Infant and early childhood dietary predictors of overweight at age 8 years in the CAPS population

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Eur J Clin Nutr. 2011 Apr;65(4):454-62.
http://doi.org/10.1038/ejcn.2011.7
http://hdl.handle.net/10616/41728

Title page

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Running Title:

Early childhood dietary predictors of overweight

Abstract

Background: Programs to address obesity are a high priority for public policy especially for young children. Research into dietary determinants of obesity is challenging but important for rational planning of interventions to prevent obesity, given that both diet and energy expenditure influence weight status.

Objective: We investigated whether early life dietary factors were predictive of weight status at 8-years in a cohort of Australian children.

Methods: We used data from the Childhood Asthma Prevention Study – a birth cohort at high risk of asthma. Dietary data (3-day weighed food records) were collected at 18 months and height, weight and waist circumference were collected at 8 years. We assessed the relationship between dietary predictor variables and measures of adiposity using linear regression.

Results: Intakes of protein, meat and fruit at age 18 months were positively associated with measures of adiposity at age 8 years, namely body mass index (BMI) and/or waist circumference. We also showed a significant negative relationship between these measures of adiposity at 8 years and intake at 18 months of dairy foods as a percent of total energy, and intake of energy dense cereal-based foods such as cookies and crackers.

Conclusions: This birth cohort study with rigorous design, measures and analyses, has shown a number of associations between early dietary intake and subsequent adiposity that contribute to the growing evidence base in this important field.

Keywords: obesity, body mass index, waist circumference, diet, dietary proteins, meat

Introduction

There is widespread concern about the obesity epidemic in western societies. In the past decade, attention has focused on the growing problem of overweight and obesity in children with almost one in three children affected in the United States and one in four children in Australia (Booth et al 2006, Ogden et al 2010). Overweight during childhood has both immediate and longer term health effects, including an increase in the prevalence of early cardiovascular disease and diabetes (Freedman et al 1999, Pinhas-Hamiel et al 1996). Programs to address obesity are a high priority for public policy (Gill et al 2009) especially for young children (Harrington et al 2010). Research into dietary determinants of obesity is challenging because diets are complex, and both diet and energy expenditure influence weight status. However, it is important that programs are based on the best possible evidence so that dietary behaviors most likely to have the greatest effects in preventing excess weight gain are targeted.

Several recent reviews have identified a number of dietary factors that may be related to obesity, by potentially conferring either risk or protection: diets high in fat or added sugars, sugar sweetened beverages, energy density of the total diet, energy-dense foods with low nutrient value, breakfast skipping, milk and dairy foods, dietary fiber, fruit and vegetables (Jebb 2007, Newby 2007, Swinburn et al 2004, Woodward-Lopez et al 2006). All reviews note most evidence comes from cross-sectional studies among adults, and that further rigorous inquiry is needed using valid dietary assessment methods, longer term prospective studies, and measurement and analysis of important covariates to confirm and clarify the direction and magnitude of the effects of these dietary factors and their importance in childhood. Further, of the few birth cohort studies to investigate determinants of obesity none has measured infant feeding and early diet in sufficient detail using rigorous assessment methods to investigate associations predictive of later weight status (Reilly et al 2005, Scaglioni et al 2000).

The Childhood Asthma Prevention Study (CAPS) offered an opportunity to examine early life dietary predictors of later weight status using rigorous dietary assessment methods, including 3-day weighed food records, and prospectively collected measurements of breastfeeding practices. In previous papers we reported that diets measured at 18 months revealed a high intake of energy-dense, nutrient-poor foods (Webb et al 2006), intake of meats high in fat and saturated fat (Webb et al 2005), excess energy intakes of approximately 10% (Webb et al 2008), and lower breastfeeding rates during the first 12 months than those reported for the general population (Mihrshahi et al 2008). We sought to investigate whether early life dietary factors were predictive of weight status at 8 years in this cohort of Australian children.

Subjects and Methods

Subjects

CAPS began as a five-year randomised controlled trial investigating the effects of a house dust mite avoidance and omega-3 fatty acid supplementation intervention from birth to five years on the primary prevention of asthma (Marks et al 2006). Details on the study design, intervention, and population have been previously described (Marks et al 2006, Mihrshahi et al 2001). In brief, pregnant women whose unborn children were at increased risk of developing asthma, because one or more parents or siblings had current asthma or wheezing, were recruited from antenatal clinics in westernSydney, Australia from 1997 to 2000. A total of 616 children were randomised at birth into active intervention or control groups. We have previously shown that this cohort was similar in most respects to the population of western Sydney but a higher proportion of both fathers and mothers of children in this cohort had tertiary education and were Australian-born, compared to those who did not participate in the study and the population of western Sydney in general (Mihrshahi et al 2002). The active supplement intervention comprised a fish-oil (omega-3) capsule, the contents of which were added to the child's formula or food when the child ceased breastfeeding or by six months of age, whichever came first. Modification of the diet was minimal, requiring only the use of low omega-6 spreads and cooking oils in the preparation of the child's food. The control group received a supplement of omega-6 oil, and omega-6 cooking oils and spreads.

