ORIGINAL ARTICLE

Associations between weight status, physical activity, and consumption of biscuits, cakes and confectionery among young people in Britain

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Summary

This study explored the associations between weight status, physical activity and diet among young people in Britain, with special reference to consumption of biscuits, cakes and confectionery (BCC) and the impact of under-reporting and dieting. The sample consisted of 1294 children aged 7–18 years (655 boys and 639 girls) who had completed all three relevant aspects of the National Diet and Nutrition Survey of Young People (*i.e.* 7-day physical activity diary, 7-day dietary record and weight/height measurement) (Gregory & Lowe 2000). Age-adjusted body mass index (BMI) was positively associated with sedentary activity and inversely associated with moderate or vigorous activity among boys. Among girls, associations between BMI and activity were weaker. After adjustment for age, gender, under-reporting and dieting, predictors of overweight in the logistic regression model included components of energy intakes, and energy expenditure. Each extra megajoule (MJ) of energy from BCC increased the odds of overweight by 24% (OR 1.24, 95% confidence interval 1.02–1.52) while energy from other foods (per MJ) increased the odds by 76% (OR 1.76, 95% confidence interval 1.55–2.0). In the same model, each hour in moderate/vigorous activity reduced the odds by 26% (OR 0.74, 95% confidence interval 0.61–0.90); while each hour watching television, playing computer games or listening to music increased it by 10% (OR 1.10, 95% confidence interval 1.0–1.21). Thus overweight young people were no more likely to over consume sweet foods (biscuits cakes and confectionery) than other sources of energy. We conclude that the problem of overweight needs to be seen in its multidimensional context, involving activity and inactivity, energy intake and food habits. Intervention studies are needed to establish cause and effect relationships, but good observational studies adjusted for confounders, can add to the evidence base.

Keywords: activity, children, confectionery, diet, overweight, sugar

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Introduction

Several studies now attest to a rising prevalence of obesity and overweight among children in Britain (Reilly & Dorosty 1999; Bundred *et al.* 2001; Chinn & Rona 2001; McCarthy *et al.* 2003; Rudolf *et al.* 2004). Childhood obesity tends to track into adulthood, with attendant risks of higher morbidity and mortality (Must *et al.* 1992; Srinivasan *et al.* 1996 Power *et al.* 1997; Dietz 1998; Freedman *et al.* 2001).

Although the causes of obesity are complex, it is self-evident that weight gain arises from an excess of energy intake over energy expenditure (Blundell & MacDiarmid 1997). The increase in prevalence of obesity may owe more to a decline in physical activity than to dietary habits, since energy intake has been stable or declining over the past 20 years (although the contribution of under-reporting remains unclear) (Prentice & Jebb 1995; Riddoch & Boreham 1995; Molnar & Livingstone 2000). On the other hand, it is now fairly well established that 'passive over consumption' can occur where diets are high in fat, or energy-dense (Poppitt & Prentice 1996). High sugar foods such as biscuits, cakes and confectionery (BCC) are seen as energy-dense and conducive to obesity (WHO/FAO 2003), although most epidemiological evidence has found either an inverse or null association between intake of dietary sugars and body mass index (BMI) (Bolton-Smith & Woodward 1994; Anderson 1995; Hill & Prentice 1995; Gibson 1996a; Astrup *et al.* 2000; Saris *et al.* 2000; Saris 2003; Overby *et al.* 2004). The aim of this study was to explore the relationships between obesity, physical activity, and consumption of BCC in the *National Dietary and Nutrition Survey of Young People aged 4–18 years* (Gregory & Lowe 2000).

Methods

National Diet and Nutrition Survey Database

The National Diet and Nutrition Survey of young people was carried out in 1997 (Gregory & Lowe 2000)

The database for this Survey was obtained from the University of Essex Data Archive. Subjects included in the present analyses were those children who had completed all three relevant aspects of the study (7-day physical activity diary, 7-day dietary record and weight/height measurement or BMI). No physical activity diaries were available for children under the age of 7 years. This yielded a sample of 1294 children aged 7–18 years (655 boys and 639 girls).

