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Energy density of the Scottish diet estimated from food purchase data: relationship with socio-economic position and dietary targets

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Abstract

Frequent consumption of energy-dense foods has been strongly implicated in the global increase of obesity. The World Cancer Research Fund suggests a population-level energy density (ED) goal for diets of 523 kJ/100 g (125 kcal/100 g) as desirable for reducing weight gain and related co-morbidities. However, there is limited information about the ED of diets of contemporary populations. The aims of the present study were to (1) estimate the mean ED of the Scottish diet, (2) assess differences in ED over time by socio-economic position, by household (HH) composition and for HH meeting dietary targets for fat and fruit and vegetables, and (3) assess the relationship between ED and the consumption of foods and nutrients, which are indicative of diet quality. ED of the diet was estimated from food (including milk) from UK food purchase survey data. The average ED of the Scottish diet was estimated as 718 kJ/100 g with no change between the survey periods 2001 and 2009. Individuals living in the most deprived areas had a higher mean ED than those living in the least deprived areas (737 *v.* 696 kJ/100 g). Single-parent HH had the highest mean ED (765 kJ/100 g) of all the HH surveyed. The mean ED of HH achieving dietary targets for fat and fruit and vegetables was 576 kJ/100 g compared with 731 kJ/100 g for non-achievers. HH within the lowest quintile of ED were, on average, closest to meeting most dietary guidelines. Food purchase data can be used to monitor the quality of the diet in terms of dietary ED of the population and subgroups defined by an area-based measure of socio-economic status.

Key words: Energy density: Obesity: Household purchase data: Socio-economic position

The global prevalence of obesity has continued to increase over the last three decades, with the WHO[1] reporting a doubling in adult obesity between 1980 and 2008 to over half a billion (more than one-tenth of the world's adult population). In 2012, just under two-thirds (64·3 %) of adults in Scotland were classed as overweight or obese[2], and this is one of the highest rates in the world[3]. It is well established that obesity increases the risk of many chronic conditions and is the most important avoidable risk factor for cancer after smoking[4,5].

ED is defined by the World Cancer Research Fund (WCRF) as 'the amount of energy per unit weight of foods or diets. The units of measure are kilocalories (kcal) or kilojoules (kJ) per 100 grams (g)'[6]. Positive associations have been found between BMI and energy density (ED) of the diet[7–17], with individuals consuming higher energy-dense diets being more likely to be overweight or obese. Experimental data have demonstrated that ED can influence energy intake[18–24], with low energy-dense foods promoting satiety, reducing hunger and decreasing energy intake[25–27]. Conversely, over consumption of energy-dense foods is likely to result in the consumption of excess energy and hence promote weight gain[28]. In addition, evidence from randomised controlled trials has highlighted that reducing the ED of the diet by the addition of water-rich foods such as fruits and vegetables can lead to substantial weight loss[29–34] even when participants were not instructed to restrict their energy intake[35].

ED of foods is associated with individuals' energy intakes[8,10,11,15,20–23,35–38], as individuals tend to consume similar weights of food rather than similar amounts of energy on a day-to-day basis[23,35–37,39,40]; therefore, the ED of food consumed is an important determinant of overall energy intake.

Abbreviations: ED, energy density; EFS, UK Expenditure and Food Survey; HH, households; LCF, UK Living Costs and Food Survey; NHANES, National Health and Nutrition Examination Surveys; SIMD, Scottish Index of Multiple Deprivation; WCRF, World Cancer Research Fund.

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The mechanism of how ED affects satiety and satiation is complex[35], but it appears that humans have a weak innate ability to recognise foods with a high ED and to appropriately reduce the quantity of food eaten in order to maintain energy balance[22,41]. Prentice & Jebb[41] compared the ED of traditional African diets and Western diets (based on British national dietary surveys). The ED of the traditional diets of subsistence farming women from the Gambia averaged 450 kJ/100 g (excluding drinks) compared with 670 kJ/100 g for the Western diets. The weight of food required to meet energy needs was 2000 g for the traditional diets compared with 1300 g for the western diets. They also presented the ED of the diet for a subset of Western women who consumed no more than 35 % energy from fat and at least 400 g fruit and vegetables per d (525 kJ/100 g), which was closer to the low ED of the traditional diets of Gambian women. As individuals commonly consume a similar weight of food on a daily basis, by lowering the ED of their diet, they can reduce their overall energy intake while maintaining the quantity (weight) of food consumed. This is possibly a more attractive strategy to weight reduction and management than reducing food intake.

