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**Evidence of High Sugar Intake and Low Fibre and Mineral Intake in The Gluten-Free Diet**

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Review

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**R2**

**Full Title: Evidence of High Sugar Intake and Low  
Fibre and Mineral Intake in The Gluten-Free Diet**

**Short Title: Assessment of a GFD**

**Article Type: Original Research**

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## Evidence of High Sugar Intake and Low Fibre and Mineral Intake in The Gluten-Free Diet

### SUMMARY

Background: The only therapy for coeliac disease (CD) is a long-term gluten-free diet (GFD). Little is known about the detailed composition of such a diet.

Aim: To clarify the nutritional composition of a GFD and to compare it to a non-GFD diet in representative non-CD populations.

Methods: 139 consecutive patients with CD were invited to fill in a prospective validated 5-day food diary, of which data from 93 were analysed. Results were compared with data from the National Diet and Nutrition Survey of Adults and the UK Women's Cohort Study.

Results: Individuals consuming a strict GFD generally had similar intakes of energy and nutrients to the comparison populations, but a higher proportion of carbohydrate intake was obtained from non-milk extrinsic sugars and intakes of non-starch polysaccharides were low. Compared to the UKWCS sample, females adhering to a GFD had lower intakes of magnesium, iron, zinc, manganese, selenium and folate. In males, intakes of magnesium and selenium were particularly low.

Conclusion: This study reinforces the need for clinicians to recognise that avoidance of gluten cannot be the sole focus of a GFD. Maintenance of adequate intakes of essential nutrients and in particular complex carbohydrates must also be the goal for patients.

## Introduction

Increasing numbers of people are being diagnosed with Coeliac Disease (CD)<sup>1</sup>, for which the only available treatment is a lifelong gluten-free diet (GFD)<sup>2</sup>.

As the GFD has to be maintained for life, any imbalances in the diet would have significant implications for the overall health of a “treated” patient with CD. Although there have been numerous studies of the benefits to patients of going from a gluten containing to a GFD, on being diagnosed with CD<sup>1</sup>, most studies considering the nutritional adequacy of the gluten free diet have been based outside the UK<sup>3-7</sup> and there is little data on the detailed composition of GFDs in the UK. Kinsey et al<sup>8</sup> reported on intakes of 49 patients with CD in the UK. They found inadequate intakes of non-starch polysaccharide (NSP), calcium and Vitamin D.

In a recent systematic review of previous research in the area, Robins et al<sup>9</sup> highlighted that when considering iron, calcium and B vitamins, there is no evidence base to suggest that nutritional deficiency is a significant problem in individuals diagnosed with CD. However, neither is there any high level evidence that individuals with CD have good nutritional status. Furthermore, all eleven studies considered as part of the systematic review were considered to be at moderate or high risk of bias<sup>9</sup>.

A GFD should meet individual requirements and Dietary Reference Nutrient Intakes (RNIs) for the general population<sup>10</sup>. There may be a case for increased nutritional requirements in those with CD<sup>9</sup> but there are currently no specific nutritional recommendations other than for calcium<sup>11</sup>.

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6 The aim of this study is to investigate and quantify the nutritional content of  
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8 the GFD in order that its nutritional adequacy can be assessed.  
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13 The objectives to achieve this aim are;

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15 To obtain high quality dietary information from a well-characterised group  
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17 of treated coeliac patients, on a strict GFD, using a validated five-day food  
18  
19 diary.  
20

21  
22 To identify how what proportion of patients on a GFD are meeting the UK  
23  
24 recommended intakes for a number of macro and micronutrients by  
25  
26 comparing the dietary analysis with RNIs <sup>10</sup> and with specific  
27  
28 recommendations for calcium in those with CD <sup>11</sup>  
29  
30