Data analysis

The energy contribution of BCC and percentage energy from BCC was calculated from the data on food groups and total energy intake (Fig. 1). BCC included biscuits, buns, cakes, pastries, fruit pies, sugar confectionery and chocolate confectionery.

Because BMI varies with age, and adult BMI cut-offs are not appropriate for children, we calculated standardised BMI scores, or z-scores (*i.e.* the degree to which each child deviated from their age and sex-specific median) using equations based on UK reference curves (CGF 1990). To examine trends across the range from underweight to obese, children were classified into quintiles of standardised BMI score (Table 1). To investigate the impact of under-reporting and dieting, we classified young people who reported being on a slimming diet, or with an energy intake of less than 1.2 times basal metabolic rate (EI : BMR < 1.2) as (potential) under-reporters (Goldberg *et al.* 1991).

Differences between quintiles were assessed using one-way Analysis of Variance (ANOVA), with Bonferroni

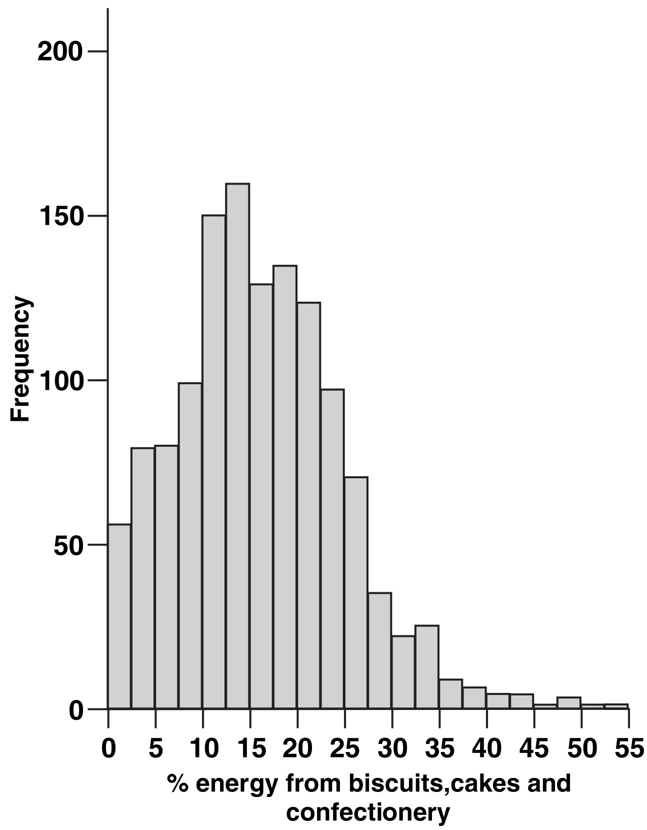

Figure 1 Histogram of consumption of biscuits, cakes and confectionery (as a percentage of energy) in the sample. Mean = 16.067, SD = 8.6829, *n* = 1294.

Table 1 Anthropometry and energy intakes by quintile of age-adjusted body mass index (BMI)

	Quintiles of age-adjusted BMI				
	1	2	3	4	5
Boys					
BMI z-score (cut-off)	<–0.54	<0.05	<0.59	<1.29	>1.29
BMI centile (mean & range)	16 (0–29)	41 (29–52)	63 (52–72)	81 (72–90)	96 (>90)
BMI (mean)	16.0	17.3	18.3	20.1	24.7
Energy MJ/day	8.0	7.9	8.4	8.5	8.9
EI : BMR ratio	1.47	1.40	1.47	1.36	1.23
% with EI : BMR < 1.2	19	19	14	27	50
% dieting	0	0	1	2	12
% underreporting or dieting	21	26	18	31	51
Girls					
BMI z-score (cut-off)	<–0.54	<0.09	<0.68	<1.30	>1.30
BMI centile (mean & range)	15 (0–29)	42 (29–54)	65 (54–75)	84 (75–90)	96 (> 90)
BMI (mean)	16.2	18.2	19.5	21.6	25.2
Energy MJ/day	6.7	6.8	7.0	7.1	6.8
EI : BMR ratio	1.38	1.32	1.31	1.28	1.17
% with EI : BMR < 1.2	28	36	34	43	53
% dieting	2	3	7	12	16
% underreporting or dieting	29	38	34	43	55

EI, energy intake; BMR, basal metabolic rate.

contrasts, or by nonparametric ANOVA (Kruskal–Wallis test) in the case of physical activity data.

