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Food portion sizes and dietary quality in Irish children and adolescents

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Abstract

Objective: To describe relationships between the portion sizes of a range of foods commonly consumed by Irish children and adolescents and key indicators of dietary quality on the days they were consumed.
Design: Cross-sectional data from the Irish National Children's Food Survey (2003–2004; 7 d weighed record) and National Teens' Food Survey (2005–2006; 7 d semi-weighed record) were used to compare mean values for a number of dietary quality indicators (e.g. energy-adjusted intakes of saturated fat, dietary fibre and Na) across portion size tertiles for a range of foods, on the days the foods were consumed.
Setting: The Republic of Ireland.
Subjects: Nationally representative samples of children aged 5–12 years (*n* 594) and adolescents aged 13–17 years (*n* 441).
Results: Relationships between food portion sizes and indicators of dietary quality on the days the foods were consumed were similar in both children and adolescents. Lower dietary energy density and saturated fat intakes, and higher dietary fibre intakes, were observed on the days larger portions of fruit and boiled potatoes were consumed. Higher dietary energy density and lower micronutrient intakes were observed on the days larger portions of sugar-sweetened beverages were consumed. Higher Na intakes were observed on the days larger portions of frying meats were consumed.
Conclusions: The current work identifies foods for which larger portion sizes may be associated with positive dietary attributes, as well as the opposite. Findings will form an evidence base from which more specific dietary guidance relating to portion size may be developed for Irish children and adolescents.

Keywords
Food portion sizes
Dietary quality
Irish children and adolescents

Research into food portion sizes in children has traditionally examined the relationship between larger food portion sizes and voluntary energy intake in controlled feeding studies. Studies have shown that serving larger portions of a macaroni and cheese entrée to children aged 2–6 years typically leads to increased energy intake at that meal, with the increase becoming more pronounced as children transition through the pre-school period[1–3]. Serving larger portions of snacks of varying energy densities (e.g. apple sauce, chocolate pudding) has also been associated with increased energy intake in children aged 2–5 years[4]. No data of this kind appear to be available for older children or adolescents. More recently, observational data have been used to investigate associations between food portion sizes and energy intake in children using large food consumption data sets. An analysis of four US nationally representative surveys from 1977 to 2006 (*n* 31 337) found significantly higher energy intakes during meals at which larger portions of selected energy-dense foods (e.g. sugar-sweetened beverages, salty snacks, French fries) were consumed in both children and adolescents, with susceptibility to increased portion sizing more marked in adolescents[5].

Traditionally, public health campaigns addressing food portion sizes have focused on a reduction in portion size, particularly for energy-dense foods, to reduce energy intake and to help tackle the obesity epidemic. However, the effect of reducing the portion size of such foods on dietary quality has not been addressed and there appear to be no available data on the relationship between food portion size and dietary quality for any population group. Such analysis is needed to identify foods for which larger portion sizes may be associated with positive dietary attributes, as well as the opposite. Findings will also be of use where strategies are being devised to target intakes of specific nutrients going forward.

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Several aspects of dietary quality have been highlighted as areas of public health concern for Irish children and adolescents in recent years. Significant proportions of Irish children and adolescents fall short of the recommended intakes of dietary fibre[6,7], Ca[8,9], Fe[8,9] and vitamin D[10]. Intakes of saturated fat as a percentage of total energy (%TE) have been shown to exceed recommendations in these groups[11]. O'Connor *et al.* showed there is a relationship between dietary energy density (DED) and dietary quality in Irish children and adolescents[12], while Joyce and Gibney described a relationship between added sugar intakes and micronutrient dilution in the same groups[13]. Na intakes in excess of the population-average target levels have also been reported in Irish children and adolescents[14,15].

The aim of the current work was to investigate associations between food portion sizes and key indicators of dietary quality (energy-adjusted intakes of saturated fat, added sugars, dietary fibre, Na, Ca, Fe and vitamin D, and DED) in Irish children (5–12 years) and adolescents (13–17 years) on the days the foods were consumed.