31  
32 To compare the nutritional content of a GFD in the UK with a normal  
33  
34 (gluten containing) diet, by comparison with National Diet and Nutrition Survey  
35  
36 (NDNS) <sup>12</sup> data for the general (Northern) population and an age/sex matched  
37  
38 cohort from the United Kingdom Women's Cohort Study (UKWCS) <sup>13</sup>  
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44 Whilst a weighed food intake is considered by some to be the gold standard  
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46 for assessing dietary intake <sup>14</sup> it has a number of disadvantages including the  
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48 time it takes to complete and the inaccuracy for people consuming foods  
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50 outside the home or those not prepared in the home. Nutritional studies in the  
51  
52 UK arms of the European Prospective Investigation of Cancer (EPIC) study  
53  
54 use a validated (against both 16 day weighed records and urinary and  
55  
56 serological biomarkers) portion sized-based food diary to assess dietary  
57  
58 intake that minimises some of these limitations<sup>15</sup>.  
59  
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## Methodology

Ethics approval was gained from Leeds (East) Research Ethics Committee.

Participants all had histologically confirmed CD (i.e. at least Marsh I criteria <sup>16</sup>) and had been on a strict GFD for 6 months or more prior to being invited to take part in the study. Dietary compliance was assessed by self-reporting and dietitian review. Available coeliac serology was also assessed, although negative serology was not an absolute prerequisite for consideration of entry into the study. Previous studies suggest between 7% and 10% of coeliac patients self-reporting high compliance with a GFD still have positive serology <sup>2</sup>.

Patients who met the inclusion criteria were recruited by a dietitian in a weekly specialist gastroenterology clinic, or specialist coeliac clinics, in a large UK teaching hospital over an 18 month period from January 2007 to May 2008. Written consent was obtained. Participation was voluntary. Participants were invited to complete a detailed 5-day food diary, to include 3 weekdays and 2 days at the weekend. The EPIC validated food diary was used <sup>15</sup> which includes colour photographs for estimating food portion sizes. The dietitian gave detailed completion instructions at the time of recruitment and a follow up telephone call was made in the week following recruitment. Diaries were returned by post and telephone contact was made to clarify details where necessary.

Participants' weights and heights were recorded in clinic at recruitment for use in calculating energy requirements and body mass index (BMI). All patients

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3 also had routine bloods and samples for micronutrient levels taken (data not  
4  
5 shown).  
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10 The diaries were analysed using Microdiet version 2.52 (2005), a  
11  
12 computerised nutrient data bank, which has details of Glutafin “Gluten Free  
13  
14 Dietary” range built-in. Data for gluten free foods provided by other  
15  
16 manufacturers were also added to the database.  
17  
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21 Portions sizes were calculated from the photographs in the EPIC food dairies  
22  
23 using conversion data from the EPIC group <sup>17</sup>, with weights provided by  
24  
25 participants or calculated from household measures using data from the FSA  
26  
27 Food Portion Sizes Guide <sup>18</sup>. Nutrients provided by supplements were not  
28  
29 included in the nutritional analysis, although details of dietary supplements  
30  
31 consumed were recorded and reported separately.  
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36 A comparison was made between reported energy intakes (calculated from  
37  
38 the 5 day food diary) and **estimated individual energy requirements based on**  
39  
40 **individual activity levels and basal metabolic rate (BMR - which in turn is**  
41  
42 **estimated using Schofield equations)**. As the original design of the study had  
43  
44 not included asking participants about their activity levels an assumption was  
45  
46 made that all patients were sedentary, which equates to a physical activity  
47  
48 level (PAL) of 1.4. **This calculated estimated individual energy requirement**  
49  
50 **was used to determine the level of under and over reporting in the food**  
51  
52 **dairies**. A threshold of +/-20% of **estimated individual energy requirement** was  
53  
54 used to assess level of under- and over- reporting in the returned food dairies;  
55  
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60 no adjustment was made for BMI. **The lack of data regarding activity levels**

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3 had no direct bearing on the interpretation of the data contained within the  
4  
5 food diaries – only on the assessment of under- and over- reporting.  
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7

