SHORT REPORT

Maternal diet in pregnancy and offspring blood pressure

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Associations between maternal nutrient intakes in late pregnancy and offspring blood pressure at 7½ years were investigated in 6944 singletons from the Avon Longitudinal Study of Parents and Children. The only finding was a weak inverse association with omega-3 fatty acids that was lost after adjustment for potential confounders, suggesting that diet in pregnancy does not influence offspring blood pressure in well-nourished populations.

We know of only five observational studies¹⁻⁵ and one randomised clinical trial⁶ that have reported on the association between maternal diet in pregnancy and offspring blood pressure (BP). Most were small, based on unusual dietary circumstances, and without clear pre-specified hypotheses, and their findings were inconsistent. Therefore, we investigated the effect of maternal diet in pregnancy on offspring BP at age 7½ in a large contemporary cohort. A longer version of this paper is available on the *ADC* website (<http://www.archdischild.com/supplemental>).

METHODS

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a population based study investigating the health and development of children (www.alspac.bris.ac.uk). Women living in three health districts of Bristol, England with expected delivery dates between April 1991 and December 1992 were eligible; 14 541 (85%) were enrolled, and 13 678 had a singleton, live born child. Of these, 11 713 completed a food frequency questionnaire at 32 weeks gestation (based on current diet), and 7431 of their children attended a clinic where BP was measured at approximately age 7½. Analysis was based on 6944 mother-child pairs with diet and BP information. Ethical approval for the study was obtained from the ALSPAC and local research ethics committees.

Twelve nutrient intakes (plus protein to carbohydrate ratio⁴) were derived from the maternal food frequency questionnaires based on standard sized portions;⁷ all of these had been associated with offspring blood pressure in previous animal or human studies. Mean systolic and diastolic BP values were recorded for the children while seated, based on two right arm measurements from a Dinamap 9301 vital signs monitor (cuff size appropriate for upper arm circumference).

Confounder information was obtained from maternal self-reported questionnaires, obstetric records, and the children's clinic. These were grouped into BP measurement factors (room temperature, time of day, state of the child), child's anthropometry (weight, height, body mass index (BMI) (weight/height²)), maternal factors (age at delivery, pre-pregnancy weight, height, BMI, previous high BP, smoking in pregnancy), social factors (partner during pregnancy, mother and partner social class and education, family income), birth weight and gestation at delivery. Mothers reported use of dietary supplements and pills/medicines during pregnancy, but as dose and frequency were not available, this information could not be combined with the nutrient intakes.

Effects of confounding factors on offspring BP were assessed using linear regression. Associations between each

maternal nutrient in quartiles (treated as categorical variables to calculate beta values, with p values for trends across the categories) and offspring BP were firstly examined using separate minimally adjusted models (sex, child's age at time of BP, maternal energy intake (as a continuous variable)). Analyses were repeated with additional adjustment for all other confounders. Two pre-specified interactions (maternal protein and carbohydrate,² and maternal calcium and child's BMI⁶) were tested using subgroups.

RESULTS

There was a suggestion of an inverse association between maternal omega-3 fatty acids and offspring BP, but this was lost after full adjustment (table 1). Carbohydrate was directly associated with systolic BP, but only after full adjustment, and there were no other relations with systolic BP (table 1). There were no relations between maternal diet and offspring diastolic BP.

When the children were grouped according to maternal animal protein (<50 g/day v ≥50 g/day), the positive effects of maternal carbohydrate on offspring BP did not reach significance in either group (p ≥ 0.1 for all). After grouping the children according to BMI quartiles, the effects of maternal calcium on offspring BP (positive in middle half, negative in extremes of BMI) did not reach significance (p ≥ 0.1 for all). Adjusting for use of calcium supplements and/or antacids containing calcium did not alter any of the relations between maternal dietary calcium and offspring BP.

DISCUSSION

This study, based on a large contemporary population, does not provide convincing evidence of an association between maternal diet in late pregnancy and offspring BP at age 7½. Previous studies in humans have reported some associations, but the most striking findings were dependent on interactions that were not pre-specified. Most studies were small, and based on women with atypical dietary conditions, such as the Dutch Famine,⁴ a randomised calcium supplementation trial,⁶ and an intervention whereby women were encouraged to eat 450 g of red meat a day and avoid carbohydrate-rich foods.⁵ In one study, women were pregnant between 1948 and 1954² and diets are likely to have changed over time, and another was based in a less well-nourished population (Philippines).³ Another study recorded BP in infancy,¹ and as "tracking" of BP may not start until later, findings cannot be compared with our study.

Our findings may have been different if all children in the cohort had been included, but it is unlikely that this would create associations, and those who attended the clinic were generally similar to those who did not. Dietary intakes were assessed by an unquantified food frequency questionnaire, but were generally similar to those reported in a national survey based on a seven day weighted intake.⁷ The child's BP was measured twice by a trained observer, and although could be argued that two measurements are inadequate, associations with other factors have been shown in this cohort, thus allowing more confidence in the BP measurement quality.

