

## Whole grain intakes in the diets of Irish children and teenagers

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### Abstract

A growing body of evidence supports the inclusion of whole grain foods in the diet to help prevent certain chronic diseases. Although much of the research has been conducted in adult cohorts, it is thought that younger populations may also benefit from whole-grain-rich diets. The aim of the present study was to quantify the intake of whole grain in Irish children and teenagers, and assess the major sources of intake. Data used in the present study were from the National Children's Food Survey and the National Teens' Food Survey, which used 7 d food diaries to collect data on habitual food and beverage consumption in representative samples of Irish children and teenagers. Results showed that over 90% of children (5–12 years) and over 86% of teenagers (13–17 years) are consumers of whole grain, with mean daily intakes of 18.5 and 23.2 g/d, respectively. Ready-to-eat breakfast cereals made the greatest contribution to whole grain intakes for both children and teenagers (59.3 and 44.3%), followed by bread (14.4 and 26.5%), with wheat being the major source of intake, accounting for over 65% of all whole grains consumed. Whole grain consumers had significantly higher intakes of fibre, P and Mg in comparison with non-consumers of whole grain, even though whole grain intakes in this sample were well below the recommendation of three servings or 48 g/d. The present study characterises, for the first time, the patterns of whole grain consumption in Irish children and teenagers and shows whole grain intake to be low.

**Key words:** Whole grain intakes: Children: Teenagers: Ireland: Intake patterns

The inclusion of whole-grain-rich foods in the daily diet is widely promoted, with epidemiological studies showing regular consumption of whole grain foods (three servings or 48 g/d) to be associated with a reduced risk of CVD, diabetes<sup>(1–3)</sup>, certain cancers<sup>(4)</sup> and obesity<sup>(5)</sup>. A number of randomised controlled trials have also produced encouraging results, with increasing intakes favourably influencing LDL-cholesterol, systolic blood pressure, insulin and C-reactive protein<sup>(6–8)</sup>. However, much of the current research has concentrated on the adult population, with few studies considering the effects of whole grain consumption in younger age groups<sup>(9,10)</sup>.

Whole grains have been defined by the American Association of Cereal Chemists<sup>(11)</sup> as consisting of 'the intact, ground, cracked or flaked caryopsis whose principal anatomical components (the endosperm, germ and bran) are present in the same relative proportions as they exist in the intact caryopsis'. However, the definition of what qualifies as a whole grain food is widely debated, and has resulted in a variety of health and content claims. One such health claim, in relation to heart disease and certain cancers, defines whole grain foods as those containing 51% or more whole grain

ingredients<sup>(12)</sup>. In comparison, to use a whole grain stamp on food packaging in Canada and the USA, the food must contain at least 8 g of whole grain ingredients per serving<sup>(13)</sup>. Few official government regulations define how much whole grain must be in a product to be deemed a whole grain food. As a result, studies assessing population whole grain intakes have differed in their criterion as to what qualifies as a whole grain food, with some studies including all foods containing a source of whole grain<sup>(14)</sup>, while others only include foods made with a certain amount of whole grain<sup>(15)</sup>.

Dietary recommendations for daily whole grain intakes have been proposed, with suggested intakes ranging from 48 g in the USA and Australia<sup>(16,17)</sup>, to 75 g in Sweden and Denmark<sup>(18)</sup>, to 115 g in the Netherlands<sup>(19)</sup>; however, the UK<sup>(20)</sup> and Germany<sup>(21)</sup> have a more vague approach, and suggest that 'cereal products such as bread, pasta, rice and grain should preferably be whole grain'. Despite these recommendations, present intakes of whole grain in adults remain low, with research showing daily intakes in the USA<sup>(22)</sup> and UK<sup>(23)</sup> to be 11 and 23 g, respectively. Intakes of whole grain in children and teenagers are also reported to be low, with daily

**Abbreviations:** NCFs, National Children's Food Survey; NTFs, National Teens' Food Survey; RTEBC, ready-to-eat breakfast cereal.

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intakes of 9.8, 13 and 26.4 g in the USA<sup>(24)</sup>, UK<sup>(15)</sup> and Germany<sup>(14)</sup>, respectively, and just 5 and 8% of children and teenagers are meeting recommendations in Denmark<sup>(18)</sup> and France<sup>(25)</sup>, respectively.

To date, there is no information on patterns of whole grain consumption in the Irish population, and so the aim of the present study was to quantify the intake of whole grains in the diets of Irish children and teenagers, and to assess the major sources of intake across age groups and mealtimes using data from the National Children's Food Survey (NCFS) and the National Teens' Food Survey (NTFS).