8 Results obtained were compared against RNI <sup>10</sup> and in the case of calcium,  
9  
10 the British Society of Gastroenterology (BSG) guidelines for CD <sup>11</sup>. Nutrient  
11  
12 intakes were also compared against a comparable population from both the  
13  
14 NDNS: Northern Region and the UKWCS.  
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19  
20 Nutrient data from 195 male and 256 female participants of the National Diet  
21  
22 and Nutrition Survey selected from Northern region were sampled to provide a  
23  
24 non-coeliac reference population. The NDNS which was carried out between  
25  
26 June 2000 and July 2001 presents the most recent dietary intake data for a  
27  
28 UK population between the ages of 19 and 64 years <sup>12</sup>. In addition, it provides  
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30 regional data and where available it is this data that was used as being most  
31  
32 comparable to the study population.  
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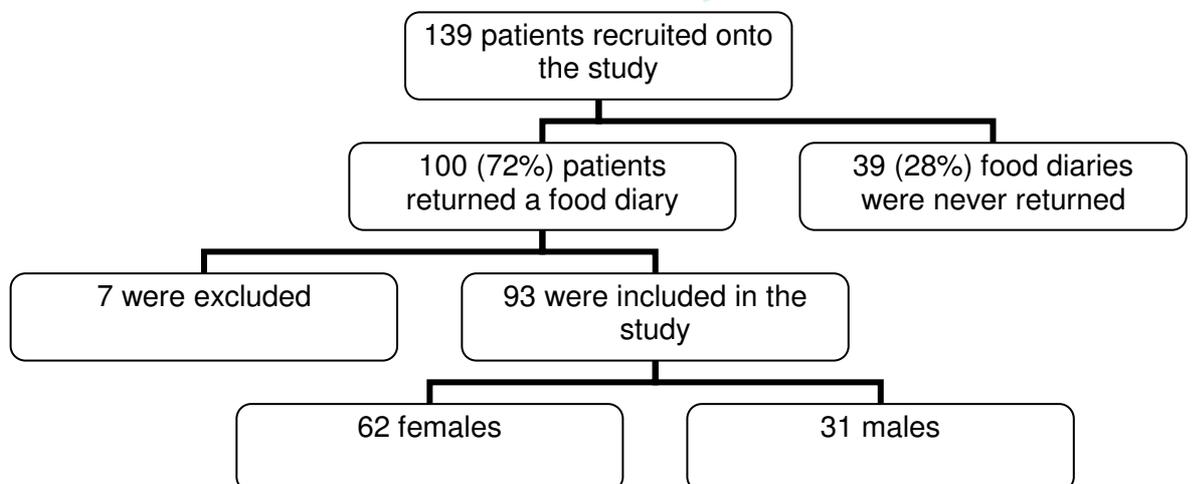
39 The UK Women's Cohort Study (UKWCS) was started in 1993 to investigate  
40  
41 diet and cancer relationships in middle-aged women in the UK. A food  
42  
43 frequency questionnaire and 4 day semi-weighed food diary were used to  
44  
45 assess dietary intake <sup>13</sup>. Participants had been initially selected to ensure a  
46  
47 wide range of dietary patterns were represented (including approximately one  
48  
49 third following a vegetarian diet) and at time of the completion of the original  
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51 questionnaire were aged 35-69. A sample of 708 randomly selected cancer-  
52  
53 free cohort participants that had a fully coded food diary was available as a  
54  
55 healthy non-coeliac reference population. Nutrient intakes were estimated  
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58 from food diaries using in-house MS Access-based software based on the  
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Fifth Edition of the Composition of Foods and related supplementary food tables<sup>19</sup>.

A Student's unpaired t-test was used for comparison of means: GraphPad software was used, with a p-value<0.05 deemed as statistically significant.

## Results

139 patients were recruited into the study; 100 (72%) food diaries were returned (mean age 54yrs; median age 55yrs). Of the 39 diaries not returned (23 females, 16 males) mean age was 41 years and median age was 43 years. Seven of the returned diaries were excluded as they did not meet the inclusion criteria on return: 3 diaries included foods containing significant amounts of gluten (1 male, 2 female) and 4 contained insufficient detail and could not be analysed accurately (3 male, 1 female). Therefore 93 diaries were included in the study; 62 (67%) by females. Females comprise 69% of coeliac clinic attendees.



## Demographic Data

Mean age for females was 53 (21-79) years and for males 56 (18-74). Mean BMI was 25.5 and 25.4 respectively. For more detailed data see Table 1.