Stepwise logistic regression was used to identify the predictors of overweight using cut-offs corresponding to the adult criteria of BMI > 25 kg/m^2 (Cole *et al*. 2000). Approximately 19% of boys ($n = 128$) and 22% of girls ($n = 149$) were 'overweight' by these criteria (z-scores > 1.3 for boys and 1.19 for girls).

Results

Consumption of biscuits, cakes and confectionery

On average, BCC contributed 16% of total energy intake (Fig. 1) with a median intake of 15.5% (interquartile range = 10–22%; 95th percentile = 31%). Only 2% ate no BCC at all during the survey week. Consumption was similar among boys and girls.

Energy intakes, dieting and under-reporting by quintile of BMI

Table 1 shows the cut-offs for classification by age-standardised BMI and the prevalence of dieting and (suspected) under-reporting in each quintile. Among overweight young people (in the fifth quintile, Q5), half recorded low energy intakes or were on a diet, but under-reporting occurred even among normal and underweight young people. There were no differences in social class, employment, income, household composition, receipt of benefits, or region between the age-adjusted BMI quintiles (data not shown).

Associations between physical activity and weight status

Boys with high BMI (Q5) spent more time in very light intensity (sedentary) activities than boys in quintile 1 (Q1) ($P = 0.001$ for linear trend) (Table 2). Types of activities are defined in Table 3. Approximately half of this sedentary time was spent watching TV, playing computer games or listening to music. Furthermore, boys in Q5 spent less time engaged in sports and exercise (P for linear trend = 0.004). However, these signs of reduced physical activity were offset by less time spent in bed, with the result that the overall calculated activity score (CAS) did not differ between BMI quintiles. For girls the trends were weaker and did not reach the 5% levels of statistical significance. However, 34% of overweight girls (Q5) took less than the recommended 30 min of moderate intensity activity, compared with 23% of girls in Q1 to Q4 ($P = 0.009$, data not shown).

Associations between BCC and weight status

Energy intake from BCC and all other sources (MJ/day) was compared across quintiles of age-adjusted BMI, firstly on the total sample (Table 4) and secondly after excluding under-reporters and dieters (Table 5). In the

Table 2 Mean time spent in physical activity of various intensities, according to body weight status

Minutes per day in various activities		Quintiles of age-adjusted BMI 1	2	3	4	5	ANOVA P-value (linear trend)
Boys							
	n =	131	131	131	131	131	
In bed	Mean	600	604	600	590	580	0.002
Very light intensity activity	Mean	303	315	329	330	352	0.001
Of which: watching TV/playing computer games/listening to music	Mean	149	164	161	173	178	0.005
Light intensity activity	Mean	448	429	412	434	422	ns
Moderate or vigorous intensity activity	Mean	87	92	91	78	77	0.030
Of which sports and exercise	Mean	52	60	49	41	42	0.0004
calculated activity score	Mean	43	43	43	43	43	ns
Girls							
	n =	127	128	128	128	128	
In bed	Mean	597	591	591	589	587	ns
Very light intensity activity	Mean	327	305	325	294	321	ns
Of which: watching TV/playing computer games/listening to music	Mean	149	153	155	143	170	ns
Light intensity activity	Mean	455	476	459	490	474	ns
Moderate or vigorous intensity activity	Mean	60	63	62	58	54	ns
Of which sports and exercise	Mean	22	26	24	22	21	ns
calculated activity score	Mean	42	43	42	43	42	ns

BMI, body mass index.