## Methodology

### *National Children's Food Survey and National Teens' Food Survey*

The NCFS and the NTFS were cross-sectional surveys conducted in representative samples of Irish children and teenagers between 2003–4 and 2005–6, respectively (Irish Universities Nutrition Alliance; IUNA, <http://www.iuna.net>). These studies were conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects/patients were approved by the St James's Hospital and Federated Dublin Voluntary Hospitals Joint Research Ethics Committee (NCFS) and the University College Cork Clinical Research Ethics Committee of the Cork Teaching Hospitals (NTFS). Written informed consent was obtained from all participants and their parents as appropriate. In total, 1035 participants took part (594 children: 293 boys, 301 girls and 441 teenagers: 224 males, 217 females). The age of the children was in the range from 5 to 12 years and that of the teenagers from 13 to 17 years. The overall response rate was 66% for the NCFS and 63% for the NTFS. The samples were representative of both population groups with respect to sex, age, location and social class, as per the most recent Irish census<sup>(26)</sup>. More detailed information about the population groups can be found at <http://www.iuna.net>

### *Data collection*

Food and beverage intake was determined using a 7 d weighed food diary for the NCFS and a 7 d semi-weighed food diary for the NTFS. Detailed information was recorded regarding the amount and types of all foods and beverages consumed over the seven consecutive survey days (at brand level where possible). Food and beverage intakes were assessed using WISP version 3.0 (Tinuviel Software), which uses data from the McCance and Widdowson's *The Composition of Foods* fifth and sixth editions<sup>(27,28)</sup>, plus supplemental volumes<sup>(29–37)</sup>. Food package

labelling was also used to assess food and beverage intakes where necessary. Each food and beverage was allocated an individual food code and subsequently assigned to one of sixty-eight food groups for ease of analysis, e.g. savoury snacks and ready-to-eat breakfast cereals (RTEBC).

In addition to comprehensive dietary information, detailed data on socio-economic level and lifestyle were also collected. Full study details, including quantification methods used, are described by Joyce *et al.*<sup>(38)</sup>.

### *The National Food and Ingredient database*

During the NCFS and the NTFS, food packaging of the consumed foods and beverages were collected and used to record information about the products. The information gathered created the Irish National Food and Ingredient Database<sup>(39)</sup>. General information recorded included brand name, product description, portion weight, country of origin and manufacturers' details. In addition, ingredient listings and nutritional information per 100 g of product were recorded. Where possible, foods were recorded at brand level and allocated an individual brand ID that could be linked back to actual consumption patterns.

### *Calculation of whole grain intakes*

The NCFS and the NTFS databases were initially searched to identify potential foods made with whole grain. From the sixty-eight original food groups, fourteen were identified as containing whole grain.

All foods within each of these fourteen food groups were then checked for the presence of whole grain and a new whole grain database was created. All foods made with whole grain ingredients were included in the present study. The grains included in the present study were grouped into one of six groups: wheat, oats, rice, maize, barley and rye (Table 1).

The amount of whole grain in each product per 100 g was recorded in the database. As the NCFS and the NTFS collected information at brand level where possible, values for whole grain could be ascribed at a brand-specific level. These values were obtained either from the food package labelling (Irish National Food and Ingredient Database) using quantitative ingredient declaration percentages or directly from the manufacturer. Where brand-specific data were not available, the whole grain content of a comparable product was used (if the ingredient list of a known whole grain product was identical to that of an unknown product); an average of similar products was used where such detail was lacking. A recipe database previously created from the NCFS and the NTFS

**Table 1.** Whole grains and the classifications considered in the present study divided into one of six whole grain groups

Wheat	Oats	Rice	Maize	Barley	Rye
Whole grain wheat	Rolled oats	Whole grain rice	Whole grain maize	Whole barley flakes	Whole rye flour
Whole wheat flakes	Whole oat flour	Brown rice	Whole grain maize		Whole rye flakes
Whole wheat durum	Oat flakes		Popcorn		
Wholemeal flour	Oatmeal				
Spelt					

was also used where appropriate, taking water losses from cooking and processing into account. The whole grain values collected per 100 g of product were then used to calculate the actual amounts of whole grain consumed.

For ease of analysis, the original sixty-eight food groups were reduced to ten food groups, one of which was a whole grain food group. This whole grain food group was subsequently broken down into the following seven sub-groups: (1) rice, pasta and their dishes; (2) breads and rolls; (3) RTEBC; (4) other breakfast cereals (including porridge and cooked breakfast cereals); (5) sweet biscuits, cereal bars and desserts; (6) savoury biscuits, crackers and popcorn; and (7) meat products, tofu and yoghurts.

### Statistical analysis

Statistical analyses were carried out using PASW Statistics version 18.0 (SPSS, Inc.). The mean and standard deviations for whole grain consumed according to sex, age group, social class, eating location and day of the week were calculated for both the total population and consumers only. Differences within the groups were detected using independent *t* tests or by one-way ANOVA as appropriate. Independent samples *t* tests were also used to test for significant differences in mean daily intakes of macro- and micronutrients for consumers and non-consumers of whole grain. In addition, the percentage contribution of each whole grain food group was analysed and the type of grains consumed were identified. Tertile analysis was also carried out in relation to whole grain intakes and values were adjusted for age and sex using ANCOVA. The Bonferroni *post hoc* test was used to identify the significant differences between each of the groups.