In addition to the potential benefits on body weight, reducing the ED of the diet tends to improve nutrient density, leading to other potential health benefits including reduced cancer risk[6]. Following a systematic review on food, nutrition, physical activity and the prevention of cancer, the WCRF[6] made a recommendation that consumption of energy-dense foods be limited, with the public health goal that average ED of the overall diet be reduced towards 523 kJ/100 g (125 kcal/100 g). To facilitate this change, they categorised food by defining high energy-dense foods as those supplying more than about 941–1151 kJ/100 g (225–275 kcal/100 g), medium energy-dense foods as 418–941 kJ/100 g (100–225 kcal/100 g) and low energy-dense foods as 251–628 kJ/100 g (60–150 kcal/100 g).

There is limited information available about the ED of diets consumed by populations within contemporary food cultures. This is partly because of the challenges of measuring dietary intake with sufficient accuracy, and also because of the difficulties in comparing results due to the various criteria used to calculate ED. ED is calculated based on the weight of food consumed including or excluding different beverages, depending on their energy content, with ED being higher if calculated from food only. ED has been calculated in US populations by Kant & Graubard[7,42] using data from the National Health and Nutrition Examination Surveys (NHANES), and by Ledikwe *et al.*[43] from the Continuing Survey of Food Intakes by Individuals 1994–6. The ED of the US diet based on NHANES III (1988–94) varied from 803 kJ/100 g for food only, to 545 kJ/100 g for foods and energy-containing beverages only, to 384 kJ/100 g for all foods and all beverages[7]. The Continuing Survey of Food Intakes by Individuals 1994–6[43] reported an ED of 703 kJ/100 g for food and milk only. Results from the NHANES studies[42] have shown an increasing trend in the ED of the diet over time of 661 kJ/100 g (1971–5), 669 kJ/100 g (1976–80), 699 kJ/100 g (1988–94) and 715 kJ/100 g (1999–2002), respectively, for all foods and nutritive beverages (milk and 100 % fruit juices). Kant & Graubard[42] also reported an association between higher income and lower ED as did Nichèle *et al.*[44] and Ricciuto & Tarasuk[45] who calculated the ED of diets in French and Canadian populations, respectively. Wrieden *et al.*[46] explored the possible ways by which ED of the Scottish diet could be calculated using the UK Expenditure and Food Survey (EFS)/UK Living Costs and Food Survey (LCF), and concluded that calculating ED from the food and milk consumed as reported by Prentice & Jebb[41] and used by the WCRF[6] (M Wiseman, personal communication) was prudent to ensure consistency of reporting and allow comparisons with previously reported dietary ED.

The aims of the present study were as follows: (1) to estimate the mean ED of the Scottish diet; (2) to assess differences in ED over time by socio-economic position, by household (HH) composition and for HH meeting dietary targets for fat and fruit and vegetables; (3) to assess the relationship between ED and the consumption of foods and nutrients, which are indicative of diet quality.

Methodology

The present study used food purchase data from the Scottish sample of the EFS (2001–7) and the LCF (2008–9)[47] to estimate food consumption at the HH level. Each year, about 550 HH from Scotland were recruited to the EFS or LCF. As part of the survey, individuals within each HH completed a detailed 14 d diary of all food and beverages purchased for consumption both in and out of the home. From these data, the mean food and nutrient consumption per person is derived. The present study examines the data from the Scottish HH in the survey between 2001 and 2009. Data for each year were obtained from the UK Data Archive[48].

Socio-economic position was measured using the Scottish Index of Multiple Deprivation (SIMD)[49], an area-based index of deprivation. Data on the sampling methodology for the HH and SIMD of the EFS/LCF were obtained from the UK Office of National Statistics and Scottish Neighbourhood Statistics[50], respectively.