Table 3 Key to types of activity

Very light	Watching TV, computer activities, board games, playing with toys, reading, homework, talking, listening to/playing music, drawing
Light	Light household chores, caring for pets, shopping, strolling, going to youth club, table tennis, snooker, horse-riding, dancing
Moderate	Football, cycling, ball games, gymnastics, swimming, walking briskly, hoovering, gardening
Vigorous	Jogging, basketball, rugby, disco-dancing
Very vigorous	Running, athletics

total sample, energy intake increased with increasing BMI among boys but this was essentially from foods other than BCC (% energy from BCC fell; $P < 0.0001$). Among girls, the association appeared curvilinear; energy from BCC (either as MJ or percentage) was highest in Q3 (Table 4).

After excluding low energy reporters and dieters (193 boys and 253 girls), the associations with total energy intake strengthened but there was no evidence of a positive association between BMI and amount of BCC in the diet (Table 5, Fig. 2a). Instead, most of the additional energy intake came from other (*i.e.* non-BCC) foods (Fig. 2b).

Models predicting overweight

We used logistic regression to explore the predictive impact of diet and activity variables on overweight, with and without adjustment for major confounders (Table 6). Physical activity variables were uncorrelated with diet. After adjustment for age, gender, under-reporting and dieting, the inverse association with BCC (per MJ) (OR 0.81, 95% CI 0.68–0.97, $P = 0.02$) became weakly positive (OR 1.24, 95% CI 1.02–1.52, $P = 0.034$). However, each MJ of energy from other (non-BCC) foods had greater significance. In the final adjusted model, significant predictors of overweight were: (1) energy (MJ) from non-BCC (OR 1.76, 95% CI 1.55–2.0, $P < 0.0001$); (2) hours in moderate/vigorous activity (OR 0.74, 95% CI 0.61–0.9, $P = 0.003$); (3) energy (MJ) from BCC (OR 1.24, 95% CI 1.02–1.52, $P = 0.034$); and (4) hours watching television (OR 1.1, 95% CI 1.0–1.2, $P = 0.06$). Overall, this model accounted for 20% of the variance and had sensitivity of 61% and specificity of 69%.

Table 4 Energy intake from BCC and other foods, according to quintile of BMI (all children)

		Age-adjusted BMI (quintiles)					
		1	2	3	4	5	ANOVA
Boys							
	n =	131	131	131	131	131	*P*-value
Energy from BCC (MJ)	Mean	1.5	1.3	1.5	1.3	1.4	0.32 (*ns*)
	SD	0.9	0.9	0.8	0.8	1.0	
	Median	1.5	1.2	1.4	1.2	1.2	
Energy from non-BCC (MJ)	Mean	6.5	6.6	6.9	7.3[1,2]	**7.5**[1,2]	<0.0001
	SD	1.8	1.8	1.6	1.7	2.1	
	Median	6.2	6.4	6.9	7.0	7.3	
Total Energy (MJ)	Mean	8.0	7.9	8.4	8.5	**8.9**[1,2]	<0.0001
	SD	2.0	2.0	1.8	1.9	2.7	
	Median	7.7	7.7	8.4	8.4	8.3	
% Energy from BCC	Mean	**18.2**[4,5]	16.6	17.9[4,5]	14.6	14.6	<0.0001
	SD	10.0	9.2	8.7	7.9	7.8	
Median	18.5	16.3	17.4	14.8	14.1		
Girls							
	n =	127	128	128	128	128	*P*-value
Energy from BCC (MJ)	Mean	1.1	1.2	**1.3**[5]	1.1	1.0	0.001*
	SD	0.7	0.7	0.8	0.6	0.7	
	Median	1.0	1.1	1.2	1.1	0.9	
Energy from non-BCC (MJ)	Mean	5.7	5.7	5.7	6.0	5.8	0.041
	SD	1.2	1.3	1.3	1.3	1.3	
	Median	5.6	5.6	5.7	5.9	5.9	
Total Energy (MJ)	Mean	6.7	6.8	7.0	7.1	6.8	0.23 (*ns*)
	SD	1.4	1.4	1.5	1.6	1.6	
	Median	6.6	6.8	7.0	7.0	6.8	
% Energy from BCC	Mean	15.4	16.9[5]	**17.5**[5]	15.2	13.8	0.001*
	SD	8.7	8.8	9.1	7.1	8.2	
	Median	13.9	16.1	17.7	14.7	13.1	