Experimental methods

Survey methodologies

The analyses were conducted on data from the Irish National Children's Food Survey (NCFS; 2003–2004) and National Teens' Food Survey (NTFS; 2005–2006), which were carried out as part of a series of national food consumption surveys by the Irish Universities Nutrition Alliance, a formal association of the nutrition units at University College Cork, University College Dublin, the University of Ulster at Coleraine and Trinity College Dublin. The NCFS used a 7 d weighed food record to collect dietary intake data, with participating children (*n* 594) asked to weigh as many food items as possible throughout the recording period, with help from their parents. The NTFS used a 7 d semi-weighed food record to collect dietary intake data, with participating adolescents (*n* 441) asked to weigh portions of commonly consumed foods and beverages only, rather than all food items. Weighed data (either directly weighed on the digital scales provided or assigned a weight using manufacturer's information) accounted for 87 % of all food items consumed on the NCFS and 46 % on the NTFS. The remainder of food items were assigned weights using a range of estimation tools (e.g. photographic food atlas[16], household measures, food portion size reference books[17]). Recorded dietary intake data were converted to nutrient intake data using WISP© (Tinuviel Software, Anglesey, UK). WISP contains data from *McCance and Widdowson's The Composition of Foods*, sixth[18] and fifth[19] editions plus all nine supplemental volumes[20–28]. The NCFS and NTFS were conducted according to the guidelines laid down in the Declaration of Helsinki. All procedures involving participants were approved by the St. James' Hospital and Federated Dublin Voluntary Hospitals Joint Research Ethics Committee (NCFS) or the University College Cork Clinical Research Ethics Committee of the Cork Teaching Hospitals (NTFS). Written informed consent was provided by the participants, as well as their parents/guardians. Further detail on the survey methodologies is available at www.iuna.net.

Definition of food portion size

Food portion size was defined as the weight of food consumed per eating occasion, i.e. weight served minus leftovers, and was estimated once for each participant for each day a food was consumed. Where a particular food was consumed on more than one occasion on one day, the largest portion size was assigned for that day (on the basis that a larger portion weight is more likely to have an influence on dietary quality for that day). For some foods, the portion size is likely to represent the mean daily intake of that food (e.g. breakfast cereal is commonly consumed on one eating occasion per day), while for other foods, the portion size may be less than the mean daily intake (e.g. bread may be consumed on more than one eating occasion per day).

Selection of foods and dietary quality indicators for analysis

A selection of foods from all of the major food categories (i.e. starchy foods, fruit and vegetables, milk and dairy foods, meat and other protein foods, foods high in fat or sugar) was included to allow for a range of associations with dietary quality to be observed. Within food categories, specific foods were selected by the authors based on how frequently they were consumed by Irish children and adolescents. The dietary quality indicators selected were energy-adjusted intakes of saturated fat, added sugars, dietary fibre, Na, Ca, Fe and vitamin D, and DED. These were selected on the basis of their public health importance in the diets of Irish children and adolescents, as highlighted in previous analyses using data from the same cohorts[6–15].

Measurement of dietary energy density

DED is defined as the amount of available dietary energy per unit weight of food or beverage, and is expressed in kJ/g. In the current study, DED was calculated to include all foods and exclude all beverages, as recommended in the most recent systematic review on methods of calculation of DED[29]. There were five recording days on the NCFS on which beverages only were consumed (e.g. because the participant was sick); these days were excluded from the DED analysis.

Statistical analysis

Statistical analysis was conducted using the statistical software package SPSS© version 15·0 for Windows.

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Participants defined as energy under-reporters (32 % of children, 64 % of adolescents) using the method of Schofield (1985) were not excluded from the analysis[30]. Some provision was made to minimise the effects of under-reporting by reporting energy-adjusted nutrient intakes as outcomes. For each food item examined, the portion size data were split by tertile (stratified by sex and age group where significant differences occurred between groups) to create relatively 'small', 'medium' and 'large' portion size groups. Mean values for each of the dietary quality indicators were compared across portion size tertiles for the days on which portions of a particular food were consumed. A one-way between-groups ANOVA was used to test for significant differences in means across tertiles where dietary quality indicators were normally distributed ($P < 0{\cdot}05$). Kruskal–Wallis tests were used where the data were not normally distributed ($P < 0{\cdot}05$). Normality was assessed using a Kolmogorov–Smirnov test. Following analysis, the Holm adjustment was manually applied to significant findings to reduce the possibility of Type 1 errors occurring.

Results

Table 1 describes the number of eating occasions of a food included for analysis as well as median portion weights within tertiles (g) for all foods consumed by both children (*n* 594) and adolescents (*n* 441). Important indicators of dietary quality in Irish children and adolescents were found to be associated with portion sizes of a range of foods on the days they were consumed. The following associations were noted in both children and adolescents (Tables 2 and 3).