Further analysis was carried out to determine the proportion of Irish children and teenagers meeting whole grain recommendations set out by the United States Department of Agriculture. The data were assessed using both the recommendation of three servings (or 48 g/d<sup>(16)</sup>) and using recommendations accounting for differences in energy intake<sup>(16,40)</sup>. For both methods, two approaches were used to assess adherence. First, the percentage of individuals in a population who met the dietary target for whole grain for the total population was calculated and referred to as 'approach 1'. However, population goals relate to the recommended mean intake of a population and it is not necessary for all individuals to achieve this intake. Compliance was also, therefore, estimated by the method of Wearne & Day<sup>(41)</sup> and referred to as 'approach 2'. This approach calculated the maximum size of a subgroup of the population, known as compliers, whose mean intake equals the population dietary recommendation. To calculate the percentage of compliers meeting the recommendation, mean daily whole grain intakes of each individual were ranked in descending order from the highest to the lowest. The mean intake of the group was calculated. The individual with the lowest mean intake of whole grain was then removed and the calculation repeated. This procedure continued until the mean result of the group was  $\geq 48$  g. The percentage of children and teenagers achieving the whole grain recommendation was then calculated.

## Results

### Whole grain intake

Tables 2 and 3 present the mean daily intakes of whole grain (g/d) for all children and teenagers. The data are described for sex, age group, social class, eating location and day of the week, for both the total population and whole grain consumers only. Overall, 90.5% of children and 86.6% of teenagers were consumers of whole grain. Mean daily intakes were 18.5 and 23.2 g/d for children and teenagers, respectively, in the total population, rising to 20.5 g/d (children) and 26.9 g/d (teenagers) in consumers only. In both age groups, males consumed significantly higher amounts of whole grain than females (22.0 g/d in children and 28.6 g/d in teenagers *v.* 15.1 g/d in children and 17.7 g/d in teenagers). Intakes of whole grain also tended to increase with age, although this was only significant for teenagers, with values in 'consumers only' increasing from 23.1 g/d (13–14 years) to 29.9 g/d (15–17 years). The home was the primary location for whole grain consumption ( $P < 0.001$ ), with minimal amounts eaten at other homes (e.g. home of friends, relatives and child minders) and outside of the home (e.g. restaurants). There was no significant difference between whole grain consumption at weekends in comparison to weekdays.

### Sources of whole grain intake

For both children and teenagers, wheat was the major grain contributing to whole grain intake, providing 65 and 67% of whole grain intakes, respectively. Oats were the second highest contributor (16.2 and 18.4%, respectively), with maize, rice, barley and rye providing lesser amounts of whole grain to the diet (Fig. 1).

Mean daily whole grain intakes (g/d) and the percentage contribution (%) of the seven whole grain food groups to total whole grain intake are presented for whole grain consumers and across tertiles of intake in Table 4. For both children and teenagers, the main food group contributor to whole grain intakes was the RTEBC group (59.3 and 44.3%, respectively), followed by bread and rolls (14.4 and 26.5%, respectively). Across the tertiles of intake, those in the highest tertile had significantly greater intakes of the food groups: 'RTEBC'; 'bread and rolls'; 'savoury biscuits, crackers and popcorn'; and 'other breakfast cereals', in comparison to those children and teenagers in the lowest tertile.

As expected, for both children and teenagers, the majority of whole grain was consumed at breakfast (62.4 and 54.0%), with more than 75% of whole grain eaten at this meal coming from RTEBC. The next most popular time to consume whole grain foods was as a snack, followed by lunch and dinner. This was evident for both children and teenagers. For children, the most popular whole grain food consumed as a snack was 'savoury biscuits, crackers and popcorn' (48%), while 'bread and rolls' (33%) was the most popular choice for teenagers. 'Bread and rolls' was also the main contributor to whole grain intakes at lunch for both children (54%) and teenagers (79%), while the 'rice, pasta and their dishes' food group was the main contributor at dinner (37 and 74.3% for children and teenagers, respectively) (data not shown).

**Table 2.** Descriptive analysis of whole grain intake (g/d) for Irish children (total population and consumers only) (Mean values, medians and standard deviations; number of children and percentages)