BCC, biscuits, cakes and confectionery; BMI, body mass index.
Superscripts indicate contrasts between quintiles that are significant at $P < 0.05$. Highest values in bold.
*P for quadratic term, others are for linear association (weighted).

Discussion

Obesity in childhood and adolescence is emerging as an important public health issue, because it is a predictor of adult obesity (Srinivasan *et al*. 1996), which in turn has deleterious health, social and economic consequences (Dietz 1998). Our analyses were conducted using the latest consensus on the definition of overweight in children (Bellizzi & Dietz 1999; Dietz & Bellizzi 1999; Cole *et al*. 2000; Jebb & Prentice 2001), using BMI z-scores standardised for age and sex.

There was some evidence that overweight children were less physically active than their normal weight peers, although this was less evident among girls. Overweight boys tended to be more *inactive* than their normal weight counterparts, spending more time watching TV, playing computer games or listening to music. This accords with evidence from other studies (Dietz 1993; Berkey *et al*. 2000; Crespo *et al*. 2001; Grund *et al*. 2001). They also spent less time participating in various types of sport or play.

The finding that overweight boys took less sleep is corroborated by a large French case-control study of 327 overweight and 704 normal weight 5 years olds, in which short sleep duration was significantly associated with obesity, even after correcting for parental obesity and TV viewing (Locard *et al*. 1992). Recently, another study has reported an inverse association between obesity and sleep duration among adults (Vioque *et al*. 2000). The counterbalancing effects of activity and sleep time may explain why the calculated activity score did not differ according to BMI. However, the calculation of the score involves an assumption that any time unaccounted for was spent in *light* intensity activity (Gregory

Table 5 Energy intake from BCC and other foods, according to quintile of BMI (excluding low energy reporters and dieters)

		Age-adjusted BMI (quintiles)					
		1	2	3	4	5	ANOVA
Boys							
	n	106	106	112	94	61	
Energy from BCC (MJ)	Mean	1.6	1.5	1.6	1.5	1.8	0.35
	SD	0.9	0.9	0.8	0.7	1.2	
	Median	1.6	1.4	1.5	1.5	1.5	
Energy from non-BCC (MJ)	Mean	6.7(5)	6.9(5)	7.1(5)	7.6(5)	**8.5**	<0.0001
	SD	1.8	1.7	1.5	1.7	2.2	
	Median	6.5	6.5	7.1	7.2	8.0	
Total Energy (MJ)	Mean	8.4(5)	8.4(5)	8.7(5)	9.1(5)	**10.3**	<0.0001
	SD	1.9	1.8	1.7	1.8	2.8	
	Median	8.1	8.0	8.6	8.7	9.9	
% Energy from BCC	Mean	**19.7**	17.9	18.3	16.6	17.2	0.023
	SD	9.6	9.2	8.2	7.5	8.1	
	Median	20.3	17.4	17.7	16.3	16.6	
Girls							
	n	91	81	80	68	54	
Energy from BCC (MJ)	Mean	1.3	1.4	1.5	1.3	1.3	0.048*
	SD	0.6	0.6	0.8	0.6	0.7	
	Median	1.2	1.3	1.5	1.3	1.2	
Energy from non-BCC (MJ)	Mean	6.0(4)	6.1(4)	6.1(4)	**6.8**	6.4	0.0001
	SD	1.1	1.1	1.1	1.1	1.0	
	Median	5.9	5.9	5.9	6.6	6.4	
Total Energy (MJ)	Mean	7.3(4)	7.5(4)	7.7	**8.1**	7.8	0.0001
	SD	1.1	1.1	1.2	1.2	1.0	
	Median	7.0	7.6	7.6	7.9	8.0	
% Energy from BCC	Mean	17.7	18.5	19.7	16.4	17.1	0.357
	SD	8.2	8.0	8.8	6.4	8.3	
	Median	16.6	18.4	19.4	16.7	16.1	