Intakes of saturated fat were higher on the days larger portions of whole milk, cheese, butter and chocolate were consumed, and were lower on the days larger portions of white bread, boiled potatoes, fruit, sugary sweets and sugar-sweetened beverages were consumed. Intakes of added sugars were lower on the days larger portions of white bread, chips and whole milk were consumed. Intakes of dietary fibre were higher on the days larger portions of brown bread, boiled potatoes, chips, fruit, vegetables and baked beans were consumed, and were lower on the days larger portions of chocolate and sugar-sweetened beverages were consumed. DED was higher on the days larger portions of cheese, butter, chocolate and sugar-sweetened beverages were consumed, and was lower on the days larger portions of boiled potatoes, fruit and vegetables were consumed. Intakes of Na were higher on the days larger portions of white bread, luncheon meats, frying meats (i.e. bacon, sausages, pudding) and cheese were consumed, and were lower on the days larger portions of chips and chocolate were consumed. Intakes of Ca were higher on the days larger portions of ready-to-eat breakfast cereals (RTEBC), whole and reduced-fat milks and cheese were consumed, and were lower on the days larger portions of chips, crisps and sugar-sweetened beverages were consumed. Intakes of Fe were higher on the days larger portions of RTEBC and

Table 1 Number of eating occasions and median weights by portion size tertile (g) for foods consumed by nationally representative samples of children aged 5–12 years (*n* 594) and adolescents aged 13–17 years (*n* 441), Republic of Ireland

	Children		Adolescents	
	Number of eating occasions	Tertile medians (g)	Number of eating occasions	Tertile medians (g)
Pasta, boiled	427	75, 129, 214	303	108, 214, 319
White bread & rolls	2973	37, 66, 84	1875	54, 72, 133
Brown bread & rolls	663	33, 60, 88	615	40, 72, 108
Potatoes, boiled	1105	66, 129, 212	637	118, 181, 292
Chips & wedges	1158	61, 102, 172	912	97, 155, 240
RTEBC	2803	21, 37, 57	1564	31, 46, 76
Fruit, excluding dried	1877	61, 98, 135	931	85, 130, 186
Vegetables, excluding pulses	1509	22, 50, 90	1153	27, 62, 115
Baked beans	343	47, 91, 147	211	71, 121, 200
Luncheon meats	1225	13, 24, 40	751	20, 32, 52
Frying meats	836	26, 47, 75	563	40, 50, 81
Whole milk	3243	103, 189, 269	1945	78, 200, 333
Reduced-fat milks	416	92, 172, 253	441	75, 180, 322
Cheeses	1048	16, 21, 37	715	20, 36, 60
Butter & spreads >59 % fat	2319	4, 8, 15	1384	7, 12, 24
Low-fat spreads <38 % fat	619	4, 8, 12	381	8, 12, 24
Biscuits	1441	17, 26, 40	641	21, 34, 64
Chocolate confectionery	1619	19, 29, 52	1134	21, 43, 61
Sugary sweets	892	10, 25, 52	385	13, 35, 60
Crisps	758	18, 25, 40	538	24, 25, 40
Sugar-sweetened beverages	2565	171, 250, 465	1482	200, 330, 500
Non-sugar-sweetened beverages	796	150, 261, 467	318	200, 300, 500

RTEBC, ready-to-eat breakfast cereals.
'Tertile medians (g)' reflect the median portion weights of the foods examined in each of the 'small', 'medium' and 'large' tertiles.

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Table 2 Mean daily nutrient intakes (energy-adjusted) by tertile of food portion size on the days the food was consumed by a nationally representative sample of children aged 5–12 years (*n* 594), Republic of Ireland

