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Trends in energy and sugar intakes and body mass index between 1983 and 1997 among children in Great Britain

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Abstract

Background: It has been suggested that rising obesity among children is partly attributable to sugary foods and soft drinks driving an increase in energy intake (EI). Yet historical data on sugar intake are sparse. The present study calculated total sugar intake *de novo* among 3296 children aged 10–11 and 14–15 years in 1983 and compared EI, macronutrients and sugar sources with data from 459 children of same age in the 1997 National Diet and Nutrition Survey.

Methods: Secondary analysis of 7-day weighed diet records and anthropometric data from two British surveys. Compositional data on sugars applied to individual food codes to calculate sugar intake and sources for 1983. Trends examined before/after adjustment for low/high energy reporting (LHER) defined as EI : basal metabolic rate <1.16 or >2.65.

Results: Mean EI (kJ day^{-1}) was 7% lower in 1997 than in 1983, mainly as a result of lower fat intake. After excluding LHER, mean EI was 3% lower in 1997. Mean body mass index (BMI) increased by 0.7–1 kg m^{-2} (2–3 kg). Total sugar intake averaged 115 g day^{-1} in 1983 and 113 g day^{-1} in 1997 (122 versus 127 g day^{-1} excluding LHER, $P = 0.08$). Excluding LHER, fat energy was lower in 1997 (35.4% versus 37.8%) and sugars slightly higher (23.6% versus 22.3%). Sugar sources showed a marked shift away from table sugar with smaller falls in milk, biscuits and cakes, counterbalanced by an significant increase in sugar from soft drinks and, to a lesser extent, fruit juice and breakfast cereals.

Conclusions: Althugh the study design precludes drawing causal inferences regarding nutrient intake and obesity, a higher prevalence of under-reporting and lower levels of physical activity in 1997 could explain the paradox of lower reported EI and rising BMI.

Introduction

Rising trends in obesity among children in the UK (Stamatakis *et al.*, 2005) have been accompanied by lifestyle changes, including eating habits and physical activity (Canoy & Buchan, 2007; Department of Health, 2007). One notable global dietary trend has been the rise in consumption of sugar-sweetened soft drinks (Nielsen & Popkin, 2004; Rugg-Gunn *et al.*, 2007; Bleich *et al.*, 2009). Such associations, combined with evidence from prospective studies and a limited number of interventions, have resulted in the widely-held hypothesis that sugary drinks may be contributing to the global increase in obesity (World Cancer Research Fund/American Institute for Cancer Research 2007). However, with respect to the many available reviews on the subject (Bachman *et al.*, 2006; Malik *et al.*, 2006; Pereira, 2006; Vartanian *et al.*, 2007; Forshee *et al.*, 2008; Gibson, 2008), not all are equivocal and many have emphasised the significant weaknesses in the evidence base.

Weight gain in a population implies an increase in dietary energy supply and/or or a reduction in energy expenditure. Sugars, especially in liquid form, are perceived to be driving an excess energy intake, although much of this evidence is derived from American studies. In Britain, annual surveys of household food consumption

(Department of the Environment Food and Rural Affairs 2006) show that total energy intakes have fallen, rather than risen, over the past 20–30 years, whereas intake of total sugar has remained broadly static or declined slightly. However, soft drinks, confectionery and foods brought into the home were only included in the survey after 1992, making comparison with earlier periods difficult. Second, these data are of limited use for discerning trends in children's intakes because consumption is not recorded at the level of the individual. Weighed dietary surveys of a nationally representative sample of the adult population in 1987 and 2000 point to a nonsignificant decline in energy intake of approximately 5.5% among men and 2.5% among women (Henderson *et al.*, 2003) and similar national data are required to evaluate trends among children.

Trends in children's sugar intake in Northumberland have been examined in repeat cross-sectional surveys in 1980, 1990 and 2000 (Fletcher *et al.*, 2004; Rugg-Gunn *et al.*, 2007). Each study included approximately 400 children aged 11–12 years whose diet was assessed by means of two, 3-day diet diaries (using household measures). Total sugars were estimated to provide 22% of energy consistently over the three surveys (Rugg-Gunn *et al.*, 2007), with nonmilk extrinsic sugars (NMES) intakes providing 16%, 17% and 16% of total energy, respectively (Fletcher *et al.*, 2004). This suggests that sugar intakes have remained relatively stable over the period, although the contributions from different sources have changed, with a particular increase in the proportion from soft drinks and a reduction in the use of table sugar (Rugg-Gunn *et al.*, 2007). However, at a national level, no trends have been reported because sugar intake was not calculated in the 1983 Department of Health (DH) survey of schoolchildren's diets (Department of Health, 1989). This has frustrated attempts aiming to compare the amounts and sources of sugars consumed in the 1980s with more recent data from the National Diet and Nutrition Survey (NDNS) (Gregory & Lowe, 2000). However, it is possible to reconstruct values for sugar intake in the 1983 survey given access to the computerised food diaries of individuals and appropriate food composition tables. The present study reports a comparison of sugar intakes and sources in 1983 and 1997 alongside differences in energy intakes and anthropometric indices. An important component was the assessment of under-reporting and its effect on the observed trends.