Following a review[8,9,41,43,51] of the different methods used to calculate dietary ED, calculations were carried out using five different methods (food; food and milk; food, milk and energy-containing (non-alcoholic) beverages; food, milk and all non-alcoholic beverages; all food and all beverages). ED (overall and by quintile) of the Scottish diet was estimated for each of the ED methods employed, and data were examined by year, deprivation category and HH composition. The results of this review are reported in a further paper[46], but it was concluded that food and milk (718 kJ/100 g) was the most accurate reflection of all food consumed. As it is not possible to distinguish between milk purchased as a drink and milk incorporated into foods (e.g. pasta sauces and milk puddings) in the food purchase data, the use of a 'food only' method would not ensure comparability with estimates of ED using individual diet records. In addition, the WCRF guidelines are based on ED calculated from food and milk. It was therefore considered prudent to use this criterion for policy purposes and in future monitoring work on the

Scottish diet to ensure consistency of reporting and comparability with other published studies.

ED of the diet for each HH was calculated by dividing the total HH energy consumption of food and milk by the total HH weight of food and milk consumed, expressed as kJ/100 g. Details on waste and adjustment factors have been reported elsewhere[47]. The data were analysed in the complex samples component of SPSS version 18 for Windows (SPSS Inc.) that allows for the data to be weighted according to the sampling methodology to make the results representative of the Scottish population. General linear modelling was used to obtain mean, 95 % CI and an indication of statistical significance for differences and trends. Linear associations between ED and year or SIMD quintile were assessed by linear regression. Overall associations between ED and HH composition were assessed by an adjusted Wald test.

The mean population ED (overall and by quintile) with 95 % CI was calculated for the survey period 2001–9, and differences in ED were examined over time by quintile of the SIMD, by HH composition and for HH meeting dietary targets for fat and fruit and vegetables (≤35 % food energy and ≥400 g/d, respectively). Consumption of foods and nutrients that are indicative of diet quality (based on the Scottish Dietary Targets[52], national targets[53,54] and the Scottish diet report[55]) was assessed according to quintile of ED.

Results

A total of 5020 HH (11 374 people), over the period 2001–9, were in the sample analysed for the present study. The average ED of the Scottish diet estimated from food and milk (2001–9) was 718 kJ/100 g (95 % CI 713, 724), and analysis of the trend by year showed that there was no significant difference over time ($P=0.611$; Table 1).

HH in the lowest ED quintile had an average ED of 515 kJ/100 g (95 % CI 510, 519) (Table 1), which is similar to the public health goal of 523 kJ/100 g (125 kcal/100 g) set by the WCRF. The average ED of the highest quintile was 964 kJ/100 g (95 % CI 953, 975) ($P<0.001$).

HH living in the most deprived quintile of the SIMD consumed diets that were significantly higher in ED than those living in the least deprived quintile of the SIMD with a clear linear trend ($P<0.001$). The average ED for the most deprived HH was 737 kJ/100 g (95 % CI 726, 748) compared with 696 kJ/100 g (95 % CI 686, 706) for the least deprived HH (Table 1).

Single-parent HH had diets with the highest ED compared with other compositions of HH. This potential confounder was found to have no effect on ED within the quintiles of the SIMD with a higher ED diet still being more likely in the most deprived quintile after adjusting for HH composition. Similarly after adjusting for the SIMD, single-parent HH remained as the group with the highest ED.

Table 1. Energy density (ED) of the Scottish Population‡

	HH (*n*)	Mean (kJ)	95 % CI	*P*
Overall ED	5020	718	713, 724	
Year				NS
2001	619	720	706, 734	
2002	585	709	696, 723	
2003	546	722	709, 736	
2004	590	722	706, 737	
2005	566	717	700, 733	
2006	577	707	693, 722	
2007	500	725	710, 740	
2008	494	717	700, 733	
2009	543	724	706, 743	
SIMD quintile (Q)				<0·001*
Q1 (most deprived)	972	737	726, 748	
Q2	1038	728	717, 738	
Q3	999	721	709, 732	
Q4	963	711	699, 724	
Q5 (least deprived)	1046	696	686, 706	
HH composition				<0·001†
Single HH	1439	711	701, 722	
Couples	1654	699	691, 708	
Two or more adults with no children (not couples)	458	733	719, 748	
Single-parent HH	358	765	748, 782	
Two or more adults with children	1111	733	723, 744	
Targets§				<0·001†
Meeting targets	417	577	568, 586	
Not meeting targets	4603	731	726, 736	