Dietary measures

The diet was measured at the 18 month assessment in association with other medical assessments. Dietary intake of foods and nutrients was assessed from three-day weighed food records. A research dietitian instructed parents or caregivers to keep records on two weekdays and one weekend day, including methods for weighing and recording, and issued a food record booklet and set of Tanita digital kitchen scales. At the end of the recording period, the dietitian visited homes to collect records and check their completeness. Raw data from the food records were checked, coded and entered into a nutrient analysis program (Williams, Sydney, SERVE version 3.95, 1998) based on Australian Composition of Foods (National Food Authority, Canberra, NUTTAB 95 version 3.0, 1995) to derive energy and nutrient estimates for all foods eaten on average over the three days. Macronutrients were expressed in absolute amounts and as a percentage of total energy. For estimates of foods consumed and their contribution to total energy intake, food items were grouped into 16 food groups based on eight-digit codes and classifications used in the Australian National Nutrition Survey (NNS) (Australian Bureau of Statistics 1998). In this analysis we have grouped foods as core foods and extra foods. Core foods were “dairy foods”, which were defined as milk and milk products, including yoghurt, cheese, ice-cream and custard; “milk”, which included skim, whole and evaporated milk; “fruit”; “vegetables”; “cereal foods”, which included bread, pasta, rice, breakfast cereals; and “meats”. Extra foods were cereal-based products (such as cookies and crackers), non-milk beverages (including juice, cordial, fruit drinks and soft drinks), fats and oils, snack foods, sugar, confectionery, savoury sauces and condiments, fried potatoes, ice-cream and some miscellaneous foods (Kellett et al 1998, Webb et al 2006). The following sub-groups of extra foods were also analysed “non-milk beverages”; “sweetened drinks” which included cordial, fruit drinks and soft drinks; “fried potatoes”; “salty snacks” which included potato crisps, cheese snacks and corn-chips; “confectionery” and “cereal-based foods” which included cookies, crackers, doughnuts, cakes, pies, buns, muffins and pizza.

Anthropometric measures

Anthropometric measurements were made by the study nurses at the eight year assessment. Height was measured using a portable stadiometer to the nearest 1 cm and weight was measured using electronic bathroom scales to the nearest 1kg. Children were dressed in light clothing without shoes. Body mass index (BMI) was calculated using kg/m^2. Waist circumference was measured with a flexible steel tape at the level of the narrowest point (or midpoint) between the lower costal border and the iliac crest, to the nearest 0.1cm. Birth weights were obtained from hospital records (Mihrshahi et al 2001).

Other covariates

Breastfeeding duration was determined prospectively during the child's first year by interview with mothers at 3-monthly intervals using standardised questions for monitoring breastfeeding. Children were classified as breastfed for at least six months when the mother reported at the six month interview that the child was still being breastfed. Parental height and weight were assessed at the eight year assessment and was measured by researchers, where possible, and otherwise by self-report. BMI was calculated, and mothers and fathers were classified as normal weight (BMI< 25kg/m^2), overweight ($25 \leq$ BMI <30), or obese (BMI$\geq$30). Ethnicity was based on the child's grandparents' country of birth collected by questionnaire when the children were 4.5 years. An ethnic classification (Caucasian, European, Middle Eastern, Indian, or Asian) was made if 3 or more grandparents were from the same country of birth region; otherwise ethnicity was undefined. Information about maternal smoking during pregnancy (Y/N) and parents' educational attainment was obtained by interview at the perinatal visit.

Statistical analysis

All statistical analyses were performed using SAS (version 9.2; SAS Institute Inc, Cary, NC). The associations between dietary predictor variables (total energy, macronutrients, or food groups) and outcome measures of adiposity (BMI and waist circumference at 8 years) were examined using linear regression. Unadjusted regression models contained only one dietary predictor variable and, where specified, were also adjusted for total energy intake. The macronutrient models contained only one macronutrient expressed as the percentage of total energy intake from fat, carbohydrate or protein respectively, or alternatively in units of 100 grams of fat, carbohydrate, or protein respectively adjusted for total energy intake. The units of MJ for total energy intake, 100 grams of fat, carbohydrate and protein were used to reduce the number of decimal places of the regression coefficients.