## Coeliac Serology

54 of the 93 patients had coeliac serology (anti-tTG) from when they submitted their food diaries. Of these only 6 (11%) were positive (2 were described as “weak positive” and 3 of the remaining 4 positives also had positive anti-endomysial antibodies). **No patient with positive anti-tTG antibodies reported eating gluten in their diary and therefore this group was not analysed separately.**

## Co-morbidities

Patients were asked about other conditions or dietary practices influencing their dietary intake (in addition to gluten restriction). One male patient reported trying to gain weight during the recorded week and 4 men had other health conditions including Type 2 Diabetes Mellitus (DM), pancreatic cancer, and enteropathy-associated T-cell lymphoma. Fifteen of the women reported other wide-ranging conditions **(including Type 1 DM and fibromyalgia, irritable bowel syndrome, Sjogrens syndrome, multiple sclerosis, Parkinson’s disease, idiopathic chronic constipation, thyroid disease and ulcerative colitis)** that could have affected their dietary intake. **One female participant was recorded**

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3 as vegetarian. Five other participants excluded other dietary components  
4 such as lactose, soya or eggs and 2 reported trying to lose weight during the  
5 week recording their diaries. The 15 females with reported co-morbidities had  
6 a mean energy intake of 7486kJ (SD 1495) compared to 8018kJ (SD 1872)  
7 for those with no reported co-morbidities (P=0.32). For the 4 males with  
8 reported co-morbidities mean energy intake was 9244kJ (SD 3329) compared  
9 to 10572kJ (SD 2977) for those with no reported co-morbidities (P=0.42) i.e.  
10 there was no statistically significant differences in overall energy intake when  
11 the data was stratified according to presence or otherwise of co-morbidities.  
12 Therefore, all subjects were included in the data analysis regardless of their  
13 health status. Co-morbidities were not recorded in NDNS and only minimally  
14 in UKWCS.

## 32 Nutrient Intake

### 36 Determining the level of under and over reporting of energy intake

37 A threshold of +/-20% of estimated individual energy requirement was used to  
38 assess level of under- and over- reporting; no adjustment was made for BMI.  
39 Based on this assumption 26% males and 23% females under-reported and  
40 23% males and 13% females over-reported their intake. No food diaries were  
41 omitted on the basis of this analysis.

### 52 Macronutrients

53 Detailed data is given in Tables 2 and 3, with numbers of patients meeting  
54 overall recommendations being given in Table 4. In summary, females on a  
55 GFD consumed significantly ( $p<0.05$ ) more energy across all macronutrients  
56 (i.e. protein, fat and carbohydrate) than an age and sex specific "local"  
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3 population i.e. Northern cohort from NDNS. Compared to UKWCS  
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5 participants, study females had significantly ( $p<0.05$ ) lower intakes of fibre  
6  
7 (NSP), but similar intakes of macronutrients. **As only 1 of our female**  
8  
9 **participants declared herself as vegetarian (in contrast to 27% of those in**  
10  
11 **UKWCS) we compared NSP intakes in those females on a GFD with only**  
12  
13 **non-vegetarians in UKWCS. There was still a significantly lower mean intake**  
14  
15 **of NSP in females in our study (13.7 g/day and 16.5 g/day respectively;**  
16  
17  **$p<0.001$ ).** Males on a GFD also consumed significantly ( $p<0.05$ ) more energy  
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19 (fat and carbohydrate, but not protein) compared to the local NDNS  
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21 population but had a similar (low) intake of dietary fibre (NSP).  
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### 32 **Micronutrients**