	Children													
	Total population (n 594)							Consumers only (n 538; 90.5%)						
	n	%	Mean	Median	SD	P97.5	P	n	%	Mean	Median	SD	P97.5	P
Total population	594	100	18.5	12.7	18.2	68.5		538	90.5	20.5	14.7	18.0	68.9	
Sex							***							***
Male	293	49.3	22.0	15.6	21.5	72.7		259	88.4	24.9	19.2	21.1	75.2	
Female	301	50.6	15.1	11.6	13.5	49.3		279	92.7	16.4	12.4	13.2	49.4	
Age							NS							NS
Age group 1†	296	49.8	17.5	12.7	16.3	60.9		267	90.2	19.4	14.3	16.1	62.7	
Age group 2†	298	50.1	19.5	12.7	19.8	71.6		271	90.9	21.5	15.2	19.7	72.3	
Social class							**							*
Professional/managerial	307	52.4	20.7 <sup>a</sup>	15.6	18.5	68.3		285	92.8	22.3 <sup>a</sup>	17.1	18.3	68.5	
Non-manual	117	20	18.6 <sup>a,b</sup>	12.6	17.9	70.9		110	94.0	19.8 <sup>a,b</sup>	13.4	17.8	71.1	
Skilled manual	93	15.9	13.8 <sup>b</sup>	9.1	15.4	66.7		82	88.2	15.6 <sup>b</sup>	12.3	15.5	68.6	
Semi-skilled + unskilled	68	11.6	14.8 <sup>a,b</sup>	8.2	18.2	65.6		53	77.9	19.0 <sup>a,b</sup>	10.8	18.6	82	
Eating location							***							***
Home	594	100	17.7 <sup>a</sup>	12.1	17.6	68.5		533	89.7	19.7 <sup>a</sup>	13.8	17.5	68.9	
Other home	349	58.7	0.79 <sup>b</sup>	0	2.6	6.2		83	23.8	3.3 <sup>b</sup>	2.3	4.4	22.5	
Outside home	464	78.1	0.55 <sup>b</sup>	0	2.4	6.1		68	14.7	3.8 <sup>b</sup>	2.7	5.2	20.4	
Day of week							NS							NS
Weekday	594	100	19.3	13.5	19.6	69.4		522	87.9	22	15.9	19.4	15.9	
Weekend	594	100	16.7	9.5	22	72.9		407	68.5	24.5	18.9	22.7	18.9	

<sup>a,b</sup> Mean values with unlike superscript letters were significantly different between mean daily intakes of whole grain (ANOVA with Bonferroni correction). Mean values were significantly different: \*  $P < 0.05$ , \*\*  $P < 0.01$ , \*\*\*  $P < 0.001$ , NS ( $P \geq 0.05$ ).  
 † Age group 1: 5–8 years; age group 2: 9–12 years.

*Whole grain intakes and dietary recommendations*

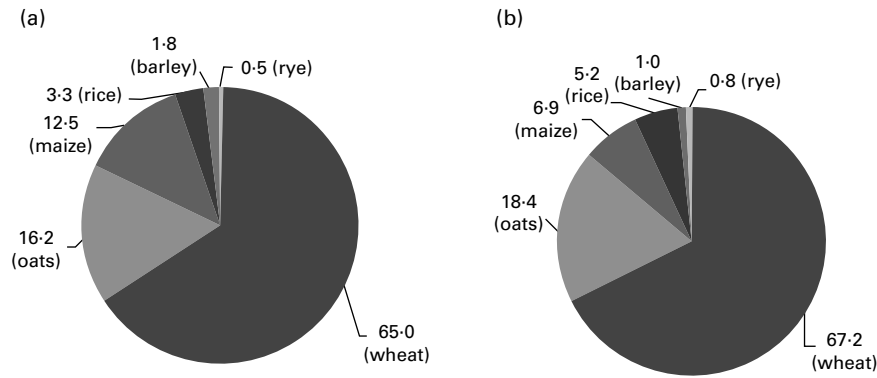
The percentage of Irish children and teenagers meeting whole grain recommendations<sup>(16)</sup> using both ‘approach 1’ and ‘approach 2’, are presented in Table 5. Using approach 1, which assesses individual compliance with the recommen-

dations, over 5% of children and almost 15% of teenagers were meeting the whole grain recommendation of three servings (48 g/d), while those meeting recommendations based on energy intake were 7.7% for children and 12% for teenagers. Using approach 2, which focuses on the proportion

**Table 3.** Descriptive analysis of whole grain intake (g/d) for Irish teenagers (total population and consumers only) (Mean values, medians and standard deviations; number of children and percentages)

	Teenagers													
	Total population (n 441)							Consumers only (n 382; 86.6%)						
	n	%	Mean	Median	SD	P97.5	P	n	%	Mean	Median	SD	P97.5	P
Total population	441	100	23.2	13.4	29.5	97.9		382	86.6	26.9	18.1	30.2	105.5	
Sex							***							***
Male	224	50.7	28.6	19.3	35.0	130.7		196	87.5	32.7	23.6	35.6	137.1	
Female	217	49.2	17.7	10.5	21.3	89.1		186	85.7	20.7	12.8	21.7	92.9	
Age							*							*
Age group 1†	188	42.6	19.6	11.2	22.9	87.3		161	85.6	23.1	15.6	23.2	92.1	
Age group 2†	253	57.3	25.9	14.8	33.4	122.1		221	87.4	29.9	19.1	34.4	131.2	
Social class							*							*
Professional/managerial	214	49.9	26.5 <sup>a</sup>	17.8	32.4	96.5		192	89.7	29.6 <sup>a</sup>	20.5	32.9	104.8	
Non-manual	79	18.4	23.1 <sup>a,b</sup>	9.9	31.9	118.5		67	84.8	27.3 <sup>a,b</sup>	15.5	33.0	125.7	
Skilled manual	85	19.8	20.6 <sup>a,b</sup>	10.7	24.2	88.9		73	85.9	24.1 <sup>a,b</sup>	13.4	24.5	97.5	
Semi-skilled + unskilled	51	11.8	11.8 <sup>b</sup>	4.3	15.6	67.0		40	78.4	15.1 <sup>b</sup>	9.7	16.2	74.4	
Eating location							***							***
Home	441	100	21.5 <sup>a</sup>	10.6	29.4	95.4		365	82.8	25.9 <sup>a</sup>	15.9	30.5	104.4	
Other home	192	43.5	0.9 <sup>b</sup>	0	2.8	10.3		41	21.4	4.4 <sup>b</sup>	3.1	4.6	19.2	
Outside home	421	95.4	1.6 <sup>b</sup>	0	3.9	14.9		124	29.5	5.5 <sup>b</sup>	3.3	5.6	21.9	
Day of week							NS							NS
Weekday	441	100	24.6	14.0	32.5	117.2		364	82.5	29.9	19.6	33.5	122.9	
Weekend	441	100	20.5	7.7	31.9	116.0		277	62.8	32.6	21.8	35.0	130.9	

