply that occurred during the period between when girls were 7 and when they were 9. To investigate whether nutrient intakes tracked over time girls were split into quartiles based on their intakes at age 5 and the mean of each quartile was plotted as a visual representation of whether or not girls maintained their relative quartile ranking. If tracking

occurs the lines for each quartile remain generally parallel and do not intersect. Energy, protein, cholesterol, vitamins D and E, phosphorus, magnesium, iron, and zinc showed the strongest tracking. For these nutrients, quartiles remained distinct over time and the lines did not intersect (see Figure 1 for sample plots). Fat, carbohydrate, saturated fat, sucrose, fiber, vitamins A, B6 and C, folate, calcium, and sodium showed moderate tracking. For these nutrients the extreme quartiles remained distinct while the middle quartiles overlapped (see Figure 1 for sample plots). Finally vitamin B12 showed poor tracking, with the middle and extreme quartiles intersecting (Figure 1).

We also calculated the rates of agreement of classification within quartiles of nutrient intake from ages 5 to 9. Rates of agreement in the highest and lowest quartiles for energy, macronutrient, and fiber intakes ranged from an average of 39% (sucrose) to an average of 47% (fiber). Among micronutrients, rates of agreement in the highest and lowest quartiles averaged 48–53% for calcium, phosphorus, magnesium and vitamin D. The majority (98%) of the rates were either significantly greater (for exact agreement) or significantly or lower (for extreme discordance) than the rates expected by chance, providing some evidence for tracking.

Food group intake

Table 5 shows the mean number of servings consumed from each of the food groups. For all food groups except fruit, the number of servings consumed increased with age. Although not significant, the number of servings from fruit decreased over time, which is due to a significant decrease in the consumption of fruit juice (data not shown). Although significant increases were found in the number of servings consumed from the grain, meat and vegetable groups ($p < 0.01$), the overall pattern of intakes is similar over time.

Table 5 also lists the recommended number of servings from each food group. At age 5, 69% of the girls were meeting the recommended number of servings from dairy, however this decreased significantly over time such that by age 9 only 36% of the girls were meeting the recommendation ($p < 0.0001$). The proportion of girls consuming the recommended number of fruit and vegetable servings was low at age 5 (27% for fruit and 8% for vegetable) and these decreased significantly by age 9 (7% for fruit and 3% for vegetable) ($p < 0.01$).

The tendency for girls' food group intakes to track over time was examined by determining to what extent girls maintained their relative quartile ranks for each of the food groups. As can be seen in Figure 2, girls' food group intakes showed some evidence of tracking and fruit intake

showed the greatest tracking. Girls who were in the lowest quartile for fruit intake at age 5 remained low at ages 7 and 9; while girls who were in the highest quartile continued to have high fruit intakes over time. Dairy intakes also showed considerable tracking; girls with high dairy intakes at age 5 continued to have high dairy intakes over time.

We also calculated the rates of agreement of classification within quartiles of food group intake from ages 5 to 9. Rates of agreement ranged from 36–60% and 29–47% in the highest and lowest quartiles, respectively and ninety-three percent of the values were significantly greater (in the case of agreement) or significantly lower (in the case of discordance) than the rates expected by chance. Fruit and dairy intakes had the highest rates of agreement, whereas grain and meat intakes had the lowest rates of agreement.

Discussion

This is the first longitudinal study of girls that investigated both the quality and tracking of nutrient and food group intakes across middle childhood. Our data provides evidence of food and nutrient intakes tracking and declining in quality during middle childhood. Tracking was evaluated using two methods: descriptive plots and percent agreement between quartiles. Both methods provide support for dietary intakes tracking during middle childhood. Only 1% of girls in this study met all of the FGP recommendations at age 5 and none of the girls met all of the recommendations at ages 7 and 9. These findings are similar to those reported by others based on nationally representative data [30].