Materials and methods

Data preparation

The proposed study used computerised raw data files from the Diets of British Schoolchildren, surveyed in 1983 (Department of Health, 1989) and the NDNS (Gregory & Lowe, 2000). Survey files and documentation were obtained under license from the ESRC National Data Archive (http://www.data-archive.ac.uk). In the DH study, satisfactory diaries were obtained from 3296 children, 13 of whom were subsequently excluded ($n = 8$ aged 12, $n = 5$ aged 16) because they fell outside the declared age range, resulting in a final sample of 3283. The 459 respondents in the NDNS who were aged 10–11 or 14–15 years were selected for comparison. All analyses are based on the unweighted data because weightings for the DH study were incomplete.

There were some differences in the sampling design between the two studies. The DH survey used a multistage, random probability design based on area, schools and age group, with deliberate oversampling of Scottish primary school children from less advantaged backgrounds, whereas the NDNS sample was based on a nationally representative sample of households within postcode sectors. The response rates in the two surveys were similar (75% versus 80%). Of those interviewed, approximately 20% in both surveys did not complete a satisfactory 7-day record. Approximately 10% of the NDNS sample reported that illness affected their eating in some way at some point during the survey but, they were not excluded because no information on illness was available for the DH survey. However, those with implausibly low energy intake were excluded under the low energy reporting criterion. Both surveys used the same high quality dietary assessment method (a weighed dietary record over seven consecutive days, with repeat calls, checks and coding by trained fieldworkers; food consumed at school was assessed from portion sizes provided by caterers in the NDNS). The food composition database (Ministry of Agriculture Fisheries and Food Nutrient Databank) evolved and expanded from 1080 items in 1982 (Department of Health, 1989) to >6000 items by 1993, comprising the database used for the 1997 survey (Gregory & Lowe, 2000).

Calculation of sugar values for foods

The food diaries for the DH survey detailed every eating occasion over 7 days (>420 000 rows), comprising the weight of each food item and its energy and nutrient content, including carbohydrate, but not sugars. Values for sugars were derived by matching each food to its counterpart in the Composition of Foods integrated dataset (CoFids) (http://www.food.gov.uk/science/dietarysurveys/dietsurveys/). This is the expanded and updated version of the database, used in Government dietary surveys such as the NDNS. The full food name/description and carbohydrate content were used to select the best match. Foods in the DH survey were subsequently aggregated into 76 groups corresponding to those used in the NDNS. Food groups containing little sugar (meat, eggs, cheese, fish, etc.) were then combined to arrive at a manageable number of 24 main food groups (defined in the Appendix).

Statistical analysis

Body mass index (BMI) was calculated from measured weight and height in both surveys. BMI *z*-scores, expressing each individual's BMI in units of standard deviation, relative to the 1990 British Reference Values for their age and sex, were calculated using LMS software (http://homepage.mac.com/tjcole/FileSharing1.html). International Obesity Task Force cut-offs for overweight were applied, corresponding to an adult BMI of 25 kg m^{-2} (Cole *et al.*, 2000).

Basal metabolic rate (BMR) was estimated using the Schofield equations based on sex, age and weight (Department of Health, 1991). Cut-offs for evaluating energy intake (EI) : BMR at the individual level based on the Goldberg equations, as revised by Black (2000), were used to identify children most likely to be mis-reporting. Black (2000: table 8) provides 95% confidence limits for EI : BMR based on dietary recording period and a physical activity level (PAL) of 1.75 as appropriate for teenagers. Children with EI : BMR values in the range 1.16–2.65 were regarded as having more reliable records, although validity cannot be guaranteed.All statistical analyses were carried out using SPSS, version 17 (SPSS Inc., Chicago, IL, USA). Distributions of dietary and anthropometric variables were assessed for normality by Kolmogorov–Smirnov tests and also by visual inspection. For normally-distributed variables, differences between groups were evaluated using *t*-tests, adjusted for equal or unequal variances based on the Levene test. For non-normally distributed variables (foods and most nutrients), nonparametric methods were used (Mann–Whitney *U*-test). A chi-square test was used to compare the difference in prevalence of obesity between surveys. $P < 0.05$ (two-tailed) was considered statistically significant.