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34 Females on a GFD consumed significantly ( $p<0.05$ ) more calcium and  
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36 magnesium than an age and sex matched "local" population i.e. Northern  
37  
38 cohort from NDNS. Compared to UKWCS, the females had significantly lower  
39  
40 intakes of magnesium, iron, zinc, manganese, selenium and folate ( $p<0.05$ ),  
41  
42 although there was no overall difference in the percentage of the population  
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44 meeting dietary reference values (DRVs) for nutrient intake apart from  
45  
46 significantly lower numbers of females in this study meeting DRVs for  
47  
48 magnesium (31% vs 71%) and selenium (11% vs 35%). However, for calcium  
49  
50 intake only 32% of under 55s and 18% of over 55s of female patients with CD  
51  
52 met current guidelines<sup>11</sup>. There was no comparable population for males with  
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54 regards to micronutrients. Looking at percentage of males meeting DRVs,  
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56 they also did not meet recommended intakes for magnesium and selenium  
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3 (23% and 6% respectively), and the level of recommended manganese intake  
4 was also low (48%). Levels of recommended calcium intake were not as low  
5 as in females. There is no UK recommended intake for Vitamin D as a large  
6 proportion is synthesised from sunshine – indeed Millen et al suggest that  
7 total vitamin D intake from foods and supplements explains only 7% of the  
8 variance in 25(OH)D concentrations between participants of the Women's  
9 Health Initiative Trial<sup>20</sup>. More details are given in Tables 2 to 5.

## 23 Dietary supplementation

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26 Just under half of the GFD study participants reported taking a combined  
27 calcium and Vitamin D supplement (47% females and 48% males) the  
28 majority having obtained these by prescription. Additionally, a further 2  
29 females stated they had calcium and Vitamin D supplements prescribed but  
30 did not take them. A smaller proportion of participants reported taking iron  
31 supplements (11 (18%) females and 2 (7%) males), and of these, most had  
32 received them on prescription.

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There was no correlation between dietary intake and dietary supplementation  
i.e. those with low dietary intake were no more likely to be taking a  
supplement than others.

## 53 Discussion

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This study shows that female patients on a GFD compared to the Northern  
region population of the NDNS, (Table 2) consumed significantly more energy  
(fat, CHO and protein), more calcium and more magnesium ( $p < 0.05$ ). When

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3 comparing the intakes with the UKWCS cohort, the study females had  
4 significantly lower intakes of fibre (NSP), magnesium, iron, zinc, manganese,  
5 selenium and folate ( $p < 0.05$ ) with no significant difference in energy intake.  
6 This suggests less nutrient dense energy food choices by females in this  
7 study, such as sugary snack foods. Comparing intakes of NMES supports  
8 this. Whilst the UKWCS has no data for NMES, comparison with the NDNS  
9 shows statistically significant higher intakes of NMES intake in those on a  
10 GFD ( $p < 0.01$ ). For the females with CD, 54% of the additional carbohydrate  
11 comes from NMES and for the males, 35.7%. The recommended intake of  
12 NMES is 10% total energy intake<sup>21</sup> (Table 4).

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In males, a comparison of macronutrient intake with that of the NDNS again  
reveals that males in this study consumed significantly more energy (fat and  
CHO but not protein), ( $p < 0.05$ ) (Table 3). Notwithstanding this only 42% of  
males and females got more than 47% of their total energy intake from  
carbohydrate sources (Table 4). It is recommended that at least 47% of total  
energy intake comes from carbohydrate sources<sup>10</sup>. These data, and the  
extrinsic sugar figures confirm that patients on a GFD are not consuming  
enough complex carbohydrates.

Calculation of estimated individual energy requirements indicates 22 (35%) of  
the reported intakes from the females and 15 (48%) of the male reported  
intakes fall outside  $\pm 20\%$  of their requirements. This is comparable to similar  
studies<sup>6, 22</sup>. Bingham<sup>23</sup> suggests an average error of  $\pm 10\%$  for calculated  
energy intake and states, "Habitual energy intakes from dietary surveys of  
groups of adults 72% or less than BMR are almost certainly invalid". None of  
the intakes in this study were below this threshold. Hallert et al<sup>6</sup> use a similar