Several researchers have investigated whether children's and adolescents' dietary patterns track over time. Studies have ranged from 1 year to more than 10 years and have included children as young as 6 months, preschool-, elementary- and high-school-aged children, and young adults. Macro- and micronutrients have been examined as well as food groups and food choices. Fruit and vegetable intakes were reported to have low to moderate tracking during elementary school [27] but showed stability from adolescence into adulthood [23]. Nutrient intakes were found to track during early and middle childhood [24-26] and during young adulthood [31] but not during adolescence [32,33]. Food choices, however, were found to track during adolescence [34] and from childhood to young adulthood [35]. Some of these results are conflicting and it is difficult to draw conclusions from these studies due to variations in the ages of the participants, study duration, diet assessment methods, and methods used for the tracking analyses.

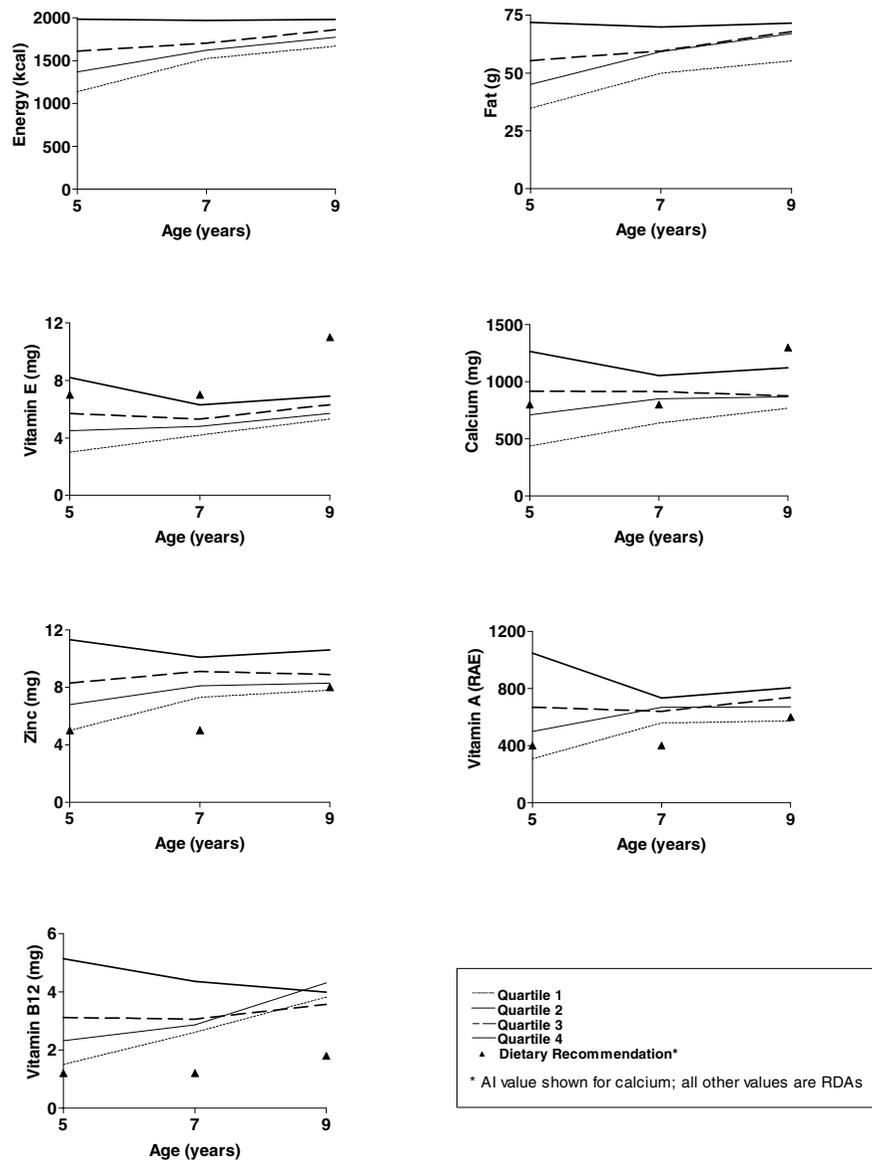


Figure 1
 Sample plots of the tracking of nutrient intakes from age 5 to age 9

Table 5: Food Group Intakes

	Recommended # of Servings ^a		# of Servings ^b			% Meeting Recommendations		
	Age 2–6	Older Children	Age 5	Age 7	Age 9	Age 5	Age 7	Age 9
Grains	6	9	5.2 ± 1.6 ‡	5.6 ± 1.5 ^δ	6.1 ± 1.7 ^ψ	23	1	7*
Vegetables	3	4	1.5 ± 1.1 ‡	1.7 ± 1.0 ^δ	1.9 ± 0.9 ^δ	8	2	3*
Fruit	2	3	1.5 ± 1.2 ‡	1.4 ± 1.3 ‡	1.3 ± 1.1 ‡	27	8	7*
Dairy	2	2–3	2.7 ± 1.4 ‡	2.9 ± 1.3 ‡	2.9 ± 1.3 ‡	69	73	36*
Meat	2	2	1.3 ± 0.7 ‡	1.3 ± 0.6 ‡ ^δ	1.5 ± 0.6 ^δ	13	13	20
Fats and Sweets	N/A	N/A	5.0 ± 2.8 ‡	5.2 ± 2.5 ‡	5.4 ± 2.6 ‡	N/A	N/A	N/A

^a Recommendations are from the Food Guide Pyramid [12]. ^b Mean ± SD; values with different symbols are significantly different at $p < 0.0001$, except for meat at $p < 0.01$ * Significant decrease from age 5 to age 9 at $p < 0.0001$, except for vegetables at $p < 0.01$