Results

Trends in diet

Total sample

Energy intakes (kJ day^{-1}) were approximately 7% lower in 1997 than in 1983 (Table 1). This was mainly attributable to a lower fat intake, both in absolute terms (−11 g day^{-1}) and as a percentage of energy (35.2% versus 37.8%). Carbohydrate and sugars accounted for a greater proportion of energy in 1997 (51.6% versus 50% and 22.7% versus 22.0%), although absolute intake of carbohydrate was lower by 10 g day^{-1} and total sugar did not change significantly (2 g day^{-1} lower in 1997). Similarly, the percentage of energy derived from protein was higher in 1997 (13.2% versus 12.1%) as a consequence of the lower energy intake (absolute protein intake was similar between surveys).

Influence of under-reporting and over-reporting

The proportion of under-reporters was estimated at 14.3% in the DH survey (1983) and 27.6% in the NDNS (1997). Over-reporting was rare (0.2% in 1983, none in 1997) (data not shown). Under-reporting was more common among the older group (40% of 14–15 year olds versus 17% of 10–11 year olds in 1997; 25% versus 8% in 1983). After excluding LHER, the estimated difference in energy intake between surveys was approximately 3% (Table 1). Mean EI : BMR among the remainder (presumed more reliable reporters) was 1.5, compared to 1.6 in 1983; this is within the acceptable range for plausible group intakes (Black, 2000).

Mean total sugar intake in this group was not significantly higher in 1997 compared to 1983 (+5 g day^{-1}, $P = 0.08$) but accounted for 23.6% of energy, compared with 22.3% ($P < 0.0001$). These trends were accompanied by reciprocal trends in fat energy. They were equally evident in both boys and girls (data not shown).

Sugar sources

Sources of sugars showed notable differences between surveys (Fig. 1). In 1983, the main source was table sugar (contributing 21 g day^{-1}). Further sources in 1983 were biscuits, cakes and pastries (mean 16 g day^{-1}), soft drinks (13 g day^{-1}) and milk and cream (12 g day^{-1}). By 1997, soft drinks were the major contributors to total sugars (mean 23 g day^{-1}). Inspection of the distribution data (not shown) revealed that this was attributable to more children consuming soft drinks (86% versus 77%), a higher median consumption (17 versus 10 g day^{-1} sugars from this source) and a longer tail of high consumers (95th percentile = 68 versus 39 g day^{-1}). Over the same period, milk consumption declined (median 8 versus 11 g day^{-1} sugars) and there were more children who did not consume milk at all in the week (13% versus 4%). There was also a reduction in consumption of sugars from biscuits, cakes and pastries (median 11 versus 14 g day^{-1}). Chocolate was more popular in 1997 (consumed by 85% versus 65% in 1983) and sweets less popular (55% versus 72%); this accounted for the shifts in median consumption (chocolate 10 versus 5 g day^{-1}, sweets 3 versus 6 g day^{-1}). There was also a small increase of approximately 3 g day^{-1} in sugar from breakfast cereals. Fruit consumption remained low (median 4–5 g sugars day^{-1}) with more than one in four children consuming no fruit at all in a week. Similarly, fruit juices only made a small contribution to sugars for most children (mean 5 g, median 0 g in 1997), although 5% consumed the equivalent of 200 mL (25 g sugars) per day.

Figures 2 and 3 illustrate the close parallel between the trends found in our study (Fig. 3) and those from 11–12 year olds in Northumberland in 1980 and 2000, redrawn from the data of Rugg-Gunn *et al.* (2007). Both show large falls in the contribution of sugars from table sugar, milk, and preserves, with increases

Table 1 Mean daily intake of energy and macronutrients of (a) 10–15 year olds, (b) 10–11 year olds and (c) 14–15 year olds in 1983 (Department of Health) and 1997 (National Diet and Nutrition Survey), including adjustment for under- and over-reporting (shaded column)

		Total sample				Excluding low and high energy reporters (LHER) (EI : BMR < 1.16 or >2.65)			
All aged 10–15 years		DH 1983	NDNS 1997	Difference*	*P*-value	DH 1983	NDNS 1997	Difference*	*P*-value†
N =		3283	459			2755	331		
Energy (kJ)	Mean	8344	7769	−7%	<0.0001†	8733	8452	−3%	0.001
	Median	8180	7687			8503	8245		
Protein (g)	Mean	59	60	2%	0.11†	61	63	3%	0.002
	Median	58	60			59	62		
Fat (g)	Mean	85	74	−13%	<0.0001†	89	81	−9%	<0.0001
	Median	83	73			87	78		
Carbohydrate (g)	Mean	261	251	−4%	0.002†	274	274	0%	0.950
	Median	255	249			265	266		
Sugars (g)	Mean	115	113	−2%	0.06†	122	127	4%	0.079
	Median	113	109			118	121		
% protein	Mean	12.1	13.2	1.1	<0.0001†	11.9	12.8	0.9	<0.0001
	Median	12.0	13.1			11.8	12.8		
% Fat	Mean	37.8	35.2	−2.6	<0.0001	37.8	35.4	−2.4	<0.0001
	Median	37.8	35.2			37.8	35.4		
% Carbohydrate	Mean	50.0	51.6	1.6	<0.0001	50.1	51.9	1.8	<0.0001
	Median	50.0	51.8			50.2	51.9		
% Sugars	Mean	22.0	22.7	0.7	0.022	22.3	23.6	1.3	<0.0001
	Median	21.9	22.6			22.2	23.8		