HH, households; SIMD, Scottish Index of Multiple Deprivation.
* *P* value for linear association ($P<0.001$).
† *P* value for overall association ($P<0.001$).
‡ 2001–9 combined HH and eating out data from the expenditure and Food Survey/Living Costs and Food Survey; from 2006, the UK Expenditure and Food Survey moved from a financial-year to a calendar-year basis. As a consequence of this, the January to March 2006 data were duplicated in the 2005/2006 and the 2006 data. Sample size: 5020 HH; 11 374 people; 45 091 people weighted – results are weighted to the Scottish population; the number provided is approximately 1000th of the Scottish population multiplied by 9, as 9 years of data are used in the analysis.
§ Fat target ≤35 % food energy; fruit and vegetable target >400 g/d.

Of the total HH, 417 (8·3 %) achieved the Scottish Dietary Targets for fat (≤35 % food energy) and fruit and vegetables (≥400 g/d). The mean ED of these HH was 576 kJ/100 g compared with 731 kJ/100 g for HH not achieving the dietary targets ($P<0·001$; Table 1). The effect was not found to be confounded by deprivation. Of the HH meeting the targets, 58 % were in quintile 1 (lowest ED), 23 % in quintile 2, 12 % in quintile 3, 5 % in quintile 4 and 2 % in quintile 5 (highest ED).

Tables 2 and 3 show the mean (95 % CI) consumption of selected foods and nutrients according to quintile of ED (quintile 1 = lowest ED; quintile 5 = highest ED). Fruit and vegetable consumption in quintile 1 of ED was more than double that of quintile 5 (387 and 174 g/d, respectively), with a significant trend across quintiles ($P<0·001$). Consumption of fruit and vegetables in quintile 5 was about the equivalent of one portion of each per d (87·3 g fruit and 86·9 g vegetables; Table 2). Consumption of brown/wholemeal bread, high-fibre breakfast cereals, oil-rich fish, white fish and fresh potatoes were all significantly higher in quintile 1, with a significant trend in consumption across the quintiles ($P<0·001$). In contrast, the consumption of cakes, sweet biscuits and pastries, confectionery, sugar-containing soft drinks, red and processed meat, processed potatoes, savoury snacks and takeaway foods were all significantly higher for HH in quintile 5 ($P<0·001$). Consumption of all types of milk was highest in quintile 1 ($P<0·001$).

Table 2 shows nutrient intake according to quintile of ED. Percentages of energy from fat, saturated fat and non-milk extrinsic sugars were lowest in quintile 1 ($P<0·001$) and, conversely, the percentage of energy from starch was highest ($P=0·010$) in quintile 1. The Scottish Dietary Targets and other guidelines were not met by any quintile of ED, with the exception of percentage of energy from fat (≤35 %) in quintile 1 and red meat consumption of ≤70 g/d[53] which was met by all quintiles of ED.

Discussion

The present study provides unique insights to the dietary ED of a population sample based on contemporary dietary data. In the present study the mean ED of the Scottish diet was estimated in a representative sample of 5020 HH over the period 2001–9. The results show that the ED of the diet did not change significantly over this period of time. The ED of the Scottish diet reported here (718 kJ/100 g) was similar to the estimates published before based on individual dietary data and calculated from food and milk (703 kJ/100 g for American adults[43], 600–730 kJ/100 g for British women in 1986[41] and 590–650 kJ/100 g for a sample of healthy adults from the South East of England[9]). Although these previously published estimates were measured using individual diet records, they can be considered comparable to the HH food purchase data in that the milk component can be incorporated into food or as a beverage. The problem with comparing ED measurements using food alone is that in individual diet records, some of the milk purchased as a liquid will be counted as food, as it could be incorporated into foods (such as pasta sauces and milk puddings), whereas with food purchase data, it is not possible to tell how the HH will use it. Johnson *et al.*[56] argued that the inclusion of drinks in the calculation of ED confuses the relationship of ED to weight gain, and therefore for consistency, the calculation should be done on food alone. However, their conclusions were based on studies using individual diet records, and they did not appear to have reviewed studies using food and milk alone. It is interesting that an earlier study by Cox & Mela[9] found little difference in ED calculated from food alone and food and milk. It is also noted that ED calculated from French food purchase data[44], excluding alcoholic drinks and drinks made up with water, gave a mean ED equivalent to 600 kJ/100 g. In the present study, estimation of ED from food and milk was partly a consequence of the fact that the public health goal set by the WCRF for ED is based on food and milk, and the purpose of the work was to find a realistic method to set and monitor a similar goal for Scotland.