BCC, biscuits, cakes and confectionery; BMI, body mass index.
Superscripts indicate contrasts between quintiles that are significant at $P < 0.05$. Highest values in bold.
**P* for quadratic term, others are for linear association (weighted).

Table 6 Predictors of overweight in logistic regression

	Significance (*P*-value)	Odds ratio	95.0% CI	
			Upper	Lower
Unadjusted model				
Energy from other foods (per MJ)	0.0011	1.14	1.05	1.23
Hours of moderate/vigorous activity per day	0.0042	0.78	0.65	0.92
Hours of TV per day	0.0183	1.11	1.02	1.22
Energy from BCC (per MJ)	0.0196	0.81	0.68	0.97
Model adjusted for sex and age				
Energy from other foods (per MJ)	0.0001	1.20	1.09	1.31
Hours of moderate/vigorous activity per day	0.0140	0.80	0.66	0.95
Hours of TV per day	0.0089	1.13	1.03	1.24
Energy from BCC (per MJ)	0.0255	0.81	0.68	0.98
Model adjusted for all major confounders (low energy reporting, dieting, sex and age)				
Energy from other foods (per MJ)	0.0001	1.76	1.55	2.00
Hours of moderate/vigorous activity per day	0.0027	0.74	0.61	0.90
Hours of TV per day	0.0570	1.10	1.00	1.21
Energy from BCC (per MJ)	0.0338	1.24	1.02	1.52