		Total sample				Excluding low and high energy reporters (LHER) (EI:BMR < 1.16 or >2.65)			
Age group (10–11 years)		DH 1983	NDNS 1997	Difference*	*P*-value†	DH 1983	NDNS 1997	Difference*	*P*-value†
N =		2057	248			1847	206		
Energy (kJ)	Mean	8029	7541	−6%	0.000	8234	7934	−4%	0.001
	Median	7971	7467			8125	7818		
Protein (g)	Mean	56	57	2%	0.289	57	59	4%	0.018
	Median	56	58			57	60		
Fat (g)	Mean	82	72	−12%	<0.0001	84	76	−10%	<0.0001
	Median	81	70			82	73		
Carbohydrate (g)	Mean	252	245	−3%	0.037	259	258	0%	0.768
	Median	249	246			254	254		
Sugars (g)	Mean	117	113	−3%	0.159	120	122	2%	0.598
	Median	115	111			117	117		
% Protein	Mean	12	13	1.0	<0.0001	11.9	12.7	0.8	<0.0001
	Median	11.9	13			11.8	12.8		
% Fat	Mean	37.7	35.2	−2.5	<0.0001	37.7	35.4	−2.3	<0.0001
	Median	37.7	35.1			37.8	35.3		
% Carbohydrate	Mean	50.2	51.9	1.7	<0.0001	50.3	52	1.7	<0.0001
	Median	50.2	52.1			50.3	52.1		
% Sugars	Mean	23.1	23.4	0.3	0.353	23.2	24.1	0.9	0.017
	Median	23.0	23.9			23.1	24.5		

Table 1 (Continued)

14–15 years		Total sample DH 1983	NDNS 1997	Difference*	*P*-value	Excluding low and high energy reporters (LHER) (EI:BMR < 1.16 or >2.65) DH 1983	NDNS 1997	Difference*	*P*-value†
N =		1226	211			908	125		
Energy (kJ)	Mean	8874	8038	−9%	0.000	9746	9305	−5%	0.005
	Median								
Protein (g)	Mean	64	63	−2%	0.667	68	70	3%	0.218
	Median								
Fat (g)	Mean	91	77	−15%	<0.0001	100	89	−11%	<0.0001
	Median								
Carbohydrate (g)	Mean	275	258	−6%	0.004	304	301	−1%	0.529
	Median								
Sugars (g)	Mean	113	113	0%	0.972	125	137	10%	0.047
	Median								
% protein	Mean	12.3	13.5	1.2	<0.0001	12	12.9	0.9	<0.0001
	Median								
% Fat	Mean	38	35.3	−2.7	<0.0001	38.1	35.4	−2.7	<0.0001
	Median								
% Carbohydrate	Mean	49.5	51.2	1.7	<0.0001	49.8	51.7	1.9	<0.0001
	Median								
% Sugars	Mean	20.2	21.8	1.6	<0.0001	20.5	22.9	2.4	<0.0001
	Median								

*Difference: for percentage energy from macronutrients, values represent absolute difference in percentage units.
†Mann–Whitney *U*-test for non-normally distributed variables.
DH, Department of Health; LHER, low/high energy reporting; NDNS, National Diet and Nutrition Survey.

from breakfast cereals and particularly soft drinks (although in the Northumberland study this included fruit juice). Total sugar intakes in the Northumberland study fell from 117 g day^{-1} in 1980 to 108 g day^{-1} in 2000 (22% energy in both periods), which compares closely with our calculations of 116 g day^{-1} in 1983 and 113 g day^{-1} in 1997 among 10–11 year olds (23% of energy).