The findings reported herein suggest that a significant proportion of Scottish HH are consuming high energy-dense diets, and that the mean ED estimates for HH in each of the top two quintiles (40 % of the sample) were 779 and 964 kJ/100 g, respectively. In comparison, the ED for women's diets calculated from British Population surveys from 1986 to 1997, using food and milk, was 670 kJ/100 g, with the highest values observed in girls' diet (730 kJ/100 g) and the lowest values in older women (600 kJ/100 g)[41]. However, there is further evidence to suggest that women tend to have a lower energy-dense diet than do men[43]. Despite on-going work to improve the quality of the diet in Scotland[52,57–59], it was found that the ED of the population's diet had remained constant over the first decade of the new millennium, and is considerably higher than that of the WCRF's goal. However, the mean ED of quintile 1 (lowest ED, 515 kJ/100 g) was similar to the public health goal set for ED (523 kJ (125 kcal)/100 g) by the WCRF, demonstrating that it is achievable at a population level. It was also found that those HH who met the dietary targets for fat and fruit and vegetables had a significantly lower ED than those who did not meet the targets. This finding is in line with that reported by Prentice & Jebb[41], who found that individuals who adhere to dietary guidelines in relation to fruit and vegetables and fat also had a mean dietary ED comparable with the goal of the WCRF.

Investigation of ED by HH composition highlighted that single-parent HH had a higher energy-dense diet than any other type of HH. This finding may be due to the fact that food purchases for children constitute a higher proportion of overall purchases in these HH. The mean ED of children's diets measured using a similar method suggests that they are less likely to be following a low energy-dense diet[41], with a mean ED of 822–828 kJ/100 g[60] for 6–8-year-olds in Northern Ireland and 850–910 kJ/100 g for 5–7-year-olds in the Avon Longitudinal Study[56] compared with 590–730 kJ/100 g for adults[9,41,43] and 718 kJ/100 g for the total population in the present study.

The quintiles of ED demonstrated the wide range of values across the population, and further investigation highlighted that fruit and vegetable consumption was more than double in quintile 1 (low ED) compared with quintile 5 (high ED)

Table 2. Consumption of selected foods and nutrients based on Scottish Diet Action Plan 1996 by quintile of energy density (ED)*

(Mean values and 95 % confidence intervals)