Intakes of food groups, both in grams and as a percentage of total energy intake, were converted into quintiles or, where the intake of some foods was limited, into quartiles or tertiles. The quantile number (1 to 5, 4 or 3, respectively) was treated as a continuous variable to test for a linear trend across the quantiles. The models in which the food groups were expressed in grams were also adjusted for total energy intake.

We considered the following potential confounders: parental obesity, time spent watching TV, ethnicity, birth weight, gestational age, gestational diabetes, breastfeeding for at least six months, introduction of solids by 3 months, education status of mothers and fathers, employment status prior to pregnancy of mothers and fathers, mothers age at child’s birth, parity, maternal smoking in pregnancy, daycare attendance, sex of the child and the CAPS diet intervention group. Several of these were found not to be significantly associated with BMI or waist circumference at 8 years and were not included in the multivariate analyses. We also considered BMI at age 18 months as a possible confounder but did not include this in the main analysis because we regarded it as being on the causal pathway between early childhood diet and BMI/waist circumference at age 8 years (Hernan et al 2002). The covariates included in the multivariate analyses were: sex, CAPS dietary intervention group from 0-5 y (to incorporate the original study design), birth weight, breastfeeding for at least six months, parental obesity, ethnicity, smoking during pregnancy, and father’s education (Parsons et al 1999, Reilly et al 2005). Significant associations were those for which the P-value was less than 0.05.

Results

There were 362 of the original 616 children of the birth cohort who had a dietary record at 18 months and anthropometric measurements taken at eight years of age. Compared with the excluded subjects, those included in the study had older and more highly educated mothers and fathers, and fathers who were more likely to be in full-time employment, but did not differ in other respects (**Supplementary Table 1**). Characteristics of the study population are shown in **Table 1**. The prevalence of overweight or obesity (≥85th centile) among study children at age 8 years was 28.5% and obesity (≥ 95th centile) was 10.8% (CDC 2007). BMI and waist circumference measures at eight years were highly correlated (ρ=0.91). In the unadjusted models the significant predictors of BMI at 8 years were birth weight, parental obesity, ethnicity, maternal cigarette smoking during pregnancy, and father's education. Similarly, the significant predictors of waist circumference were birth weight, breastfeeding for at least six months, parental obesity, maternal cigarette smoking during pregnancy, and father's education.

The association of total energy and macronutrient intake with BMI and waist circumference at 8 years is shown in **Table 2**. Higher intakes of protein, both in units of 100 grams and as a percentage of total energy intake, at 18 months predicted a higher BMI at 8 years, and this relationship remained significant after adjusting for confounders. Total energy intake and intakes of fat and carbohydrates at 18 months did not predict BMI at 8 years. However, total energy intake at 18 months did predict waist circumference at 8 years, and the relationship remained significant after adjusting for confounders. Absolute intakes of protein, fat and carbohydrates, respectively, were associated with waist circumference in the unadjusted models but did not remain significant after adjusting for confounders. The effects of the major food groups and also of vegetable and cereal intake at 18 months were attenuated when the analysis was adjusted for BMI at 18 months (**Supplementary Tables 2-5)**.

Table 3 shows the relationship between intake of various food groups at 18 months, expressed as trends across quintiles of intake in grams and percentages of total energy intake, and BMI and waist circumference at 8 years. In both the unadjusted and adjusted models, the intake of meat at 18 months predicted BMI and waist circumference at 8 years. Higher intakes of cereal-based foods at 18 months were associated with a decrease in BMI and waist circumference at 8 years. Higher intakes of dairy foods as a percentage of total energy were associated with a decrease in BMI at 8 years. Higher intake of fruit in grams was associated with a larger waist circumference at 8 years.

In the majority of the adjusted models in Table 2 and Table 3 birth weight, parental obesity, ethnicity and maternal cigarette smoking during pregnancy remained significant predictors of BMI; similarly birth weight, parental obesity and maternal cigarette smoking during pregnancy remained significant predictors of waist circumference at 8 years.

Discussion

In this sample of Australian children, 28% of whom were overweight or obese at age 8 years, we have shown that protein intake and meat intake at age 18 months were positively associated with measures of adiposity at age 8 years, namely BMI and waist circumference. We have also shown a significant negative relationship between BMI at 8 years and intakes of dairy foods as a percentage of total energy and cereal-based foods such as cookies and crackers at 18 months. Further, we observed that higher intakes of fruit at 18 months was associated with a larger waist circumference.