Results from the current study provide evidence of nutrient and food group intakes tracking during middle childhood. Among nutrients, energy, protein, cholesterol, vitamins D and E, phosphorus, magnesium, iron, and zinc showed the strongest tracking. Plots of these nutrients showed that each quartile remained distinct over time. The rate of exact agreement between quartiles (highest and lowest) for these nutrients was approximately 45%, which exceeds the rate expected by chance (i.e. 25%). Other micronutrients also showed evidence of tracking, although not as strong. Among food groups, fruit and dairy intakes showed the strongest evidence of tracking. On the other hand, tracking of grain and meat intakes was low.

There were several lines of evidence to indicate that diet quality declined between 5 and 9 years of age. A larger proportion of girls at 9 years of age failed to meet the dietary recommendations for most food groups than they did in the younger years. At age 5, 69% of the girls met the dairy recommendation, however by age 9 only 36% met this recommendation. Few girls met the fruit and vegetable recommendations at age 5 (27% for fruit and 8% for vegetable) and even fewer met these recommendations at age 9 (7% for fruit and 3% for vegetable). It might be argued that decline in dietary quality reflects the increased recommendations for the older girls. The FGP [12] recommendations specify the number of servings for children aged 2–6 years and older children, therefore at ages 7 and 9 the recommended number of servings is increased. This could explain why fewer girls were meeting recommendations at age 9, however energy intakes were increased at age 9 making it possible for girls to come closer to meeting the increased FGP recommendations.

The data on nutrient density indicate that the decline in quality is not fully accounted for by increases in recom-

mendations that occur at ages 7 and 9. Nutrient densities of several nutrients, including vitamins C and D, calcium, phosphorus and magnesium were lower at both 7 and 9 years of age than at 5 years; zinc density was lower at 9 years as compared to 5 years. While energy intake increased, there were no increases in the number of servings in the dairy or fruit group, which could explain the decreased density for nutrients such as calcium and vitamin C. More comprehensive analyses of food subgroups would be necessary to determine whether choices made within the major food groups were more or less nutrient dense.