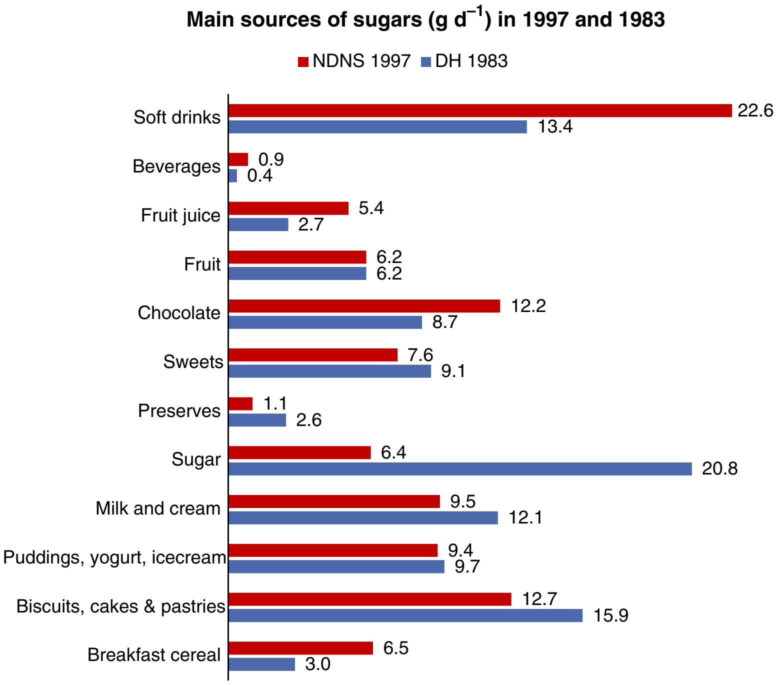

Figure 1 Main sources of sugars in 1997 (National Diet and Nutrition Survey; NDNS) versus 1983 (Department of Health; DH) (mean contribution g day^{-1}, total sample). All differences are significant at $P < 0.05$ except fruit and puddings/yogurt/icecream.

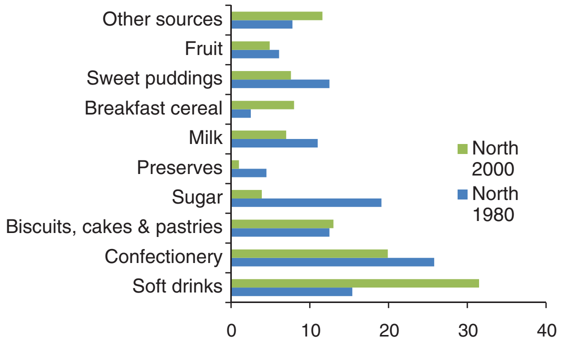

Figure 2 Sources of sugars in the diet of 11–12 year olds in Northumberland 1980–2000 (redrawn from Rugg-Gunn *et al.*, 2007) (mean g day^{-1}) (note that 'soft drinks' includes fruit juice).

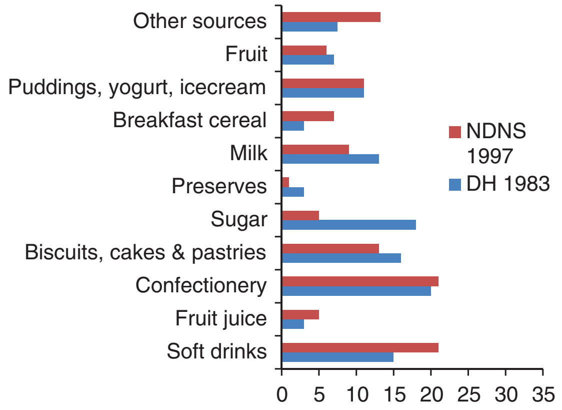

Figure 3 Sources of sugars in the diet of 10–11 year olds in Britain 1983–1997 (mean g day^{-1}); current study based on Department of Health (DH) (1983) and National Diet and Nutrition Survey (NDNS) (1997).

Anthropometric trends

Mean body weight increased significantly ($P < 0.0001$) between the two National surveys (by 1.9 kg among 10–11 year olds and 3.4 kg among 14–15 year olds; Table 2). Children were of similar height (the net increase of 1 cm was not significant); hence, BMI also increased by approximately 0.7 units (from 17.9 to 18.6 kg m^{-2}) in the younger group and by 1.1 units (from 20.2 to 21.3 units) in the older group; $P < 0.001$. In the DH survey, the 10–11 year olds were slightly older (mean 11.1 years, compared to 10.9 years in the NDNS sample), and so these differences are very slightly underestimated.

Expressed as *z*-scores (SDs) of BMI, the secular trend was similar across age groups (mean BMI *z*-score +0.08 in 1983, rising to +0.41 in 1997). The prevalence of being overweight (including obese) in 1983 was 13% according to International Obesity Taskforce (IOTF) criteria. By 1997, this was 21–22%. Few children were frankly obese (equivalent to BMI of 30 at age 18 years), although the prevalence had increased from 3.1% to 4.8% among 10–11 year olds and from 1.9% to 4.3% among 14–15 year olds. All these differences were significant at $P < 0.001$ (Table 2).