The role of protein in predicting later obesity or preventing excessive weight gain has received little attention in research on dietary determinants of obesity. Indeed most focus has been on carbohydrate and fat intakes, because of their larger contribution to total energy intake. A 2006 systematic review of the dietary determinants of obesity identified several longitudinal studies that examined protein intake and obesity among children (Woodward-Lopez et al 2006). Several of these found a positive association between protein intake and adiposity (Rolland-Cachera et al 1995, Scaglioni et al 2000, Skinner et al 2004) while others found no association (Alexy et al 2004, Maffeis et al 1998, Magarey et al 2001). The mechanisms to explain such an association, if one exists, are not well understood. Rolland-Cachera et al (1995) has suggested that high protein intakes may contribute to early adiposity rebound, growth acceleration, and adipose storage. Simpson and Raubenheimer (2005) suggest that protein plays a key role in the physiologic regulation of food choice and gluconeogenesis in the presence of abundant energy-dense carbohydrate and fat rich foods. The 2006 review concluded that evidence regarding the role of protein in the development of obesity is inconclusive and merits further study (Woodward-Lopez et al 2006).

We previously reported that the important dietary sources of protein in the diets of these children were milk (48%), meat (17%), breads and cereals (12%) and cereal based foods

(6%) (Webb et al 2008) and the diet of this subsample was similar. In this study (results not shown) we also examined the relationship between the percentage of protein from meat, dairy foods, and cereal based foods respectively. We found that the percent contribution to protein intake from cereal-based foods and milk were negatively associated with BMI and the percentage of protein from meat was positively associated with BMI (all $P < 0.05$). Our finding that both protein intake and meat intake were predictive of BMI and waist circumference in mid-childhood, suggests that meat intake may itself be influential, or may be a marker for other factors alone or in combination. Indeed the most commonly consumed meats in this sample of children at age 18 months were McDonalds Chicken McNuggets™, beef mince and beef sausage, all of which are high in fat and energy (Webb et al 2005) and high intakes of these in early childhood may track to later childhood. There is limited evidence in adults that diets or dietary patterns high in meat are associated with adiposity but we could find no studies investigating this association among children (Maskarinec et al 2000, Woodward-Lopez et al 2006). We reported in our earlier work that children in the highest quintile of meat intake were significantly taller and heavier and had higher energy and protein intakes at 18 months than those with lower meat intakes (Webb et al 2005). Thus, the long-term effects of early meat and protein intakes, if any, on BMI may be evident from early childhood. It may also be that high meat and protein intake are markers for “big eaters” and higher intakes of all foods and beverages in early life. Indeed, the associations we found between higher absolute intakes of fruits at 18 months and higher waist circumference at 8 years may indicate that larger intakes of several core food groups in early life are related to adiposity in mid-childhood. Further investigation is needed to assess whether higher intakes of these foods in early childhood track to mid-childhood.

Previous cohort studies in adults have demonstrated a protective effect of higher milk, dairy foods or calcium intake on obesity (Zemel and Miller 2004). However, before this study, findings in children have been conflicting, partly attributable due to lack of adequate control for confounding (Newby 2007, Woodward-Lopez et al 2006).

Our finding that higher intake of “cereal-based foods” at 18 months was negatively associated with BMI and waist circumference at age 8 years appears to be counter-intuitive. Cereal-based foods are energy-dense, typically high in carbohydrate and fat, and largely nutrient-poor and are often highlighted as targets for obesity prevention efforts. We reported in previous papers the most commonly eaten of these foods in our sample were cookies and crackers and the median intakes were small (Webb et al 2008, Webb et al 2006). Several alternative explanations for these findings are possible. Many studies have shown that higher carbohydrate and/or lower fat intakes are associated with lower adiposity. However, we did not find such associations in our study. Dietary intakes measured in our study during the rapid transition period from an infant milk-based diet to a solid food diet may not be reflective of habitual solid food diet in early childhood, for example at ages 2-3 years. Further, it is unclear whether intakes of energy-dense nutrient-poor food track from the transition diet period through early and mid-childhood. Parent feeding behaviours may also account for the counter-intuitive findings; the literature suggests that parental concern about overweight in young children tends to lead to restrictive feeding practices and in turn may lead to later overconsumption of the restricted foods (Scaglioni et al 2008). Further, concern about underweight, slow weight gain, and/or picky eating may result in pressure to overconsume foods (Scaglioni et al 2008). Cross-sectionally at 18 months, we observed that children with higher intakes of “extra” foods (cereal-based foods being the largest contributor to energy from “extras”) did not have significantly higher energy intakes than children who consumed lesser amounts of “extra foods” (Webb et al 2008).

It is notable that the intake of total “extra foods”, which explained 28% of energy intake of these children at age 18 months, including its component groups of sweetened drinks and snack foods, were not significantly associated with later adiposity. Few longitudinal studies of children have investigated associations between intake of energy dense, nutrient-poor foods and the results have been conflicting (Field et al 2003, Newby et al 2003, Phillips et al 2004). Evidence of a positive association between sweetened beverage intake and adiposity in children is more consistent and supported by experimental evidence (Woodward-Lopez et al 2006).