Our data show that diet quality decreases but also that dietary intakes track across middle childhood. In other words, girls who eat few servings of dairy at age 5 are likely to eat few servings of dairy at age 9. Likewise, girls who eat greater amounts of dairy at age 5 are likely to eat greater amounts at age 9. From an intervention perspective this suggests that eating patterns are developed early in life, before the age of 5. Thus intervention approaches to reduce the risk of chronic diseases such as osteoporosis would need to be targeted at a very young population and their caregivers. Although, our data provide evidence that diet quality will decline during middle childhood, those who start out with 'healthier' diets at a young age will be less likely to be at risk for inadequate intakes during middle childhood than those who start out with less healthy eating patterns.

Several micronutrients, including thiamin, riboflavin, and niacin, were not reported in this study because analysis of these nutrients revealed that mean intakes from our sample were nearly twice the RDA. The pattern of findings for food group intakes in combination with micronutrient data suggest that adequate intake of these vitamins was most likely a result of food fortification. For all three of

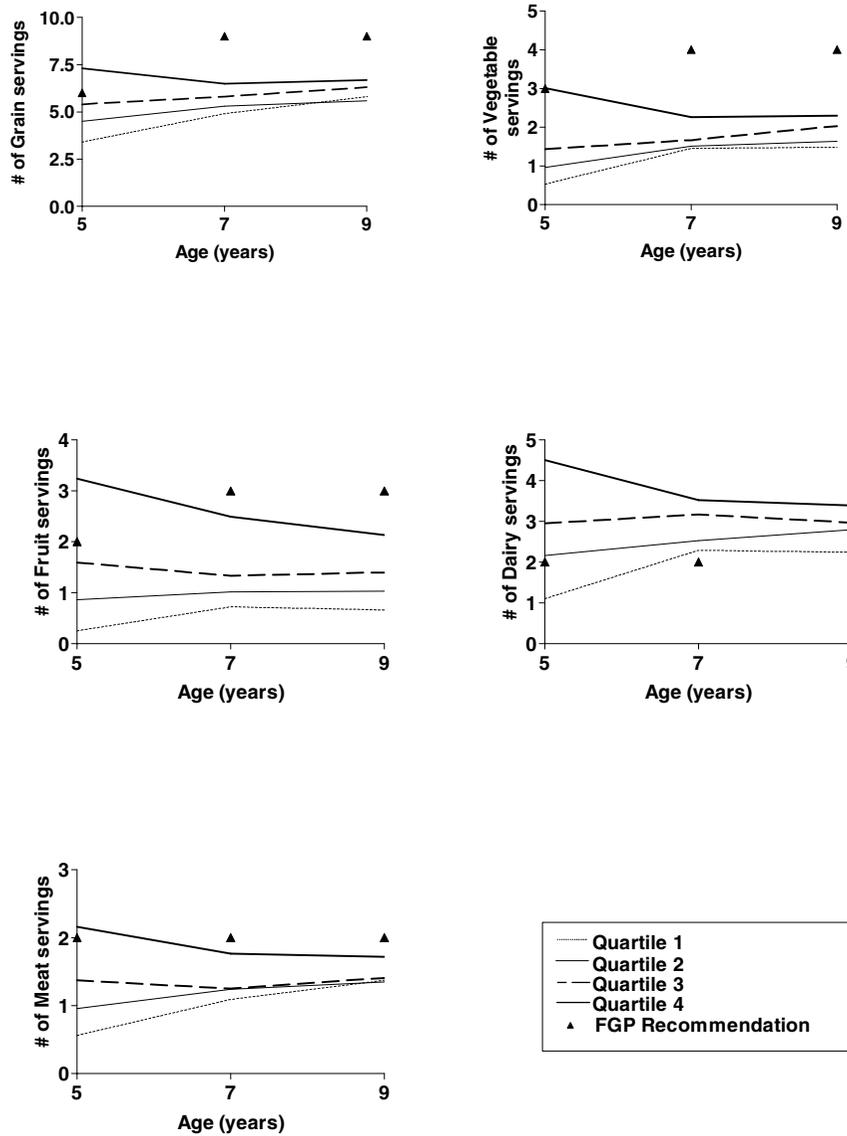


Figure 2
Tracking of food group intakes from age 5 to age 9

these vitamins, fortified ready-to-eat cereals are top contributors to intakes of the U.S. population [14] and children commonly consume ready-to-eat cereals. Food fortification also explains the increase in nutrient density of folate. During the course of this study The Department of Health and Human Services mandated that all enriched cereal grains be fortified with folate, whereas previously only ready-to-eat and cooked cereals were fortified with folate [14]. These findings that fortified foods contribute substantially to children's micronutrient intakes are similar to those reported by Berner [36] and Subar [37] for nationally representative data.

In this study, mean calcium intakes were below the recommendations and only one-third of girls met the FGP recommendations for dairy at age 9. It has been reported that calcium intakes are declining among children as a result of decreased dairy consumption and that it is not possible to obtain adequate calcium without a source of milk in the diet [38]. Furthermore, drinking milk during childhood has been associated with the likelihood of meeting calcium recommendations [39] and with reducing the risk of developing osteoporosis later in life [40]. These findings emphasize the importance of milk and dairy foods, especially during childhood.

A significant increase in the prevalence of overweight among our sample was noted. By age 9, nearly one-third of our sample was at or above the 85th BMI-for-age percentile. The prevalence of overweight in our sample of girls was similar to national data, which report 20% of females aged 2–5 years and 28% of females aged 6–11 years are above the 85th percentile [41]. When our sample was split into quartiles based on BMI percentiles at age 5 and plotted the results showed nearly perfect tracking (data not shown); girls maintained their relative quartile ranking for BMI percentile and the lines for each quartile were parallel.