<sup>a,b</sup> Mean values with unlike superscript letters denote significant differences between mean daily intakes of whole grain (ANOVA with Bonferroni correction). Mean values were significantly different: \*  $P < 0.05$ , \*\*  $P < 0.01$ , \*\*\*  $P < 0.001$ , NS ( $P \geq 0.05$ ).  
 † Age group 1: 13–14 years; age group 2: 15–17 years.



**Fig. 1.** Contribution of whole grain ingredients (%) to daily whole grain intakes for Irish (a) children and (b) teenagers.

of the population that achieved the recommendations, 17% of the children and 39% of teenagers satisfied the 48 g/d recommendation, while 20% of children and 32% of teenagers satisfied the recommendations based on energy intakes.

### Consumers v. non-consumers of whole grain

A comparison of nutrient intakes between non-consumers and consumers of whole grain across the tertiles of intake for children and teenagers are presented in Table 6. For both children and teenagers, significant differences were seen for mean daily intakes of energy (MJ) and for a range of nutrients (fibre, P, K, Mg, riboflavin and niacin) across the tertiles of intake or when comparing consumers of whole grain with non-consumers of whole grain. The percentage energy contribution derived from added sugars for both children and teenagers was significantly lower in the highest tertile of whole grain intake in comparison to non-consumers of whole grain ( $P < 0.05$ ).

### Discussion

The present paper analysed whole grain intakes in the diets of Irish children and teenagers. Mean daily intakes were 18.5 g/d for children and 23.2 g/d for teenagers, with 90% of children and 86% of teenagers being consumers of whole grain. Comparable studies around the world have found similarly low results, with mean daily intakes of 9.8, 13.0 and 26.4 g/d in the USA<sup>(24)</sup>, UK<sup>(15)</sup> and Germany<sup>(14)</sup>, respectively. Consumer rates of children and teenagers in these aforementioned studies are reported to have been 55, 73 and 80%, respectively, all lower than that observed in this Irish population. However, there is currently no universally agreed list of whole grain foods and scientific studies can apply differing criteria when identifying a whole-grain-containing food, making direct comparisons between studies difficult. Moreover, a UK study only included foods made from a minimum whole grain content of 10%<sup>(15)</sup>, in comparison to the present study and that of Alexy *et al.*<sup>(14)</sup> (a German study), which included all sources of whole grain. The aim of the present study was to quantify whole grain intakes, and therefore it was deemed appropriate to include all sources of whole grain. Nevertheless, intakes

were well below the dietary recommendation of 48 g/d set out by the United States Department of Agriculture<sup>(16)</sup>, with just a maximum of 17% of children and 39% of teenagers observed to satisfy this recommendation. The suitability of applying this recommendation to younger children, where portion sizes are typically lower, is questionable; therefore, intakes were also assessed using recommendations that accounted for energy intake<sup>(16,40)</sup>. Using this second approach, similar numbers of children (20%) and teenagers (32%) satisfied the recommendations. Dietary recommendations for whole grain intake have been developed alongside growing evidence that increasing intakes of whole grain can protect against disease, specifically CVD<sup>(42)</sup>, type 2 diabetes<sup>(43)</sup> and certain cancers, e.g. colorectal cancer<sup>(44)</sup>. It is likely that the mechanisms by which these benefits are likely to occur (improved inflammatory status<sup>(45)</sup>, insulin response<sup>(6)</sup>, vascular function<sup>(46)</sup> and lipid profile<sup>(2)</sup>) may also play a role in younger cohorts, or at least pave the way for a healthier adulthood. Furthermore, a recent review investigating the link between whole grain consumption and colorectal cancer concluded that a diet rich in whole grains (90 g/d) could bring about a 20% reduced risk of developing colorectal cancer. The review also highlighted the protective effects of increasing fibre intakes, particularly cereal fibre (10 g/d), to reduce the risk by a further 10%<sup>(44)</sup>.