The role of breastfeeding in the development of later obesity has been controversial and the evidence is mixed. This has been attributed in part to impossibility of conducting randomised controlled trials, recall bias in observational studies, and the lack of a clear definition of breastfeeding by investigators (in terms of exclusivity and/or timeframe used – birth, three months, six months, one year etc). In our study, recall bias was avoided because breastfeeding duration was measured prospectively over the first 12 months. In all multivariable models that incorporated breastfeeding for at least six months there was no relationship between breastfeeding for at least six months and adiposity (all $P > 0.05$) despite the significant relationship between breastfeeding for at least six months and waist circumference in the univariate model.

We assume that diet at 18 months of age is correlated with diet at earlier ages. Hence, BMI at 18 months is actually an early outcome of early childhood diet. For this reason we would expect that, adjusting the association between the exposure, early childhood diet, and the outcome BMI or waist circumference at 8 years for an early outcome of the exposure, that is, BMI at 18 months, would attenuate the apparent effect. Supplementary Tables 2-5 show the association under four conditions of adjustment: no adjustment for birth weight or BMI at 18 months, adjustment for birth weight, adjustment for BMI at 18 months, and adjustment for both birth weight and BMI at 18 months. This confirms our expectation and shows attenuation of the effects, particularly for the major food groups and for vegetables and cereals. However, for the reasons stated above, we believe that the appropriate analysis, and on which interpretations should be based is the one adjusted only for potential confounders that are not on the causal pathway, in this case birth weight. A full exploration of this issue, including guidelines for when it is inappropriate to include covariates in the analysis, can be found in Hernan et al 2002.

We also tested the relationship between other dietary predictors and adiposity (results not shown) including dietary fibre, portion sizes of particular food groups, cholesterol, HDL and LDL and found no significant relationship.

While our study had many strengths including the longitudinal design, and rigorous early measures of diet, breastfeeding, and potential confounding factors, the study was initially designed and powered to detect associations and predictors of asthma, not obesity. We therefore did not have measures of some potential confounders, such as physical activity, gestational weight gain and childhood sleep patterns, or of interim measures of diet between 18 months and 8 years, that could have increased the explanatory power. However, the sample size was large enough to demonstrate several statistically significant associations.

In conclusion, this birth cohort study with rigorous design, measures and analyses, has shown a number of associations between early dietary intake and subsequent obesity that contribute to the growing evidence base in this important field. The findings warrant further inquiry into the possible mechanisms that may explain these associations and further experimental research to confirm or refute the findings prior to widespread application as dietary objectives of preventive interventions.

Acknowledgements

We would like to thank the CAPS families for their participation in the study, the CAPS investigators for study direction and the study team for collection of the data; Margaret-Allman Farinelli for initial work on the data analysis for this paper; Pat Crawford, Mark Hudes and Lorrene Ritchie for comments on the manuscript.

Sources of support: National Health and Medical Research Council of Australia, Cooperative Research Centre for Asthma, New South Wales Department of Health, Children's Hospital Westmead, University of Sydney, Faculty of Medicine, Commonwealth Department of Health and Aging. Dr Almqvist was funded by the Swedish Heart Lung Foundation and Swedish Society of Medicine. Contributions of goods and services were made by Allergopharma Joachim Ganzer KG Germany, John Sands Australia, Hasbro, Toll refrigerated, AstraZeneca Australia, and Nu-Mega Ingredients Pty Ltd. Goods were provided at reduced cost by Auspharm, Allersearch and Goodman Fielder Foods. University of Sydney, Faculty of Medicine, Strategic Research Grant 2008.

Conflict of interest: None of the authors had a personal or financial conflict of interest.

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Table 1 Characteristics of the study sample and the relationship between BMI and waist circumference at 8 y[1]

	BMI (kg/m^2)				Waist circumference (cm)			
	n	**%**	**Mean ± SD**	***P***	**n**	**%**	**Mean ± SD**	***P***
Overall	**362**		**17.3 ± 2.9**		**339**		**59.1 ± 7.5**	
Sex				0.48				0.18
Male	183	50.6	17.4 ± 3.0		174	51.3	59.7 ± 8.0	
Female	179	49.5	17.2 ± 2.8		165	48.7	58.6 ± 7.0	
Asthma study intervention group[2]				0.31				0.50
Control	178	49.2	17.2 ± 2.7		165	48.7	58.9 ± 7.1	
Active	184	50.8	17.5 ± 3.2		174	51.3	59.4 ± 8.0	
Breastfed ≥ 6 months				0.06				0.04
No	211	58.3	17.6 ± 3.1		196	57.8	59.8 ± 8.2	
Yes	151	41.7	17.0 ± 2.6		143	42.2	58.2 ± 6.4	
Parental weight status[3]				0.01				0.03
Both parents overweight or obese	155	42.8	17.7 ± 2.7		153	45.1	59.7 ± 7.0	