Food	Scottish Dietary Targets	ED quintile 1		ED quintile 2		ED quintile 3		ED quintile 4		ED quintile 5		*P* for linear association
		Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	
ED†		515	510, 519	628	626, 629	698	697, 700	779	777, 781	964	953, 975	<0·001
Foods												
Fruit and vegetables (g)‡§	400 g/d	387	367, 407	319	302, 335	270	259, 282	233	221, 245	174	164, 185	<0·001
Fruit (g)‡		204	191, 217	172	160, 183	148	138, 158	124	115, 133	87·3	80·2, 94·4	<0·001
Vegetables (g)§		183	171, 195	147	139, 155	122	117, 127	109	103, 114	86·9	81·8, 91·9	<0·001
Total bread (g)	154 g/d	91·3	87·8, 94·8	99·7	96·4, 103	107	103, 111	109	105, 113	95·9	91·7, 100	0·009
Brown/wholemeal bread (g)		24·5	22·3, 26·7	23·5	21·6, 25·5	22·9	21·2, 24·7	19·7	18·2, 21·3	15·9	14·1, 17·8	<0·001
Total breakfast cereal (g)	34 g/d	21·3	19·1, 23·6	22·3	20·7, 23·8	22·8	21·3, 24·2	20·6	18·7, 22·5	15·9	14·5, 17·4	<0·001
High-fibre breakfast cereal (g)		14·5	12·6, 16·3	13·5	12·0, 15·0	11·6	10·6, 12·6	11·1	9·7, 12·4	7·9	6·9, 9·0	<0·001
Oil-rich fish (g)	88 g/week	49·1	41·9, 56·4	39·3	34·0, 44·6	33·4	24·6, 42·1	30·8	25·7, 35·8	19·8	16·7, 22·8	<0·001
White fish (g)	No decrease‖	113	104, 122	105	96·8, 114	88·8	81·4, 96·2	89·7	82·4, 97·0	70·5	63·2, 77·9	<0·001
Fresh potatoes (g)¶		79·5	72·5, 86·5	63·1	58·7, 67·5	58·4	54·1, 62·7	49·9	46·0, 53·8	35·5	31·3, 39·6	<0·001
Energy and nutrients												
% Food energy, fat	≤35	34·7	34·2, 35·2	37·4	37·0, 37·9	38·6	38·3, 39·0	40·0	39·6, 40·4	43·2	42·7, 43·7	<0·001
% Food energy, saturated fat	≤11	14·5	14·2, 14·8	15·1	14·9, 15·4	15·7	15·5, 15·9	15·9	15·7, 16·1	15·9	15·7, 16·2	<0·001
% Food energy, NMES	Adults, no ↑**; children, <10	13·7	13·2, 14·2	14·9	14·5, 15·3	15·6	15·2, 16·1	16·4	15·9, 16·8	15·8	15·3, 16·3	<0·001
Complex carbohydrate (g)	155 g/d	125	120, 130	137	133, 141	147	143, 151	151	147, 154	153	148, 157	<0·001
Starch (g)		113	108, 117	124	121, 128	134	131, 138	138	135, 142	140	136,144	<0·001
% Food energy, starch		24·3	23·7, 24·8	24·5	24·1, 24·9	24·5	24·1, 24·8	24·1	23·7, 24·5	23·5	23·1, 23·9	0·010
NSP (g)††		12·6	12·1, 13·1	12·5	12·0, 12·9	12·4	12·1, 12·8	12·4	12·0, 12·7	12·6	12·2, 13·1	0·967
Food energy												
MJ		7·2	7·0, 7·4	8·0	7·8, 8·2	8·7	8·5, 8·9	9·0	8·8, 9·3	9·4	9·1, 9·7	<0·001
kcal		1721	1674, 1767	1900	1844, 1956	2062	2012, 2111	2151	2095, 2208	2243	2171, 2315	<0·001
HH (*n*)		1001		1005		1006		1005		1003		
People (*n*)		1964		2256		2411		2454		2289		
People weighted (*n*)‡‡		7672		9022		9422		9863		9111		

NMES, non-milk extrinsic sugars; HH, households.

* 2001–9 combined HH and eating out data from the Expenditure and Food Survey/Living Costs and Food Survey (units/person per d with the exception of fish g/person per week).

† ED quintiles: 1 = least dense; 5 = most dense (assigned for each year separately to negate any differences due to time).

‡ Fruit includes fruit and vegetable juice.

§ Vegetables include baked beans.

‖ The National Food Survey estimate reported by Wrieden *et al.*[65] for 1996 was 107 g/week.

¶ Part of complex carbohydrate target.

** Dietary reference value (DRV) for adults was 11 % food energy.

†† DRV = 18 g[53].

‡‡ The results are weighted to the Scottish population; the number provided is approximately 1000th of the Scottish population.

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Table 3. Consumption of additional foods and drinks indicative of diet quality by quintile of energy density (ED)*

(Mean values and 95 % confidence intervals)