The composition of whole grains (the germ, the endosperm and the outer bran layers) makes them a rich source of vitamins, minerals, fibre and antioxidants. Even within the boundaries of the present study, we found that children and teenagers who consumed whole grain had more favourable intakes of fibre and a number of micronutrients in comparison to non-consumers of whole grain. The strong association between whole grain and fibre was clearly evident in the present study, with a stepwise increase observed across the tertiles of whole grain intake. These results are comparable to an American study, which also showed a positive relationship between whole grain and fibre consumption<sup>(24)</sup>. Although previous research in the present study population has showed fibre intakes to be poor<sup>(47,48)</sup> and below dietary recommendations<sup>(49)</sup>, the present study suggests that inclusion of whole-grain-rich foods in the daily diet presents a viable way of boosting fibre intakes as well as other micronutrients.



**Table 4.** Intake (g/10MJ per d) and contribution (%) of food groups to mean daily whole grain intakes across tertiles of intake in whole grain consumers (Mean values and standard deviations)

	Tertiles of mean daily whole grain intakes (g/10 MJ per d)																	P
	Whole grain consumers (n 538 children/382 teenagers)				Tertile 1 (n 179 children/127 teenagers)				Tertile 2 (n 180 children/128 teenagers)				Tertile 3 (n 179 children/127 teenagers)					
	% Cons	Mean	SD	% Ctr	% Cons	Mean	SD	% Ctr	% Cons	Mean	SD	% Ctr	% Cons	Mean	SD	% Ctr		
Ready-to-eat breakfast cereals																		
Children	72.3	22.2	19.0	59.3	45.8	7.5 <sup>a</sup>	4.8	41.0	79.4	16.1 <sup>b</sup>	8.6	56.0	91.6	35.0 <sup>c</sup>	21.9	62.7	***	
Teenagers	59.2	21.8	19.8	44.3	29.1	5.7 <sup>a</sup>	2.6	28.0	71.1	14.7 <sup>b</sup>	9.6	47.5	77.2	34.0 <sup>c</sup>	22.7	42.9	***	
Bread and rolls																		
Children	33.8	11.8	12.8	14.4	24.0	5.0 <sup>a</sup>	3.1	16.2	30.6	8.8 <sup>b</sup>	6.4	11.7	46.9	17.2 <sup>c</sup>	16.2	15.2	***	
Teenagers	49.0	17.7	20.5	26.5	33.1	5.7 <sup>a</sup>	3.8	30.4	45.3	12.4 <sup>a</sup>	8.1	21.3	68.5	27.4 <sup>b</sup>	26.3	30.6	***	
Savoury biscuits, crackers and popcorn																		
Children	40.9	8.2	7.8	12.0	31.3	5.5 <sup>a</sup>	3.5	21.5	47.8	8.3 <sup>b</sup>	5.7	19.3	43.6	9.9 <sup>c</sup>	11.0	8.1	***	
Teenagers	27.2	8.5	6.8	7.2	22.0	4.2 <sup>a</sup>	2.8	15.1	32.8	11.7 <sup>b</sup>	7.0	16.1	26.8	8.2 <sup>b</sup>	7.0	3.6	***	
Other breakfast cereals																		
Children	19.3	8.8	10.6	6.5	14.0	3.1 <sup>a</sup>	2.7	5.6	20.6	7.1 <sup>b</sup>	5.5	7.7	23.5	14.0 <sup>c</sup>	14.5	6.2	***	
Teenagers	17.0	18.1	18.2	10.8	8.7	5.0 <sup>a</sup>	2.9	7.1	15.6	12.9 <sup>a</sup>	9.0	9.1	26.8	25.6 <sup>b</sup>	21.4	11.2	***	
Rice, pasta and their dishes																		
Children	4.6	24.8	19.0	3.9	NA	NA	NA	NA	2.8	10.4	10.0	1.2	11.2	28.4	19.2	5.4	NA	
Teenagers	8.8	40.9	27.9	6.6	0.8	5.2	NA	1.3	1.6	7.5 <sup>a</sup>	4.4	0.4	13.4	46.9 <sup>b</sup>	25.7	8.6	*	
Sweet biscuits, cereal bars and desserts																		
Children	33.5	2.3	2.4	2.7	30.7	2.1	2.2	8.9	31.7	2.2	2.2	3.2	38.0	2.5	2.8	1.9	NS	
Teenagers	65.0	2.5	2.8	3.2	33.1	1.9	1.8	10.7	33.6	2.3	2.0	3.6	48.8	3.0	3.7	2.4	NS	
Meat, tofu and yoghurts																		
Children	14.9	2.1	1.4	1.1	21.8	2.3	1.6	6.7	10.0	2.3	1.4	0.9	12.8	1.8	1.0	0.5	NS	
Teenagers	17.5	2.3	2.0	1.4	17.3	2.5	1.7	7.4	14.8	2.9	2.7	2.0	20.5	1.8	1.4	0.6	NS	

% Cons, % consumers of each whole grain food group; % Ctr, % contribution of food groups to whole grain intakes; NA, not available.

<sup>a,b,c</sup> Mean values with unlike superscript letters were significantly different between the mean values of whole grain intake across the tertiles of whole grain intake (adjusted for sex) (ANCOVA, Bonferroni *post hoc* test).