This study has some limitations. The sample is exclusively white girls and at entry into the study included only 2-parent families. Thus, our results cannot be generalized to other socioeconomic, ethnic and racial groups. Supplement intake was not quantified; however, the prevalence of supplement use declined from 52% of the sample at age 5 to 32% at age 9. Also, supplement users in this sample of girls were found to have higher quality diets than nonusers [42], thus it is unlikely that including intakes from supplements would reduce the proportion of girls in this sample who were found to be at risk. Children's dietary data were recalled by mothers and daughters and are subject to errors of under-reporting or over-reporting for individuals, however we used the multiple pass technique to facilitate recall and reduce error. Intra-individual variation in intake does vary by nutrient, however, we collected

3 days of dietary intake data, which is generally acceptable for estimating the usual intakes of groups. Finally, continued dietary monitoring of the girls in this study is important as the girls make the difficult transition from childhood to adolescence.

Conclusions

Results from this study show evidence of dietary intakes declining in quality. The evidence for decline identified several micronutrients that are classified as current or potential public health issues in nutrition [43]. These longitudinal data also suggest that there is some degree of persistence in dietary patterns across middle childhood. The tracking is of particular concern for girls with low food group and nutrient intakes. Our findings highlight the importance of developing healthy eating patterns early in childhood and suggest that early nutritional assessment is important. Targeted interventions should focus on children in the lowest intake groups and support the tracking of dietary intakes but with higher quality diets. Participants in this study are approaching developmental transitions, both physiological and social. Continued dietary monitoring of this sample of girls will provide valuable information regarding how dietary patterns change as children move into adolescence.

Competing interests

None declared.

Authors' contributions

MLM drafted the manuscript and participated in the collection and analysis of the data. YL participated in the data analysis. DCM participated in the collection of data and provided significant advice and consultation regarding the manuscript. HW provided significant advice and consultation regarding the manuscript. LLB designed the experiment and provided significant advice and consultation regarding the manuscript. All authors read and approved the final manuscript.

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