Only mother overweight or obese	51	14.1	17.6 ± 3.3		50	14.7	59.5 ± 8.1	
Only father overweight or obese	88	24.3	17.3 ± 3.1		86	25.4	59.4 ± 7.8	
Both normal	38	10.5	15.7 ± 1.8		37	10.9	55.3 ± 5.1	
Missing	30	8.3	17.3 ± 3.5		13	3.8	59.3 ± 11.8	
Child's grandparents' ethnicity/country of birth[4]								
Caucasian	199	55.0	17.0 ± 2.4	0.006	184	54.3	58.7 ± 6.1	0.40
European	32	8.8	17.7 ± 2.5		30	8.8	59.4 ± 6.3	
Middle Eastern	13	3.6	18.6 ± 3.1		12	3.5	60.7 ± 6.5	
Indian	18	5.0	16.1 ± 2.8		17	5.0	56.8 ± 9.4	
Asian	14	3.9	16.8 ± 2.7		14	4.1	58.8 ± 7.8	
Undefined	86	23.8	18.1 ± 4.0		82	24.2	60.4 ± 9.9	
Maternal cigarette smoking during pregnancy				<0.0001				<0.0001

None	283	78.2	16.9 ± 2.4		267	78.8	58.2 ± 6.3	
1-10/day	47	13.0	18.7 ± 4.5		43	12.7	62.1 ± 11.4	
11-40/day	32	8.8	18.8 ± 3.6		29	8.6	63.4 ± 8.5	
Fathers Education				0.02				0.02
≤ 10 years of school	121	33.4	17.7 ± 3.2		113	33.3	59.9 ± 7.9	
11-12 years of school	65	18.0	17.6 ± 3.5		58	17.1	60.5 ± 8.7	
Tertiary Education	174	48.1	16.9 ± 2.3		166	49.0	57.9 ± 6.3	

	n	Mean ± SD	***P***^{1}	**n**	Mean ± SD	***P***^{1}
Birth Weight (g)	362	3493±492	0.002	339	3493±488	0.004
Weight at 18 months (kg)	359	11.6±1.4	<0.0001	336	11.6±1.4	<0.0001
Length at 18 months (cm)	357	83.4±3.1	0.003	334	83.4±3.1	<0.0001

Footnotes for Table 1:

[1] Linear regression analysis was used to model the relationship between each characteristic and BMI and waist circumference respectively

[2] Childhood Asthma Prevention Study dietary intervention group from 0-5y

[3] Overweight or obese was defined as BMI ≥ 25, Normal weight was defined as BMI <25

[4] Ethnicity was defined based on the child's grandparent's country of birth. An ethnic classification was made if 3 or more grandparents were from the same country of birth region; otherwise ethnicity was undefined

Table 2. Characteristics of total energy and macronutrient intakes; and regression coefficients for total energy intake and macronutrient intake at 18 months in predicting BMI and waist circumference at 8 y[1]

			BMI (kg/m^2)						Waist circumference (cm)					
			Unadjusted[2]			Adjusted[3]			Unadjusted[2]			Adjusted[3]		
Variable[4]	**Unit**	**Overall[5]**	**Coefficient**	**95% CI**	***P***	**Coefficient**	**95% CI**	***P***	**Coefficient**	**95% CI**	***P***	**Coefficient**	**95% CI**	***P***
Total energy	MJ	4.36 ± 1.0	0.28	-0.02, 0.58	0.07	0.15	-0.14, 0.44	0.31	1.17	0.38, 1.95	0.004	0.83	0.05, 1.61	0.04
Protein	100 grams of protein	0.4 ± 0.1	3.86	1.07, 6.66	0.01	4.66	0.19, 9.12	0.04	12.21	4.93, 19.48	0.001	9.75	-2.28, 21.77	0.11
Percentage of total energy from protein	%	15.3 ± 2.6	0.14	0.02, 0.25	0.02	0.12	0.01, 0.23	0.03	0.26	-0.04, 0.56	0.09	0.24	-0.05, 0.53	0.11
Fat	100 grams of fat	0.4 ± 0.1	1.31	-1.14, 3.77	0.30	0.57	-1.80, 2.93	0.64	7.32	0.81, 13.83	0.03	-2.10	-13.87, 9.67	0.73
Percentage of total energy	%	36.2 ± 5.5	-0.02	-0.07, 0.04	0.57	-0.01	-0.06, 0.04	0.76	-0.01	-0.15, 0.14	0.94	0.01	-0.13, 0.15	0.92

from fat														
Carbohydrates	100 grams of carbohydrates	1.3 ± 0.3	0.74	-0.15, 1.63	0.10	0.37	-0.49, 1.23	0.40	2.91	0.59, 5.24	0.01	-0.29	-4.53, 3.94	0.89
Percentage of total energy from Carbohydrates	%	49.9 ± 7.1	-0.01	-0.05, 0.03	0.71	-0.01	-0.05, 0.03	0.62	-0.03	-0.14, 0.08	0.63	-0.03	-0.14, 0.08	0.57