	Saturated fat (%TE)	Added sugars (%TE)	Dietary fibre (g/10 MJ)	DED (kJ/g)	Na (mg/10 MJ)	Ca (mg/10 MJ)	Fe (mg/10 MJ)	Vitamin D (μg/10 MJ)
Mean intake	14·0	15·0	18·3	8·34	3007	1217	13·7	3·4
	T1, T2, T3	T1, T2, T3	T1, T2, T3	T1, T2, T3	T1, T2, T3	T1, T2, T3	T1, T2, T3	T1, T2, T3
Pasta, boiled	14·5, 13·9, 13·1	14·2, 12·9, 12·5	17·5, 18·8, 19·2	8·06, 7·73, 7·34	2785, 2768, 2629	1304, 1254, 1213	13·8, 14·0, 14·7	3·5, 3·5, 3·0
White bread & rolls	14·6, 14·1, 13·4 ↓	14·9, 14·2, 13·6 ↓	17·2, 17·4, 18·1 ↑	8·30, 8·44, 8·50	2894, 3089, 3281 ↑	1239, 1263, 1284	12·8, 13·3, 13·6 ↑	3·3, 3·3, 3·0
Brown bread & rolls	14·5, 13·8, 13·3	13·4, 12·3, 11·8	19·8, 21·5, 24·4 ↑	7·86, 8·05, 7·62	3089, 3287, 3370	1186, 1251, 1236	14·1, 14·0, 15·7 ↑	3·8, 4·0, 4·4
Potatoes, boiled	14·9, 14·3, 13·4 ↓	14·4, 13·3, 13·0	17·6, 19·6, 21·3 ↑	7·87, 7·39, 6·74 ↓	2980, 3043, 3007	1321, 1303, 1200 ↓	13·8, 15·4, 14·3 ↑	4·4, 3·9, 2·9 ↓
Chips & wedges	14·0, 14·0, 13·5	16·6, 15·2, 13·9 ↓	16·4, 17·3, 19·6 ↑	9·31, 9·19, 9·18	2942, 2852, 2607 ↓	1178, 1042, 1009 ↓	12·6, 11·9, 12·5	3·1, 3·2, 2·6 ↓
RTEBC	14·4, 14·2, 13·7 ↓	14·8, 14·1, 15·1 –	17·3, 18·0, 18·8 ↑	8·36, 8·29, 8·62 ↑	2900, 2964, 3003 ↑	1229, 1299, 1324 ↑	12·4, 15·1, 17·5 ↑	3·3, 3·6, 3·5
Fruit, excl. dried	14·4, 13·9, 13·4 ↓	13·7, 13·2, 12·9	18·2, 20·4, 21·6 ↑	8·04, 7·34, 6·90 ↓	2971, 2895, 2873	1279, 1261, 1235	13·7, 13·6, 13·4	3·7, 3·3, 3·4
Vegetables, excl. pulses	14·6, 14·0, 13·9	14·2, 13·3, 13·2	17·8, 19·2, 20·8 ↑	8·08, 7·37, 6·86 ↓	2883, 2918, 2834	1266, 1277, 1228	13·3, 14·0, 14·1	3·6, 3·7, 3·5
Baked beans	14·4, 14·2, 13·1	14·4, 13·4, 14·7	21·5, 24·4, 30·2 ↑	8·11, 7·79, 7·56	3167, 3555, 3882 ↑	1318, 1329, 1264	13·5, 15·1, 14·5 ↑	3·2, 3·2, 2·7
Luncheon meats	14·0, 13·8, 13·9	13·9, 14·9, 13·7	18·4, 17·6, 17·5	7·92, 8·23, 8·09	3179, 3199, 3535 ↑	1296, 1286, 1253	13·7, 13·0, 13·9	3·2, 3·2, 3·4
Frying meats	14·8, 14·9, 15·1	14·2, 13·9, 13·9	16·7, 17·0, 16·7	8·51, 8·76, 8·83	3363, 3506, 4051 ↑	1221, 1149, 1125	13·2, 12·7, 12·5	3·6, 3·6, 3·8
Whole milk	13·3, 14·6, 15·4 ↑	16·2, 14·2, 12·9 ↓	18·2, 18·4, 18·0	8·58, 8·26, 8·26 ↓	2979, 2962, 2930	1055, 1301, 1475 ↑	13·9, 14·5, 13·8 ↑	3·6, 3·5, 3·0 ↓
Reduced-fat milks	11·8, 12·5, 13·0	15·9, 14·2, 14·9	18·8, 18·3, 18·5	7·94, 8·21, 8·24	3045, 3068, 3100	1137, 1412, 1548 ↑	14·6, 14·9, 13·6	3·6, 3·7, 4·3
Cheeses	14·6, 15·2, 16·9 ↑	13·0, 13·3, 12·7	19·1, 17·5, 17·6	8·08, 8·13, 8·72 ↑	3026, 3108, 3258 ↑	1336, 1433, 1543 ↑	13·4, 13·2, 12·8	3·1, 3·7, 3·2
Butter & spreads >59 % fat	14·0, 14·8, 15·1 ↑	13·8, 13·1, 13·5	18·4, 17·9, 17·4 ↓	8·26, 8·31, 8·73 ↑	3039, 3048, 3202 ↑	1260, 1294, 1226	13·9, 13·2, 13·2 ↓	3·3, 3·3, 3·0
Low-fat spreads <38 % fat	13·8, 13·2, 13·3	14·1, 13·9, 13·6	18·4, 18·5, 18·8	7·98, 7·83, 8·13	3002, 2994, 3234	1345, 1333, 1316	14·2, 13·3, 13·3	3·9, 4·4, 5·0 ↑
Biscuits	14·4, 14·8, 15·1	14·4, 14·9, 15·4	17·6, 17·8, 17·2	8·31, 8·47, 8·81 ↑	2879, 2912, 2807	1270, 1221, 1201	13·3, 13·2, 13·3	3·4, 3·1, 3·3
Chocolate confectionery	14·2, 14·9, 15·8 ↑	14·9, 16·1, 19·2 ↑	18·0, 16·7, 14·8 ↓	8·31, 8·78, 9·24 ↑	2962, 2812, 2588 ↓	1226, 1202, 1141 ↓	13·2, 13·3, 12·3 ↓	3·5, 3·0, 3·1
Sugary sweets	14·4, 13·7, 12·7 ↓	15·3, 18·6, 23·0 ↑	17·9, 16·4, 15·5 ↓	8·35, 8·66, 9·25 ↑	2853, 2850, 2577 ↓	1265, 1181, 1037 ↓	13·3, 12·6, 11·8 ↓	3·4, 2·9, 2·7
Crisps	14·2, 14·8, 15·4 ↑	16·1, 14·8, 14·8	18·3, 19·2, 18·7	8·22, 8·89, 9·58 ↑	2765, 2956, 2973	1237, 1166, 1043 ↓	13·1, 12·3, 12·1	5·0, 2·8, 2·6 ↓
Sugar-sweetened beverages	14·4, 14·0, 12·9 ↓	13·8, 16·7, 21·4 ↑	18·1, 16·7, 16·2 ↓	8·29, 8·54, 8·93 ↑	2942, 2904, 2877	1201, 1200, 1070 ↓	13·9, 13·1, 12·0 ↓	3·3, 3·3, 2·8 ↓
Non-sugar-sweetened beverages	14·4, 14·7, 13·9	13·6, 13·4, 12·8	17·3, 17·5, 19·4 ↑	8·33, 8·56, 8·15	2990, 3056, 3188	1235, 1262, 1221	13·1, 13·4, 14·1	3·5, 3·7, 3·9