Mean values were significantly different: \*  $P < 0.05$ ; \*\*\*  $P < 0.001$ ; NS ( $P \geq 0.05$ ).

Whole grain intakes in Ireland

**Table 5.** Percentage of Irish children and teenagers from the National Children's Food Survey and the National Teens' Food Survey meeting the whole grain recommendations advised by the United States Department of Agriculture<sup>(52)</sup>

Total population	Irish children and teenagers meeting whole grain recommendations			
	Recommendation of 48 g/d		Recommendation based on energy intakes*	
	Approach 1	Approach 2	Approach 1	Approach 2
Children (5–12 years)	5.5	17.2	7.7	20.4
Teenagers (13–17 years)	14.7	39.2	12.0	32.4

\* The recommendation suggests average daily intake amounts for whole grain at energy intakes of 4184 kJ (1000 kcal) to 13389 kJ (3200 kcal)<sup>(17)</sup>, and for those consuming < 4184 kJ (< 1000 kcal)<sup>(41)</sup>.

The major food group contributing to whole grain intake was RTEBC (52%). Other countries have also presented similarly high results, with RTEBC contributing 56% to whole grain intakes in British children and teenagers<sup>(15)</sup>, while in America, this figure is 31%<sup>(50)</sup>. The high consumption rates of whole grain RTEBC observed in this Irish population was no surprise (72% of children and 59% of teenagers), as earlier research has shown over 90% of Irish children and 81% of teenagers to be consumers of RTEBC<sup>(51,52)</sup>. European studies examining the change in food choices over time have also reported intakes of RTEBC to be rising<sup>(14,53)</sup>.

There are a number of strategies that could be followed to increase whole grain intakes in this population. For whole grain breakfast cereals, bread and rolls, the potential remains to increase the range of whole grain varieties available and/or to encourage an increased frequency of consumption of existing foods. Another option involves the food groups

'savory biscuits, crackers and popcorn' and 'sweet biscuits, cereal bars and desserts'. Typically, these foods are deemed as 'treat foods' due to their fat, salt and/or sugar content, yet both groups made small contributions to whole grain intake (12% on average), and over 34 and 49% of the present study sample were consumers of these food groups. A practical way to increase whole grain intakes in this population is to act on the finding that whole grain foods are poorly consumed outside of the home, and to work with various stakeholders to increase the availability of whole-grain-containing foods in restaurants and catering establishments. On a positive note, the overall high rate of whole grain consumers, as seen in the present study, contests previous views that inferior taste and texture may be the reason for such poor compliance<sup>(54)</sup>. It may also reflect the 20-fold increase in availability of products made with whole grain in the last decade<sup>(55)</sup>. Such increasing availability, coupled with growing consumer

**Table 6.** Mean daily intakes of energy (MJ/d), and macro- and micronutrients (per 10 MJ and % total energy) for non-consumers of whole grain and across tertiles of mean daily whole grain intakes in Irish children and teenagers