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Footnotes for Table 2:

[1] Estimates were made using linear regression analysis

[2] Models with intakes of fat, protein and carbohydrates measured in 100 grams are adjusted for total energy intake

[3] Adjusted for: sex, asthma study intervention group, birth weight, breastfeeding for at least 6 months, parental obesity status, ethnicity, smoking in pregnancy, and father's education. Models with intakes of fat, protein and carbohydrates measured in 100 grams are also adjusted for total energy intake

[4] Each variable was modeled using a separate linear regression

[5] Mean ± SD for dietary intake at 18 months

Table 3. Quintiles of food intake at 18 months and associated regression coefficients for predicting BMI and waist circumference at 8 y[1]

			BMI (kg/m^2)						Waist circumference (cm)					
			Unadjusted[2]			Adjusted[3]			Unadjusted[2]			Adjusted[2]		
Food group	**Units**	**Quintile cut points[4]**	**Coefficient**	**95% CI**	***P for trend***	**Coefficient**	**95% CI**	***P for trend***	**Coefficient**	**95% CI**	***P for trend***	**Coefficient**	**95% CI**	***P for trend***
Core Foods														
Dairy Foods[5]	grams	0, 278, 437, 561, 693	-0.10	-0.32, 0.11	0.35	-0.20	-0.41, 0.02	0.07	-0.10	-0.67, 0.46	0.72	-0.51	-1.09, 0.07	0.08
	% of total energy	0, 23, 33, 39, 47	-0.24	-0.45, -0.03	0.03	-0.21	-0.41, 0.01	0.04	-0.51	-1.07, 0.05	0.07	-0.45	-0.99, 0.08	0.10
Milk[6]	grams	0, 157, 356, 491, 643	-0.02	-0.23, 0.20	0.88	-0.11	-0.32, 0.11	0.33	0.10	-0.47, 0.67	0.73	-0.30	-0.87, 0.28	0.31
	% of total energy	0, 11, 23, 30, 38	-0.19	-0.41, 0.02	0.08	-0.17	-0.38, 0.03	0.10	-0.26	-0.82, 0.31	0.37	-0.21	-0.76, 0.34	0.45
Fruit	grams	0, 17, 45, 80, 124	0.15	-0.07, 0.36	0.18	0.17	-0.04, 0.38	0.11	0.57	-0.01, 1.15	0.05	0.63	0.05, 1.20	0.03
	% of total energy	0, 1, 3, 5, 8	0.11	-0.11, 0.32	0.34	0.18	-0.03, 0.39	0.09	0.31	-0.27, 0.89	0.29	0.56	0.00, 1.12	0.05
Vegetables	grams	0, 20, 35, 54, 82	0.29	0.08, 0.50	0.01	0.20	0.00, 0.40	0.05	0.73	0.17, 1.29	0.01	0.50	-0.04, 1.04	0.07
	% of total energy	0, 1, 3, 5, 7	0.16	-0.05, 0.37	0.13	0.13	-0.06, 0.33	0.19	0.35	-0.22, 0.92	0.22	0.29	-0.25, 0.83	0.29