Table 2. Anthropometric measurements from the two surveys (Department of Health in 1983 and National Diet and Nutrition Survey in 1997)

		10–11 years			14–15 years		
		DH 1983	NDNS 1997	*P*-value	DH 1983	NDNS 1997	*P*-value
Age	Valid *n*	2016	248	0.001	1218	209	0.5
	Mean	11.1	10.9		14.9	15.0	
	SD	0.3	0.6		0.3	0.6	
Height (cm)	Mean	143	144	0.121	164	165	0.142
	SD	7	8		8	8	
Weight (kg)	Mean	36.6	38.5	<0.0001	54.4	57.8	<0.0001
	SD	7.7	8.6		9.5	12.1	
EI : BMR	Mean	1.55	1.43	<0.0001	1.39	1.23	<0.0001
	SD	0.29	0.27		0.35	0.30	
BMR (MJ)	Mean	5.21	5.32	0.013	6.38	6.56	0.010
	SD	0.56	0.63		0.79	0.96	
BMI (kg m^{-2})	Mean	17.9	18.6	0.001	20.2	21.3	<0.0001
	SD	3.1	3.2		3.0	3.5	
BMI *z*-score	Mean	0.08	0.41	<0.0001	0.08	0.41	<0.0001
SD	1.06	1.07	1.03		1.12		
% Overweight (IOTF)		13.3%	21.4%	0.001	12.7%	22.0%	0.0001
% Obese (IOTF)		3.1%	4.8%		1.9%	4.3%	

BMI, body mass index; BMR, basal metabolic rate; DHSS, Department of Health and Social Security; EI, energy intake; IOTF, International Obesity Taskforce; NDNS, National Diet and Nutrition Survey.

Discussion

The observed difference in energy intake between surveys, conservatively estimated at 3%, may be suggestive of a decline in physical activity, residual under-reporting, less over-reporting, or a combination of these. Given that BMR increased by approximately 3% between surveys as a result of higher body weights, mean energy intake relative to basal requirements was estimated to be even lower (6%), supporting the hypothesis of a reduction in physical activity. However, direct evidence is lacking, although there is indirect evidence for the increasing sedentary nature of adults' and children's lifestyles (Prentice & Jebb, 1995; Maffeis, 2000).

One of the more enduring criticisms levelled at dietary surveys concerns the reliability of food intake records. Attempts to correct for mis-reporting will only ever be partially successful in the absence of measures of energy expenditure such as double-labelled water or weight change and physical activity. Arbitrary EI : BMR cut-offs are acknowledged to have poor sensitivity for identifying individuals who under-report (Livingstone *et al.*, 2003) but may be a useful means of establishing uncertainty limits around estimates (Poslusna *et al.*, 2009). The cut-offs used in the present study (1.16 < EI : BMR < 2.65) are based on a PAL of 1.75, which is higher than the normal sedentary level of 1.55, but at a level commensurate with activity levels recorded in teens (Black, 2000). Similar studies have tended to use a cut-off for under-reporting of 1.1 (Fletcher *et al.*, 2004) or 1.2, sometimes in conjunction with other criteria (Gibson & Neate, 2007). Others have used a Goldberg cut-off of 1 to represent the limit of plausible habitual intake (EI : BMR 1.35) (Mendez *et al.*, 2004) although there are suggestions that this should be abandoned because it ignores measurement error and day to day variation (Black, 2000).

The findings obtained in the present study are broadly consistent with the Northumberland studies in which energy intakes were estimated to have remained static (Fletcher *et al.*, 2004). Studies using other data collection methods further suggest that energy intakes have been declining slowly ever since the 1960s (Durnin *et al.*, 1974; Whitehead *et al.*, 1982), whereas steady declines in energy intake have been recorded in family food purchase data from approximately 1964 (DEFRA, 2006). The paradox of rising BMI despite a 2–3% increase in BMR and an energy intake that is static or falling suggests that declining energy expenditure must have played a role. Rennie *et al.* (2005) examined secular trends in under-reporting in these same two studies, estimating energy requirements from published equations. They concluded that average energy needs were under-reported by approximately 20% in the NDNS (Rennie *et al.*, 2005) and similar values have been found in other studies (Rennie *et al.*, 2007). Rennie *et al.* concluded 'the data may in all probability be explained by a combination of an increase in under-reporting and a decrease in physical activity' (Rennie *et al.*, 2005). Thus, although caution is required in asserting definitively that energy intakes have declined in the UK over the past 25 years because of the residual problems of under-reporting, evidence from a variety of sources and methods gives confidence that true energy intake is unlikely to have increased.