%TE, percentage of total energy; DED, dietary energy density; RTEBC, ready-to-eat breakfast cereals.
T1, T2 and T3 describe mean intake values of the indicator being examined for each of the small (T1), medium (T2) and large (T3) portion size tertiles.
'↑' denotes a significant increase in values of the dietary quality indicator being examined with increasing portion size; '↓' denotes a significant decrease in values of the indicator being examined with increasing portion size; '–' denotes no discernible trend in values of the indicator across portion size tertiles, though significant differences may exist between pairs. Significance accepted at the level of $P<0·05$.

Table 3 Mean daily nutrient intakes (energy-adjusted) by tertile of food portion size on the days the food was consumed by a nationally representative sample of adolescents aged 13–17 years (*n* 441), Republic of Ireland

	Saturated fat (%TE)	Added sugars (%TE)	Dietary fibre (g/10 MJ)	DED (kJ/g)	Na (mg/10 MJ)	Ca (mg/10 MJ)	Fe (mg/10 MJ)	Vitamin D (μg/10 MJ)
Mean intake	13·9	12·7	19·1	8·57	3107	1076	15·6	3·2
	T1, T2, T3	T1, T2, T3	T1, T2, T3	T1, T2, T3	T1, T2, T3	T1, T2, T3	T1, T2, T3	T1, T2, T3
Pasta, boiled	13·4, 13·2, 13·8	11·9, 10·7, 9·8	20·2, 20·4, 21·5	7·70, 7·47, 7·05	3024, 2915, 2508 ↓	1161, 1065, 1026	15·9, 17·5, 21·7	3·3, 3·8, 3·3
White bread & rolls	14·2, 13·9, 13·7 ↓	13·2, 13·2, 11·3 ↓	18·5, 18·7, 18·0	8·70, 8·63, 9·03 ↓	3086, 3269, 3474 ↑	1056, 1114, 1133	14·0, 16·0, 14·3	3·5, 3·0, 2·8
Brown bread & rolls	13·6, 13·5, 13·1	12·2, 11·0, 10·3	21·9, 23·3, 26·3 ↑	8·19, 8·06, 7·80	3351, 3122, 3361	1044, 1193, 1151 ↑	15·9, 15·6, 17·6	3·3, 4·2, 3·6
Potatoes, boiled	14·5, 13·2, 13·1 ↓	12·4, 11·5, 10·9	19·4, 22·3, 22·4 ↑	7·63, 7·10, 6·59 ↓	3183, 3145, 2884 ↓	1147, 1056, 1043	15·5, 16·2, 15·3	3·4, 3·5, 3·6
Chips & wedges	14·1, 13·0, 13·4 ↓	13·7, 13·4, 12·0 ↓	18·5, 18·9, 20·1 ↑	9·12, 9·12, 9·40	3113, 2932, 2633 ↓	1017, 937, 840 ↓	15·6, 13·8, 13·8 ↓	2·7, 2·6, 2·2 ↓
RTEBC	14·1, 13·9, 13·4	13·1, 21·9, 11·9	20·1, 18·4, 20·7 –	8·40, 8·64, 8·86	3056, 3041, 2983	1126, 1208, 1271 ↑	15·5, 16·0, 20·4 ↑	3·3, 3·8, 3·7
Fruit, excl. dried	13·9, 13·0, 12·8 ↓	13·0, 11·5, 10·6 ↓	19·9, 23·1, 25·6 ↑	7·95, 7·12, 6·61 ↓	2990, 2920, 2995	1069, 1085, 1108	16·4, 14·9, 17·1	3·6, 3·7, 4·0