Cereal Foods[7]	grams	6, 37, 51, 68, 95	0.24	0.03, 0.45	0.03	0.16	-0.05, 0.37	0.14	0.65	0.09, 1.22	0.02	0.35	-0.21, 0.91	0.22
	% of total energy	1, 9, 12, 16, 21	0.13	-0.08, 0.35	0.23	0.12	-0.08, 0.33	0.23	0.27	-0.30, 0.83	0.36	0.28	-0.27, 0.83	0.32
Meats	grams	0, 9, 21, 34, 53	0.35	0.14, 0.56	0.001	0.25	0.04, 0.45	0.02	0.87	0.32, 1.42	0.00	0.59	0.03, 1.15	0.04
	% of total energy	0, 2, 4, 7, 11	0.36	0.15, 0.57	0.001	0.27	0.07, 0.47	0.01	0.79	0.24, 1.34	0.01	0.63	0.10, 1.17	0.02
Extra Foods														
Total Extra foods[8]	grams	0, 52, 87, 149, 229	0.05	-0.16, 0.27	0.61	-0.04	-0.25, 0.17	0.71	0.12	-0.44, 0.68	0.68	-0.21	-0.77, 0.34	0.45
	% of total energy	0, 16, 22, 30, 37	-0.05	-0.26, 0.17	0.67	-0.10	-0.30, 0.11	0.36	-0.15	-0.71, 0.42	0.61	-0.31	-0.85, 0.23	0.26
Non-milk Beverages[9]	grams	0, 40, 112, 168, 291	0.08	-0.14, 0.29	0.48	0.04	-0.17, 0.25	0.71	0.33	-0.24, 0.89	0.26	0.16	-0.40, 0.73	0.57
	% of total energy	0, 2, 5, 8, 13	0.08	-0.14, 0.29	0.48	0.07	-0.14, 0.27	0.53	0.20	-0.36, 0.76	0.49	0.19	-0.36, 0.73	0.50
Sweetened drinks[10]	grams	0, 1, 17, 70, 158	0.13	-0.06, 0.33	0.18	0.10	-0.08, 0.29	0.27	0.29	-0.24, 0.82	0.28	0.20	-0.31, 0.70	0.44
	% of total energy	0, 0.002, 1, 4, 8	0.06	-0.14, 0.25	0.59	0.04	-0.15, 0.23	0.68	0.08	-0.45, 0.61	0.77	0.04	-0.46, 0.54	0.89
Fried potatoes	grams	0, 0.01, 8, 20	0.14	-0.12, 0.41	0.29	0.07	-0.17, 0.32	0.56	0.40	-0.31, 1.10	0.27	0.16	-0.50,	0.63

													0.83	
	% of total energy	0, 0.001, 2, 4	0.17	-0.10, 0.43	0.21	0.11	-0.13, 0.35	0.38	0.42	-0.28, 1.12	0.24	0.24	-0.42, 0.90	0.48
Salty snacks[11]	grams	0, 0.5, 7	0.23	-0.01, 0.46	0.06	0.07	-0.16, 0.29	0.56	0.41	-0.22, 1.04	0.20	-0.10	-0.70, 0.51	0.76
	% of total energy	0, 0.2, 3	0.21	-0.03, 0.45	0.08	0.09	-0.13, 0.31	0.44	0.38	-0.25, 1.02	0.23	0.04	-0.55, 0.64	0.88
Confectionery	grams	0, 1, 7, 15	-0.21	-0.47, 0.05	0.12	-0.25	-0.49, 0.00	0.05	-0.23	-0.94, 0.47	0.52	-0.36	-1.02, 0.30	0.28
	% of total energy	0, 0.3, 3, 6	-0.26	-0.52, 0.00	0.05	-0.24	-0.48, 0.01	0.06	-0.29	-0.99, 0.41	0.42	-0.22	-0.87, 0.44	0.52
Cereal based foods[12]	grams	0, 8, 17, 28, 51	-0.17	-0.38, 0.05	0.13	-0.23	-0.44, -0.22	0.03	-0.36	-0.94, 0.21	0.21	-0.61	-1.17, -0.05	0.03
	% of total energy	0, 3, 6, 10, 14	-0.28	-0.49, -0.07	0.01	-0.27	-0.47, -0.07	0.01	-0.80	-1.36, -0.24	0.01	-0.76	-1.29, -0.23	0.01

Footnotes for table 3:

[1] Estimates were made using linear regression analysis by modeling the quintile of food intake as a continuous variable

[2] Models with intake of food in grams were adjusted for total energy intake

[3] Adjusted for: sex, asthma study intervention group, birth weight, breastfeeding for at least 6 months, parental obesity status, ethnicity, smoking in pregnancy, and father's education. Models with intake of food in grams were also adjusted for total energy intake

[4] The value for the start of each quintile is listed. Where intake was small, quartiles or tertiles were used as indicated.

[5] Milk and milk products including milk, yoghurt, cheese, ice-cream, custard

[6] Milk including skim, whole and evaporated milk

[7] Includes bread, breakfast cereal, pasta, rice etc

[8] Includes cereal-based products (such as cookies, etc see footnote 11), non-milk beverages (except for fruit juice), fats and oils, snack foods, sugar, confectionery (chocolate, jellies, energy bars), savory sauces and condiments, miscellaneous foods, fried potatoes, and ice-cream

[9] Juice, cordial, fruit drinks and soft drinks

[10] Cordial, fruit drinks, and soft drinks

[11] Potato crisps, cheese snacks, corn chips

[12] Cookies, crackers, doughnuts, cakes, pies, buns, muffins, pizza etc