	ED quintile 1		ED quintile 2		ED quintile 3		ED quintile 4		ED quintile 5		
Food	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	Mean	95 % CI	*P* value for linear association
ED†	515	510, 519	628	626, 629	698	697, 700	779	777, 781	964	953, 975	< 0·001
Cakes and pastries	12·7	11·7, 13·8	16·0	14·7, 17·4	19·0	17·8, 20·1	20·0	18·4, 21·5	18·3	16·7, 19·9	< 0·001
Sweet biscuits	13·9	12·7, 15·1	19·6	18·2, 21·0	23·6	22·1, 25·0	26·6	24·9, 28·3	26·4	24·4, 28·5	< 0·001
Cakes, sweet biscuits and pastries	26·7	25·0, 28·3	35·7	33·5, 37·8	42·5	40·5, 44·6	46·6	44·1, 49·1	44·7	41·7, 47·8	< 0·001
Sugar and preserves	13·7	11·8, 15·6	15·7	14·1, 17·3	19·0	17·1, 20·8	19·5	17·6, 21·4	20·7	18·1, 23·3	< 0·001
Chocolate confectionery	7·6	6·7, 8·6	11·1	10·2, 12·0	15·5	14·2, 16·8	18·1	16·6, 19·6	19·7	17·7, 21·6	< 0·001
Sugar confectionery	4·1	3·5, 4·7	6·2	5·4, 7·0	7·2	6·4, 8·0	8·7	7·9, 9·5	8·8	7·9, 9·7	< 0·001
Total confectionery	11·7	10·5, 12·9	17·3	15·9, 18·7	22·7	21·2, 24·2	26·8	25·1, 28·6	28·5	26·2, 30·8	< 0·001
Sugar containing soft drinks	156	140, 172	203	187, 219	244	225, 263	267	249, 286	269	250, 288	< 0·001
Sugar-free soft drinks	67·9	57·6, 78·1	81·8	71·0, 92·5	108	95·0, 121	111	96·5, 126	102	88·3, 115	< 0·001
Total soft drinks	224	204, 243	285	267, 303	352	330, 374	378	354, 403	371	348, 394	< 0·001
Total red meat‡	50·9	47·9, 53·8	61·9	58·4, 65·4	67·2	64·0, 70·4	66·2	63·1, 69·4	64·1	59·8, 68·4	< 0·001
Bacon and ham	10·5	9·7, 11·2	13·0	11·9, 14·0	12·7	12·0, 13·5	12·8	11·8, 13·7	10·9	10·0, 11·7	0·935
Other red meat products‡§	19·4	17·9, 20·9	24·9	23·3, 26·6	30·3	28·6, 31·9	31·5	29·7, 33·3	31·3	29·5, 33·1	< 0·001
Butter	4·4	3·7, 5·1	5·2	4·6, 5·9	6·3	5·7, 7·0	7·6	6·7, 8·5	7·7	6·9, 8·4	< 0·001
Whole milk	91·3	75·3, 107	73·8	63·6, 84·0	75·3	64·9, 85·6	63·6	55·2, 72·1	52·8	45·2, 60·3	< 0·001
Semi-skimmed milk	194	177, 212	157	146, 168	135	126, 144	109	101, 117	70·9	63·5, 78·3	< 0·001
Skimmed milk	30·4	23·7, 37·1	17·6	14·0, 21·2	12·3	9·9, 14·8	8·9	5·4, 12·3	5·7	3·8, 7·5	< 0·001
Total milk	350	333, 368	271	259, 282	238	228, 249	196	189, 204	144	133, 155	< 0·001
Processed potatoes	21·1	19·0, 23·3	25·6	23·5, 27·7	32·4	30·4, 34·4	34·0	31·6, 36·5	32·5	30·4, 34·6	< 0·001
Savoury snacks	7·3	6·7, 7·9	10·5	9·7, 11·2	14·1	13·1, 15·2	15·7	14·8, 16·7	17·7	16·5, 19·0	< 0·001
Takeaway foods	13·1	11·7, 14·6	20·0	17·7, 22·4	21·7	19·5, 23·9	22·6	20·3, 24·9	24·8	22·2, 27·3	< 0·001
HH (*n*)	1001		1005		1006		1005		1003		
People (*n*)	1964		2256		2411		2454		2289		
People weighted (*n*)‖	7672		9022		9422		9863		9111		

HH, households.

* 2001–9 combined HH and eating out data from the Expenditure and Food Survey/Living Costs and Food Survey (g/person per d).

† ED quintiles: 1 = least dense; 5 = most dense (assigned for each year separately to negate any differences due to time).

‡ Meat portion only; see appendices 2 and 4 of Barton & Wrieden[62] for methodology.

§ Other red meat products include the meat portion of sausages, meat pies, corned beef, burgers and pâté and is a component of total red meat.

‖ The results are weighted to the Scottish population; the number provided is approximately 1000th of the Scottish population.