Vegetables, excl. pulses	13·9, 13·7, 13·6	12·3, 12·0, 11·0	18·1, 20·2, 22·4 ↑	8·56, 7·46, 6·86 ↓	3073, 3115, 3057	1077, 1120, 1118	14·4, 15·9, 16·3 ↑	3·5, 3·7, 3·8
Baked beans	13·4, 12·9, 12·8	12·3, 12·2, 11·2	23·1, 27·5, 34·9 ↑	8·17, 7·98, 7·52	3590, 3852, 3994	1132, 1050, 1202	14·2, 17·6, 19·1 ↑	3·5, 2·8, 3·6
Luncheon meats	13·8, 13·8, 14·4	14·1, 12·0, 11·1 ↓	19·5, 19·9, 18·0 ↓	8·82, 8·24, 8·55	3229, 3491, 3696 ↑	1114, 1187, 1216	15·1, 14·8, 13·8	3·1, 3·0, 3·1
Frying meats	14·4, 15·1, 14·8	12·5, 11·4, 11·5	19·7, 17·8, 16·5 ↓	8·81, 8·66, 9·31	3530, 3951, 3939 ↑	1029, 1066, 976	13·1, 14·5, 13·6	3·3, 3·7, 3·5
Whole milk	13·5, 14·0, 16·2 ↑	14·2, 13·0, 10·5 ↓	19·2, 19·3, 17·4 ↓	8·75, 8·60, 8·62	3186, 3059, 2920 ↓	941, 1091, 1392 ↑	15·3, 17·1, 14·3 –	2·7, 3·3, 3·3
Reduced-fat milks	12·4, 12·0, 12·6	12·6, 13·0, 11·6	21·4, 22·7, 19·3	8·51, 8·04, 8·51	3251, 3221, 3086	1058, 1278, 1581 ↑	15·3, 19·6, 19·4 ↑	3·9, 4·7, 4·6
Cheeses	13·9, 15·8, 17·9 ↑	12·4, 12·1, 10·4 ↓	19·5, 17·9, 17·8 ↓	8·53, 8·45, 9·05 ↑	3230, 3184, 3366 ↑	1156, 1333, 1533 ↑	15·8, 15·1, 15·5	3·1, 3·9, 3·4
Butter & spreads >59 % fat	13·5, 14·3, 15·8 ↑	12·9, 12·9, 10·8 ↓	19·5, 18·9, 18·4	8·41, 8·91, 9·12 ↑	3113, 3282, 3209	1090, 1120, 1075	13·5, 14·6, 14·9	2·6, 3·2, 3·1
Low-fat spreads <38 % fat	12·5, 12·7, 13·4	12·9, 12·3, 11·9	20·9, 21·7, 20·2	8·00, 8·00, 8·47	3249, 3510, 3232	1084, 1114, 1129	17·8, 15·3, 13·1	4·4, 4·8, 4·8
Biscuits	14·3, 14·5, 14·9	14·2, 13·9, 12·6	19·5, 18·7, 18·6	8·59, 8·73, 9·11	3108, 3005, 2901	1067, 1105, 1068	16·0, 16·7, 14·9	3·6, 3·8, 2·6
Chocolate confectionery	14·3, 14·9, 15·5 ↑	16·7, 16·3, 15·5	18·5, 16·7, 15·8 ↓	8·77, 9·28, 9·74 ↑	2948, 2818, 2733 ↓	1087, 1010, 1008	14·8, 13·8, 13·8	3·1, 2·7, 2·8
Sugary sweets	14·4, 13·4, 12·2 ↓	19·2, 20·4, 18·7	17·6, 16·3, 15·0	9·14, 9·17, 9·25	2884, 2894, 2732	1028, 1021, 904	12·8, 12·5, 13·3	2·9, 3·2, 3·0
Crisps	14·8, 14·8, 15·2	13·6, 14·8, 13·7	19·5, 20·4, 20·0	9·30, 9·40, 9·86	2962, 3193, 3005	1070, 930, 902 ↓	13·0, 12·2, 14·3	3·0, 2·9, 2·8
Sugar-sweetened beverages	13·8, 13·4, 12·8 ↓	16·0, 17·8, 16·0 –	18·3, 17·4, 16·2 ↓	8·58, 9·13, 9·27 ↑	3165, 3007, 2872 ↓	1068, 983, 931 ↓	14·7, 13·3, 12·9 ↓	3·4, 2·7, 2·5 ↓
Non-sugar-sweetened beverages	14·0, 13·3, 14·3	12·0, 12·4, 11·3	20·3, 19·0, 18·0	8·24, 8·84, 8·80	3162, 3043, 3339	1031, 950, 1090	14·3, 13·5, 13·4	3·0, 3·2, 2·9