International comparisons show large differences in sugar intake between countries, partly because of differing definitions, methodologies and age groups used in analysis (Gibney *et al.*, 1995). In a review of dietary intakes among children across the European States, Lambert *et al.* (2004) found that intakes of total sugars (as a percentage of energy) tended to fall with increasing age and were lower in Southern Europe. Mean values ranged from 12% (Spain) to 29% (Netherlands) (Lambert *et al.*, 2004). High values have also been reported from contemporaneous data on children in the USA (28%) (Nicklas 1999). The total sugar intakes reported in the present study (22–24%) are similar to those obtanied for Northumberland schoolchildren aged 11–12 years as assessed in 1980, 1990 and 2000 (22%) (Rugg-Gunn *et al.*, 2007) and among 12-year-olds from Northern Ireland studied in 1991 (20–21%) (Strain *et al.*, 1994). More recently, the Low Income Diet and Nutrition Survey in 2006 reported a total sugar intake averaging 22% among 11–18 year olds (Nelson *et al.*, 2006), whereas a recent survey from Scotland estimated total sugars at 28–29% of energy (Sheehy *et al.*, 2008), partly as a result of a higher than expected consumption of fruit.

Few studies appear to have examined secular trends in sugar intake with which our results can be compared. However, it is noteworthy that the Northumberland study judged intakes of both total sugars and NMES to have remained stable over 20 years at approximately 22% of energy and 16–17% of energy, respectively (Fletcher *et al.*, 2004; Rugg-Gunn *et al.*, 2007). In the present study, the mean intake of NMES is approximately estimated at 89 g (17% energy) in 1983 and 87 g (17.6% energy) in 1997, based on the contribution of major food groups in Fig. 1. These values most likely represent slight overestimates as a result of the presence of small amounts of intrinsic and milk sugars in some products. Recent data from the UK Low Income Diet and Nutrition Survey in 2006 reported NMES intakes of approximately 17% with little variation by age, whereas a survey of sugar intakes among children in Scotland in 2008, estimated NMES intakes of 17% among 8–11 year olds and 19% among 12–17 year olds (Sheehy *et al.*, 2008). Taken together, these studies suggest little change in proportion of NMES over more than

25 years. The counterbalancing trends for increasing soft drinks and decreasing table sugar may explain much of this stability. Similarly, in the DONALD study, conducted in Dortmund, Germany, Alexy *et al.* (2002) found no significant difference in the percentage energy from added sugars among children between 1985 and 2000 (Alexy *et al.*, 2002). Finally, UK Household food consumption data indicate that NMES intakes were static at approximately 15.5% of energy between 1994 and 2000 (where 1994 is the first year in which meals out, soft drinks, confectionery, alcohol and eating out were included) and have declined slightly subsequently (Department of the Environment Food and Rural Affairs 2006).

Intakes and recommendations for macronutrients are normally given in terms of percentage energy to aid comparison across differing ages and energy requirements. However, relative expressions of macronutrient intake can be misleading if not considered in conjunction with absolute values. First, it is self-evident that where the amount of energy (denominator) is reduced, the percentage energy from sugar increases by default, even if the absolute amount has not changed. Second, the percentage of energy from fat is often reciprocally related to the percentage energy from sugar (the sugar : fat see-saw) in observational studies (Gibney *et al.*, 1995) and interventions (Drummond & Kirk, 1999; Dwyer *et al.*, 2003). In the present study, the statistical effect is illustrated among 14–15 year olds, where the change in sugar intake from 20.2% to 21.8% is mainly attributable to the fall in fat intake, with sugar intake being 113 g day^{-1} in both surveys.

This effect aside, there is some evidence from the present study that sugars energy among older children with more reliable records was higher in 1997 than in 1983. However, it is arguable that the exclusion of large numbers of low energy reporters (who tended to report low intakes of sugars) may create its own bias by elevating estimates of intake. Lower recorded sugar intakes among the excluded sample could also represent genuine avoidance/undereating. There is no clear consensus as to whether or not under-reporting is macronutrient-specific or food-specific but further exploration of macronutrient composition according to EI : BMR ratio may be warranted in these data.

Data from the Health Survey for England (HSE) attest to a rise in the prevalence of being overweight and obesity among both adults and children over the past 20–30 years (Department of Health, 2007). Similar trends have also been reported among 12–15 year olds in Northern Ireland (Watkins *et al.*, 2005) and Scotland (Chinn & Rona, 2001). However, the use of different cut-offs makes it difficult to compare prevalence statistics between sources, both nationally and internationally (Flegal *et al.*, 2006). The HSE defines 'overweight' in children as a BMI greater than the 85th percentile (in the 1990 British Growth charts) and 'obesity' as a BMI greater than the 95th percentile, whereas the IOTF cut-offs are higher, approximately corresponding to the 91st and 98th percentiles for being overweight and obesity, respectively (Cole *et al.*, 2000).