(387 and 174 g/d, respectively). Consumption of brown/wholemeal bread, breakfast cereals, oil-rich fish and white fish was also highest in quintile 1. In contrast, consumption of foods associated with a poor-quality diet (e.g. cakes, sweet pies and pastries, confectionery, sugar-containing soft drinks, and red and processed meat) was higher for those HH in quintile 5 of ED. This is not surprising considering that many of the foods targeted for reduction are high in ED and add credibility to dietary guidance that targets these types of foods as key contributors to excess energy intake.

Interestingly, milk consumption of all types was highest for those HH in quintile 1 of ED, suggesting that the fat content of milk may not be important in determining the overall ED of the diet. Milk consumption may help to lower ED (due to its relatively low ED) while providing valuable nutrients not found in other liquids. However, it is also a contributor to saturated fat, and it is notable that none of the ED quintiles met the Scottish Dietary Targets for the percentage of energy from saturated fat. A higher milk consumption is likely to decrease ED because of its low ED, but the fat in whole and semi-skimmed varieties will add to saturated fat intake.

HH within quintile 1 of ED were on average closest to meeting all nutrient guidelines compared with the other quintiles, and were on average meeting the guideline for the percentage of energy from fat. These findings that HH within the lowest quintile of ED were on average closest to achieving the food- and nutrient-based targets help to verify the close link between healthy eating guidelines and the ED of the diet and suggest adherence to healthy eating advice that contributes to reducing ED, which in turn may help prevent obesity and other chronic diseases.

It is perhaps not surprising that the least-deprived HH had diets with a lower ED. The clear gradient of decreasing ED of the diet with a decreasing level of deprivation has been implicated in other work where the link between low energy-dense diets has been associated with higher costs and better diet quality[61]. A similar pattern was found in a study using Canadian purchase data where a negative association between income and ED[45] was observed, and in a further French study based on purchased data where HH with the highest education level and those in the highest-income quartile had diets with the lowest ED[44]. The Canadian study did not include purchases of food outside the home, but the results presented here calculated from the Scottish purchase data provide a combined measure of the ED of both HH food and food eaten outside. The food eaten outside the home contributed about 13 % of energy[62], and although there was no linear trend in the ED of food eaten outside the home by deprivation, Wrieden & Barton[63] found that the least-deprived quintile had the highest ED for this component compared with other quintiles (calculated from 2001–2008 data). This might explain why the differences due to socio-economic position are not as large as those observed between the different ED quintiles.

A major strength of the present study is the large sample size that is nationally representative of the Scottish population. The survey continues on an annual basis to collect information that can be used to assess contemporary diets and evaluate changes in relation to dietary guidance. The food purchase data were collected over a 14 d period and analysis included adjustments for wastage. This is valuable as energy and nutrient intakes are balanced over longer periods than usual methods of individual dietary assessment. However, because the data were recorded at the HH level, the study design did not enable sex or age differences in the diet within the sample to be assessed. As dietary guidelines are most often presented at a population level, this limitation is not a major problem, but it should always be remembered that the data collected are from HH purchase data and may, despite adjustments, not be strictly comparable with those obtained from individual dietary records (e.g. the UK National Diet and Nutrition Surveys). ED calculations are likely to be higher using purchase data as foods cooked at home from raw ingredients, such as stews, curries, casseroles and pasta bakes, will have tap water added that was not purchased.

Nevertheless, the results obtained herein compare favourably with other published results. In conclusion, the results show that the average ED of the diet for the Scottish population is considerably higher than the public health goal recommended by the WCRF. Consistent with other dietary variables[64], there has been no change in the ED of the Scottish diet over the last decade. However, it is promising that lower ED levels that are close to the recommendations have been found within a small group of the population. A better understanding of how these groups achieve this healthier diet would help to identify ways to promote favourable dietary choices and to decrease the risk of obesity and cancer in the population. The present study demonstrates how food purchase data can be used to monitor the quality of the diet in terms of dietary ED of the population and subgroups defined by an area-based measure of socio-economic status.

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A. S. A., managed the project; K. L. B., W. L. W., A. S., J. A. and A. S. A. designed the research; K. L. B. and W. L. W. conducted the research; K. L. B. analysed the data; K. L. B., W. L. W., A. S., J. A. and A. S. A. wrote the paper; K. L. B., W. L. W. and A. S. A. had primary responsibility for the final content. All authors read and approved the final manuscript.

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