%TE, percentage of total energy; DED, dietary energy density; RTEBC, ready-to-eat breakfast cereals.
T1, T2 and T3 describe mean intake values of the indicator being examined for each of the small (T1), medium (T2) and large (T3) portion size tertiles.
'↑' denotes a significant increase in values of the dietary quality indicator being examined with increasing portion size; '↓' denotes a significant decrease in values of the indicator being examined with increasing portion size; '–' denotes no discernible trend in values of the indicator across portion size tertiles, though significant differences may exist between pairs. Significance accepted at the level of $P<0.05$.

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baked beans were consumed, and were lower on the days larger portions of sugar-sweetened beverages were consumed. Intakes of vitamin D were lower on the days larger portions of chips and sugar-sweetened beverages were consumed.

Discussion

Saturated fat

Lower intakes of saturated fat were observed on the days larger portions of white bread, boiled potatoes, fruit, sugary sweets and sugar-sweetened beverages were consumed. In this, there appears to be some evidence for the 'sugar–fat see-saw' phenomenon, whereby as sugar intakes (total, added or non-milk extrinsic) as a percentage of total energy increase, fat intakes decrease[31–33]. The significance of this is that dietary guidance for these population groups must be carefully considered, as goals recommending simultaneous reductions in the proportion of energy coming from saturated fat and sugar may be difficult to achieve[34,35]. As might be expected, intakes of saturated fat were higher on the days larger portions of whole milk, cheese, butter and chocolate were consumed. There was a marked difference between the saturated fat intakes of consumers of whole and reduced-fat milks, regardless of the portion size consumed; a similar difference was observed between consumers of butter and reduced-fat spreads. In both groups, the highest saturated fat intakes recorded were observed on the days larger portions of cheese were consumed.

Added sugars

Intakes of added sugars were significantly higher on the days larger portions of sugary sweets and sugar-sweetened beverages were consumed in children, but not in adolescents. In both groups, however, intakes of added sugars were highest on the days large portions of sugary sweets were consumed (23·0 and 18·7 %TE, respectively). These values were above mean intake values for the cohorts as a whole (15·0 and 12·7 %TE, respectively) and well above the population goal of a maximum of 11 %TE from added sugars daily[36].

Dietary fibre

Intakes of dietary fibre increased significantly with increasing portion size of baked beans in both children and adolescents. Children and adolescents who consumed large portions of baked beans had mean dietary fibre intakes of 30·2 and 34·9 g/10 MJ, respectively, on the days they were consumed; these are the highest intakes reported for dietary fibre in the current analysis and are significantly higher than the mean values reported for the cohorts as a whole (18·3 and 19·1 g/10 MJ, respectively). In both groups, intakes of dietary fibre increased significantly with increasing portion size of brown (but not white) bread. Children and adolescents who consumed brown bread had higher dietary fibre intakes on the days it was consumed compared with the mean values for the cohorts as a whole, and were among a minority of consumers to meet the European Food Safety Authority's dietary fibre recommendation of 2 g/MJ daily[37]. This finding provides further support for the current dietary guidance in Ireland, which is to choose 'mostly wholegrain' breads for digestive health[38].

Sodium

In both children and adolescents, intakes of Na were significantly higher on the days larger portions of frying meats were consumed. Children and adolescents who consumed large portions of frying meats had mean Na intakes of 4051 and 3939 mg/10 MJ, respectively, notably higher than the mean Na values for the cohorts (3007 and 3107 mg/10 MJ, respectively). Current dietary guidance in Ireland does address this in recommending that 'processed meats such as bacon or ham' be limited due to their high salt content[38]. In both groups, intakes of Na were higher on the days larger portions of white (but not brown) bread were consumed.

Micronutrients (calcium, iron and vitamin D)

Larger portions of RTEBC were associated with increased intakes of Ca and Fe (and a range of B-vitamins for which results are not published) on the days they were consumed in both children and adolescents, agreeing with previous findings on the beneficial effects of RTEBC consumption on micronutrient intakes in children aged 4–15 years[39–41]. This is likely to reflect both the fortification of RTEBC and the additional milk that tends to be consumed with them. Ca intakes were higher in both groups on the days larger portions of whole and reduced-fat milks and cheese were consumed. Fe intakes were significantly increased in both children and adolescents on the days larger portions of baked beans were eaten. In both children and adolescents, decreased intakes of Ca, Fe, vitamin D (and a range of other micronutrients for which results are not published) were observed on the days larger portions of sugar-sweetened beverages were consumed. Interestingly, however, no such effect was observed with increasing portion size of non-sugar-sweetened beverages in either group, despite comparable portion weights of both beverage types being consumed (Table 1). Increased intakes of sugar-sweetened beverages have previously been linked to micronutrient dilution in both children and adolescents[29,37,38]. There were relatively few relationships observed between intakes of vitamin D and portion sizes of any foods. This may be explained by the fact that dietary intakes of vitamin D are known to be largely influenced by the use or non-use of a vitamin D-containing supplement, rather than dietary intake, in Irish children and adolescents[10].