Although our data do not suggest that dietary recommendations for pregnancy should be altered because of any effect

Table 1 Regressions of offspring systolic BP (mm Hg) at age 7½ on maternal dietary variables (32 weeks gestation)

Quartiles of daily dietary intake		Minimally adjusted models*			Fully adjusted model†		
		β	95% CI	p	β	95% CI	p
Carbohydrate (g) (baseline <182)	182–218	0.51	–0.17 to 1.19		0.98	0.16 to 1.79	
	218–258	0.02	–0.79 to 0.83		1.00	0.02 to 1.97	
	>258	0.73	–0.39 to 1.85	0.5	1.52	0.17 to 2.87	0.04
Protein (g) (baseline <55)	55–66	–0.10	–0.75 to 0.55		0.22	–0.56 to 1.01	
	66–79	–0.45	–1.17 to 0.27		–0.18	–1.06 to 0.70	
	>79	–0.58	–1.47 to 0.31	0.1	0.19	–0.90 to 1.28	0.999
Total fat (g) (baseline <55)	55–68	–0.11	–0.79 to 0.56		0.32	–0.48 to 1.13	
	68–84	–0.48	–1.26 to 0.30		–0.19	–1.12 to 0.75	
	>84	–0.50	–1.54 to 0.54	0.2	–0.57	–1.83 to 0.68	0.3
Saturated fat (g) (baseline <21)	21–27	0.18	–0.47 to 0.84		0.24	–0.54 to 1.02	
	27–35	–0.15	–0.88 to 0.59		0.03	–0.84 to 0.89	
	>35	0.10	–0.82 to 1.02	0.9	–0.64	–1.74 to 0.48	0.3
Polyunsaturated fat (g) (baseline <9)	9–12	0.05	–0.59 to 0.68		0.37	–0.40 to 1.14	
	12–16	–0.19	–0.85 to 0.48		0.41	–0.39 to 1.21	
	>16	–0.31	–1.04 to 0.43	0.3	0.48	–0.41 to 1.36	0.3
Monounsaturated fat (g) (baseline <19)	19–24	0.20	–0.47 to 0.87		0.44	–0.36 to 1.24	
	24–30	0.02	–0.77 to 0.80		0.05	–0.89 to 1.00	
	>30	–0.07	–1.13 to 0.98	0.8	–0.20	–1.48 to 1.07	0.7
Calcium (mg) (baseline <759)	759–938	–0.11	–0.75 to 0.52		–0.21	–0.97 to 0.55	
	939–1127	–0.003	–0.70 to 0.69		0.12	–0.71 to 0.95	
	>1127	–0.38	–1.22 to 0.45	0.5	–0.48	–1.48 to 0.52	0.5
Potassium (mg) (baseline <2177)	2177–2582	–0.03	–0.68 to 0.62		0.22	–0.56 to 1.01	
	2583–3021	0.13	–0.59 to 0.85		0.26	–0.61 to 1.13	
	>3021	0.21	–0.69 to 1.12	0.6	0.25	–0.83 to 1.34	0.7
Magnesium (mg) (baseline <206)	207–254	0.26	–0.38 to 0.91		0.56	–0.23 to 1.35	
	255–308	–0.06	–0.75 to 0.63		0.55	–0.32 to 1.41	
	>308	–0.31	–1.12 to 0.51	0.3	0.33	–0.71 to 1.37	0.6
Protein/carbohydrate (baseline <0.26)	0.26–0.30	–0.36	–0.97 to 0.25		–0.06	–0.81 to 0.68	
	0.31–0.35	–0.60	–1.22 to 0.01		–0.33	–1.08 to 0.42	
	>0.35	–0.16	–0.78 to 0.45	0.5	–0.18	–0.94 to 0.57	0.5
Animal protein (g) (baseline <35)	35–44	–0.20	–0.82 to 0.43		–0.10	–0.85 to 0.65	
	44–53	–0.20	–0.85 to 0.46		–0.10	–0.90 to 0.70	
	>53	–0.41	–1.15 to 0.34	0.3	–0.32	–1.22 to 0.58	0.5
Omega-3 fatty acids (g) (baseline <0.03)	0.03–0.09	0.41	–0.19 to 1.00		1.03	0.30 to 1.75	
	1.00–0.27	–0.38	–1.03 to 0.27		0.20	–0.59 to 0.98	
	>0.27	–0.43	–1.04 to 0.18	0.04	0.47	–0.28 to 1.22	0.7

*Adjusted for sex, child's age for BP, maternal pregnancy energy intake.

†Adjusted for measurement factors, current anthropometry, maternal and social factors, birth weight, and gestation.

Beta values were calculated from separate regression models, treating the nutrient quartiles as categorical variables, and p values are for trends across the categories.

on offspring BP, it is possible that effects may emerge as the children grow older. However, this is unlikely as there were not even weak relations at this age, and the overall ranking according to BP may remain similar so associations with maternal diet would not alter substantially. Other cohorts with good quality dietary data at different stages in pregnancy, as well as long term follow ups of further randomised controlled trials in pregnancy are needed to confirm that there is indeed no association between diet in pregnancy and offspring BP in well-nourished populations.

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