This study found a substantial increase in mean body weight, body mass index and BMI *z*-score between the DH and NDNS surveys in 1983 and 1997, and a corresponding rise in the prevalence of being overweight in all groups. Overall, the data suggest that there has been a general upward shift of the distribution of relative weight, with BMI increasing by approximately 0.7 units (kg m^{-2}) in younger children and 1 unit among older children between 1983 and 1997, with mean BMI *z*-score increasing in each age group from 0.08 to 0.41 (SD units). According to these calculations, the prevalence of being overweight (plus obesity), as defined by IOTF cut-offs (91st percentile), rose from 13% to 21–22% between surveys. More recent data from the HSE shows that obesity increased among 11–15 year olds between 1995 and 2004 but may now be flattening out or even decreasing (National Health Service, 2010).

The cross-sectional design of both studies precludes interpretations of cause and effect. Changes in the sugar content of specific foods (such as nondiet cola) are not represented in the estimates, although most items have a standard composition within their sub-type. Moreover, food choice trends, such as more children choosing diet varieties of soft drink or increased consumption of presweetened cereal, are captured at the level of food codes. We are unaware of any changes in formulation within major brands of soft drinks, confectionery or baked goods that would affect sugar content significantly. Furthermore, compositional data for carbohydrate content (g 100 g^{-1}) of the 973 foods in the DH survey were very closely correlated with the matched COFids foods ($r = 0.991$). Overall, it is more likely that changes in formulation are downwards, thus underestimating sugar content in 1983 and suggesting a rise in sugar intake where none exists.

Conclusions

Analysis of data from these two surveys of British children suggests that energy intakes have not increased and may have decreased slightly between 1983 and 1997. Over the same period, BMI increased on average by 0.7–1 unit (kg m^{-2}), equivalent to 2–3 kg in 14 years. Among older children in particular, there was an increase in total sugar intake (g day^{-1} and %) once LHER were excluded. A shift in the sources of dietary sugars was observed, notably a rise in soft drinks, fruit juice and cereals, counteracted by a large decline in table sugar and smaller falls in milk and in biscuits, cakes and pastries.

Given the cross-sectional nature of these data, the findings obtained in the present study cannot directly assess dietary change, nor draw conclusions relating to the aetiology of obesity or the role of sugars or soft drinks. Nevertheless, it would appear unlikely that the rise in BMI, which is genuine, can be attributed to increased consumption of sugars in any form, given the context of static or declining energy intake in relation to increasing basal energy requirements. This epidemiological perspective does not deny that, at an individual level, the consumption of excess calories should be avoided by those who are already overweight or at risk of becoming overweight.

Accurate assessment of normal food intake remains an ongoing problem for nutrition science, but less intrusive dietary methods coupled with the use of appropriate biomarkers should help to ensure that future estimates of energy and nutrient intake are less distorted by under-reporting. New results from the rolling programme NDNS will be able further to explore associations of diet and activity with obesity. However, the best evidence will only come from prospective studies and long-term interventions that can capture individual differences in response to diet and lifestyle changes over time.

Conflict of interests, source of funding and authorship

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The author is an independent consultant working for a variety of organisations and government agencies. Methods, analysis, interpretation and the writing of this paper were all undertaken by SG.

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Appendix

Food groups used in analysis	Definition
Table sugar	Sugar added at the table (to food and drinks)
Biscuits, cakes and pastries	All types
Soft drinks	All types other than 100% fruit juice
Milk and cream	All types
Puddings, yogurt, ice-cream	Includes hot puddings
Chocolate	Chocolate confectionery
Sweets	Sugars confectionery, chewing gum, etc.
Fruit	All fruit, fresh, canned, frozen, dried
Bread	All types of bread
Breakfast cereal	Ready to eat cereal and porridge
Fruit juice	100% fruit juice (fruit drinks are classified as soft drinks)
Preserves	Jams, syrups, honey, chocolate spread, etc.
Vegetables	All vegetables, fresh, canned, frozen, dried
Potatoes	All types
Meat and meat products	Including composite dishes containing meat
Fish	Including fish pie, etc.
Cheese	Soft and hard
Eggs	Including egg dishes (quiche, etc.)
Fat spreads	Butter, margarine, spreads
Pasta, rice, pizza	All types
Sauces	Savoury sauces
Soup	All types
Alcoholic drinks	All types
Beverages	Tea, coffee, hot chocolate, etc.