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Dietary energy density

In the current study, DED was significantly lower on the days larger portions of boiled potatoes, fruit and vegetables were consumed in both children and adolescents. It has previously been observed that Irish and Swedish children and adolescents in low DED tertiles are more likely to be consumers of potatoes, fruit and vegetables, and to have higher energy-adjusted intakes of these foods[12,42]. In the current work, DED was significantly higher in both children and adolescents on the days larger portions of sugar-sweetened beverages were consumed. As DED was calculated to include foods only (and exclude beverages) however, the sugar-sweetened beverages themselves cannot be responsible for the increased DED. Instead, it would seem that they are markers for the consumption of other foods that, in turn, affect DED. Interestingly, on the days larger portions of non-sugar-sweetened beverages were consumed, there was no increase in DED in either children or adolescents.

Reasons for observations described

There appear to be three discernible trends with respect to the observations described in the present study. First, larger food portion sizes may be associated with increased intake of a nutrient as a consequence of the composition of the food itself (e.g. larger portions of high-salt frying meats were associated with increased Na intakes on the days they were consumed). Findings may also occur as a result of 'food associations' resulting from typical patterns of consumption. This might explain, for example, why DED was significantly higher in both groups on the days larger portions of sugar-sweetened beverages were consumed, although beverages themselves were excluded from the calculation of DED. Lastly, some observations may be explained by food displacement. For instance, children who consumed large portions of sugary sweets had decreased intakes of many micronutrients on the days they were consumed. As the sweets cannot be responsible for the decreased micronutrient intakes *per se*, it may be that the consumption of large portions of sweets displaced other micronutrient-dense snacks, such as fruit or yoghurt, from the diet on the days they were consumed.

Strengths and limitations of the work

The current analyses are based on food intake data that have been collected from nationally representative samples of the population and very carefully quantified, and therefore are based upon a set of high-quality and reliable portion weight data. The work is novel for its focus on food portion size in relation to dietary quality (rather than energy intake), and for examining a wide range of foods, rather than just energy-dense foods, which are more typically involved in discussions on food portion size. A limitation of the work is that it did not take into account the number of eating occasions per day of any the foods examined. A recent study using cross-sectional data to examine the relative contributions of portion size, energy density and number of eating occasions to increased daily energy intakes in adults in the USA (1977–2006) found that changes in portion size and number of eating occasions had accounted for most of the change[43], and so inclusion of this information would have provided a more complete picture on the relationship between food portion size and dietary quality. Since it was not possible to know by which means energy under-reporting had occurred, and some provision had been made to help minimise its effect on outcomes (by energy-adjusting), we believe that the inclusion of all reporters in the current study is acceptable. Additionally, as the aim of the study was to describe eating patterns in a nationally representative sample, the exclusion of all under-reporters could have introduced a secondary 'selection bias' to the work[44].

Policy implications and practical uses for the work

Reduction in portion size, particularly for energy-dense foods, to reduce DED and energy intake and to help tackle the obesity epidemic is increasingly addressed in healthy eating guidelines. The findings of the current study provide a useful evidence base to support the portion size guidance related to DED and dietary energy intake currently available for Irish children and adolescents. The study also identifies potential effects on dietary quality (both positive and negative) of varying portion sizes of different energy-dense foods, as well as other foods. This may help to further develop guidance on food portion sizes, e.g. relating guidance to foods that may be appropriate to consume in larger quantities. Findings from the study will also be of use to policy makers in devising strategies to target intakes of specific nutrients going forward, particularly if considered in conjunction with previously published data on the typical portion weights of foods consumed by these groups[45].

Conclusions

The current study describes observations between food portion sizes and indicators of dietary quality in Irish children and adolescents on the days the foods were consumed. Energy under-reporters (32 % of children, 64 % of adolescents) were not excluded from the analysis. Lower DED and saturated fat intakes, and higher dietary fibre intakes were observed on the days larger portions of fruit and boiled potatoes were consumed. Higher DED and lower micronutrient intakes were observed on the days larger portions of sugar-sweetened beverages were consumed. Findings from the current work will form an evidence base from which more specific dietary guidance relating to portion size may be developed and may be of use where strategies are being devised to target intakes of specific nutrients going forward.

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