	Children					Teenagers				
	Tertiles of mean daily whole grain intakes					Tertiles of mean daily whole grain intakes				
	Non-consumers	Tertile 1	Tertile 2	Tertile 3	P	Non-consumers	Tertile 1	Tertile 2	Tertile 3	P
Energy (MJ)	6.8 <sup>a</sup>	6.7 <sup>a</sup>	6.9 <sup>a</sup>	7.6 <sup>b</sup>	***	7.6 <sup>a</sup>	7.8 <sup>a</sup>	8.1 <sup>a</sup>	9.4 <sup>b</sup>	***
% Energy from protein	13.2	13.4	13.6	13.9	NS	14.0 <sup>a</sup>	14.3 <sup>a</sup>	14.9 <sup>a,b</sup>	15.4 <sup>b</sup>	**
% Energy from carbohydrate	53.1	51.4	52.1	52.1	NS	48.9	48.5	48.8	49.8	NS
% Energy from total sugar	24.3	24.2	24.0	23.4	NS	20.5	20.1	20.4	20.7	NS
% Energy from added sugar	16.4 <sup>a</sup>	15.3 <sup>a</sup>	14.6 <sup>a,b</sup>	13.3 <sup>b</sup>	***	14.0 <sup>a</sup>	12.8 <sup>a,b</sup>	12.2 <sup>a,b</sup>	11.5 <sup>b</sup>	*
% Energy from fat	33.4	34.7	33.8	33.5	NS	36.4	36.9	42.3	46.3	NS
% Energy from saturated fat	14.5	15.1	14.5	14.5	NS	14.5	14.5	14.4	14.2	**
Fibre/energy (g/10 MJ)	14.9 <sup>a</sup>	16.8 <sup>b</sup>	18.4 <sup>c</sup>	19.6 <sup>c</sup>	***	16.4 <sup>a</sup>	16.9 <sup>a</sup>	18.6 <sup>b</sup>	22.0 <sup>c</sup>	***
Na/energy (mg/10 MJ)	3042	3027	3103	3026	NS	2938 <sup>a</sup>	3178 <sup>b</sup>	3086 <sup>a,b</sup>	3020 <sup>a,b</sup>	*
Fe/energy (mg/10 MJ)	12.1 <sup>a,b</sup>	12.1 <sup>a</sup>	13.5 <sup>b</sup>	15.1 <sup>c</sup>	***	15.5	15.8	14.3	17.1	NS
Ca/energy (mg/10 MJ)	1216	1219	1239	1294	NS	1010	996.5	1084	1162	NS
Vitamin E/energy (mg/10 MJ)	9.0	8.6	9.4	9.8	NS	9.8	9.4	10.1	11.9	NS
K/energy (mg/10 MJ)	3025 <sup>a</sup>	3110 <sup>a,b</sup>	3080 <sup>a</sup>	3238 <sup>b</sup>	**	3153 <sup>a</sup>	3157 <sup>a,b</sup>	3219 <sup>b</sup>	3275 <sup>a,b</sup>	*
P/energy (mg/10 MJ)	1347 <sup>a</sup>	1416 <sup>a,b</sup>	1443 <sup>b</sup>	1550 <sup>c</sup>	***	1360 <sup>a,b</sup>	1354 <sup>a</sup>	1452 <sup>b</sup>	1567 <sup>c</sup>	***
Mg/energy (mg/10 MJ)	247.5 <sup>a</sup>	260.0 <sup>a</sup>	271.3 <sup>b</sup>	305.5 <sup>c</sup>	***	252.9 <sup>a</sup>	257.9 <sup>a</sup>	278.4 <sup>b</sup>	316.7 <sup>c</sup>	***
Thiamin/energy (mg/10 MJ)	2.2	2.0	2.1	2.6	NS	1.9	2.4	2.7	3.2	NS
Riboflavin/energy (mg/10 MJ)	2.4 <sup>a,b</sup>	2.4 <sup>a</sup>	2.5 <sup>a,b</sup>	3.1 <sup>b</sup>	*	2.1 <sup>a</sup>	2.3 <sup>a</sup>	3.0 <sup>a,b</sup>	3.9 <sup>b</sup>	*
Niacin/energy (mg/10 MJ)	25.3 <sup>a,b</sup>	22.7 <sup>a</sup>	24.9 <sup>a,b</sup>	27.0 <sup>b</sup>	***	23.1 <sup>a</sup>	25.7 <sup>a,b</sup>	28.2 <sup>b,c</sup>	29.8 <sup>c</sup>	*
Vitamin B <sub>6</sub> /energy (mg/10 MJ)	3.0	2.7	2.8	3.3	NS	2.9	3.1	3.5	3.8	NS
Vitamin B <sub>12</sub> /energy (µg/10 MJ)	5.6	6.0	6.2	6.9	NS	5.2	5.5	6.0	6.9	NS
Vitamin D/energy (µg/10 MJ)	2.8	3.0	3.4	3.5	NS	2.2	3.1	3.4	3.5	NS

<sup>a,b,c</sup> Mean values with unlike superscript letters were significantly different between non-consumers and tertiles of whole grain intakes for mean intakes of whole grain food groups (adjusted for sex) (ANCOVA, Bonferroni *post hoc* test).

Mean values were significantly different: \*  $P < 0.05$ ; \*\*  $P < 0.01$ ; \*\*\*  $P < 0.001$ ; NS ( $P \geq 0.05$ ).

awareness, suggests a potential to further improve compliance to recommendations in future years.

There are a number of strengths and limitations associated with the present study that deserve mentioning. First, a definite strength of this analysis was the thorough data collection methodology that was followed, providing very detailed information on whole grain intakes. Previous similar studies have used 24 h recall<sup>(24)</sup>, FFQ<sup>(1,56)</sup> and 3 d weighed food diaries<sup>(14)</sup>. The present study, however, used 7 d weighed (children) and semi-weighed (teenagers) food diaries, with continuous involvement of the research team (four visits per subject). In addition, over 46% of whole grain data were collected at the brand level.

In terms of limitations, data received from manufacturers and food labels must be accepted with caution. Further investigation of whole grain pasta consumed in the present study labelled as 100% durum whole wheat semolina was found to contain just 88% whole grain content by alkylresorcinol analysis. A second limitation of the present study is the possibility of under-reporting, which would result in the underestimation of whole grain intakes. In addition, despite best efforts to encourage respondents to maintain usual eating practices, the burden of completing 7 d dietary records is acknowledged. Furthermore, the lack of involvement from very low socio-economic groups and those with poor or self-conscious health lifestyles must also be taken into account; these problems being not uncommon in large food-consumption surveys.

In conclusion, despite high consumer rates of whole grain, the percentage of Irish children and teenagers meeting whole grain recommendations advised by the United States Department of Agriculture<sup>(16)</sup> is poor. RTEBC were the greatest provider of whole grain, with wheat being the primary source. In the present study, whole grain intake was associated with a more nutrient-dense diet. To further improve whole grain intakes in Irish children and teenagers, a combination of effective nutritional education programmes and increased product availability and variety are required.

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