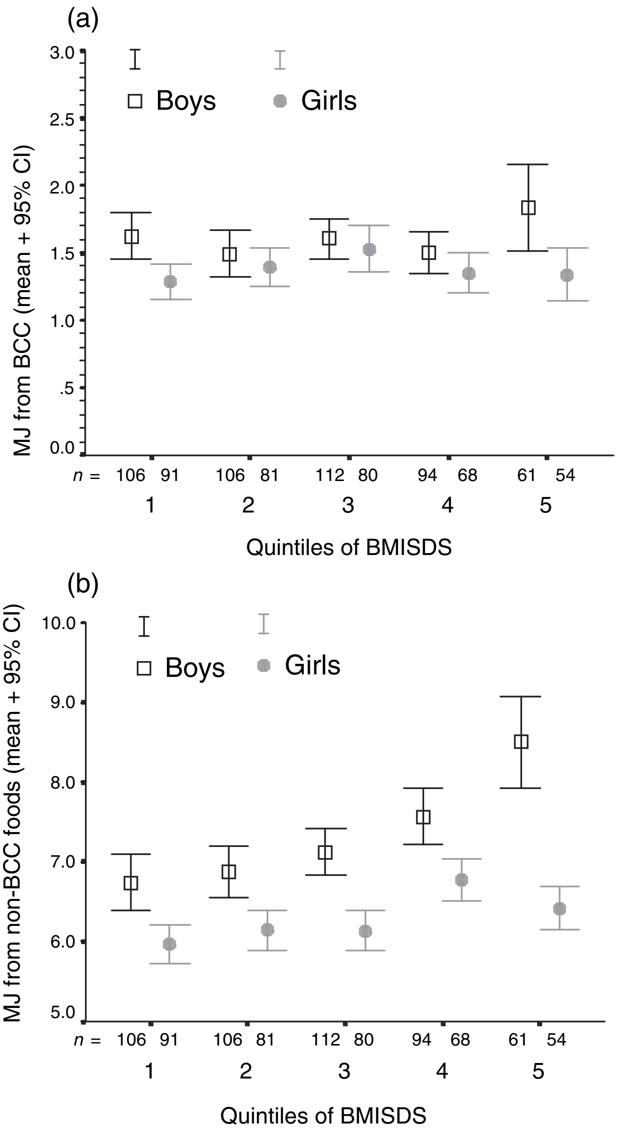

Figure 2 (a) Consumption of biscuits, cakes and confectionery (BCC) (MJ) according to quintile of age-adjusted body mass index (BMI) (excluding dieters and low energy reporters). anova Welch test: Boys $F = 1.3$, $P = 0.29$; Girls $F = 1.3$, $P = 0.26$. (b) Consumption of non-BCC foods (MJ) according to quintile of age-adjusted BMI (excluding dieters and low energy reporters). ANOVA Welch test: Boys $F = 8.8$, $P < 0.0001$, Girls $F = 6.2$, $P < 0.0001$.

& Lowe 2000). This may have overestimated energy expenditure, particularly in overweight children, who spend proportionately more time in *very light* intensity activity. Indices that try to estimate overall physical activity may not be sufficiently sensitive to its multidimensional nature and thus fail to detect subtler differences in activity patterns (Livingstone 2001).

It is generally accepted that foods or diets that are high in fat or energy-dense can lead to weight gain because they are less satiating on an isocaloric (Joule for Joule) basis and hence are easily passively over-consumed (Blundell *et al.* 1993; Blundell & MacDiarmid 1997). Percentage energy from fat has been positively associated with BMI and/or body fatness in several studies (Ortega *et al.* 1995; Gibson 1996a; Macdiarmid *et al.* 1996; Tucker *et al.* 1997; Maffeis 2000; McGloin *et al.* 2002), although some have found no association (Davies 1997). Conversely, high sugar diets and sugary foods tend to be *inversely* associated with overweight (Bolton-Smith & Woodward 1994; Gibson 1996a; Gibson 1996b; New & Grubb 1996; Ortega *et al.* 1996). Since the results of some of these studies may have been confounded by under-reporting (which may affect snacks more than other foods) we decided to pay particular attention to this potential bias in the present study.

Under-reporting and under-eating pose difficulties for the interpretation of all dietary surveys, especially if absolute intakes of foods or nutrients are being compared. There is no clear consensus on how best to identify or correct for under-reporting, but it is necessary to investigate means of adjustment in order to avoid false conclusions. Expressing food intakes as a percentage of energy can help reduce error, while exclusion of under-reporters reduces power significantly. It also does not eliminate the problem, since some under-reporting (and indeed some over-reporting) occurs at all levels of energy intake. We used a variety of methods, before and after excluding under-reporters and finally adjusting for under-reporting in logistic regression while retaining sample size.

In logistic regression models of overweight, the initial inverse association between overweight and BCC (MJ) (OR 0.81, 95% CI 0.68–0.97, $P = 0.02$) became weakly positive (OR 1.24, 95% CI 1.02–1.52, $P = 0.034$) after adjustment for age, gender, under-reporting, dieting and physical activity. According to this model, each additional MJ of energy from BCC (or nearly doubling current intake) was associated with a 24% increase in odds of overweight. This should been seen alongside other sources of energy, each MJ of which was associated with a 76% increase in odds of overweight. Clearly it would be desirable to investigate associations of some of these 'other' food components with weight status, particularly savoury snacks, fast foods and soft drinks. We are currently looking in more depth at dietary patterns in this dataset. Ultimately, however, only intervention studies can establish whether selective avoidance of particular foods produces better or worse weight loss than limiting total energy intake.

Declining levels of physical activity and ready supplies of palatable food have undoubtedly contributed to the rise in obesity in the past 20–30 years. Excess calories in the diet may come from any number of food sources. Further work is required to explore food patterns associated with energy-dense diets, since this (rather than consumption of specific foods) may be the key to excess energy intake. Better methods also need to be found to monitor habitual energy expenditure accurately, because relatively subtle differences in physical activity (like walking to school or playing outdoors instead of indoors) may have an impact over the longer term.

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