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3 method for validating their data and suggest patients under-estimated intake  
4 by about 25% which is a little more than levels found in this study. The NDNS-  
5 reported intakes are compared to estimated average requirement (EAR) -  
6 which does not take into account weight or activity, unlike the estimated  
7 individual energy requirement. This comparison suggests the males (all  
8 regions) reported an intake on average 92% of the EAR and females 85%  
9 EAR. Corresponding figures for this study are 102.2% and 98.3% i.e. in this  
10 study males “over-report” by only 2.2% and females “under-report” by only  
11 1.7%.  
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24 We collected data using a five-day food diary including a weekend (or 2 non-  
25 working days) whilst previous studies<sup>3-8</sup> used three or four day diaries.  
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28 Levine and Morgan<sup>24</sup> suggest that a week is too short to assess intakes of  
29 vitamins, minerals & trace elements. However, Livingstone et al<sup>25</sup> argue that  
30 recordings lasting longer than 4 days may not necessarily be superior.  
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34 Strengths of this study are that it is comprehensive, with nutritional  
35 composition of gluten-free foods verified by contact with manufacturers. All  
36 (bar one) of the patients in this study had been on a GFD for at least 6 months  
37 – median time on a GFD was nearly 7 years for males and 9.5 years for  
38 females.  
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48 Unlike many other studies<sup>9</sup>, this study does present data of co-morbidities  
49 and compares intake to comparable populations.  
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52 Weaknesses of this study include the relatively small sample size (although  
53 the authors are not aware of any larger cohort of patients on a GFD that have  
54 been dietetically assessed). Previous similar studies<sup>3-8</sup> have sample sizes  
55 ranging from 30 to 71 participants. The cohort in the UKWCS by definition is  
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3 a health conscious cohort of middle aged women, and a higher micronutrient  
4 intake than those on a GFD could **therefore** be anticipated. However as the  
5 study participants have maintained a rigid diet (GFD) and been regular  
6 attendees of a specialist clinic, it could be contended that this group are  
7  
8 “health conscious” too. As comparator populations, younger ages were under-  
9 represented in the UKWCS cohort and in NDNS there is concern about the  
10 probable under-reporting of nutrient intake (given the overall reported energy  
11 intakes). In NDNS too the younger age ranges were under-represented - of  
12 the women only 9 were aged 18-40.

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15 Significant differences between GFD and non-GFD groups of consumption of  
16 home-prepared and processed food would skew our data, and it is generally  
17 easier for non-GFD patients to “snack” and eat processed foods  
18 spontaneously, especially outside the home. Data with regards to food  
19 preparation is incomplete but a **random** subgroup of 30 diaries was  
20 reanalysed, and of these only 5 (17%) patients had consumed a ready meal  
21 during the 5 days covered by the food diary. **However**, in percentage terms  
22 47% of energy intake was attributable to processed foods in those on a GFD.  
23  
24 There is no such equivalent data in UKWCS, **although** NDNS differentiates  
25 between food eaten within and outside the household, allowing some  
26 implications to be made. **Nonetheless**, the data is not robust enough to allow  
27 comments upon (and therefore comparisons with this study) with regards to  
28 eating of processed foods. **If this high percentage of energy from processed  
29 food is typical of a GFD, appropriate and detailed labelling of processed food  
30 is vital so as those on a GFD can make fully informed decisions.**

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3 In summary, this study of nutrient intakes in CD reveals adequate  
4 macronutrient intakes but higher proportions of carbohydrate from NMES.  
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6 Intakes of magnesium, iron, zinc, manganese, selenium and folate in females  
7  
8 are lower than a comparative population taking a gluten containing diet. In  
9  
10 males, the percentage of patients with CD achieving the RNI for magnesium  
11  
12 and selenium is particularly low. Whilst mean intakes of calcium are higher  
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14 than in gluten containing diets, many patients, particularly those over 55 years  
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16 of age, fail to achieve BSG recommended intakes for calcium.  
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18 Current dietary advice and recommendations for supplementation need  
19  
20 review to take account of these deficiencies. Where possible  
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22 recommendations should be made to address the low intakes of fibre, calcium  
23  
24 and iron. Maintaining available carbohydrate intakes without resorting to  
25  
26 sugary foods should be done. Patients should be encouraged that this could  
27  
28 occur without the need to wholly rely on special GF products, but rather by  
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30 increasing intake of food products such as beans and pulses, starchy  
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32 vegetables such as sweet potato and potato or alternative grains as recently  
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34 suggested by Lee et al.<sup>26</sup>  
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43 This work highlights the importance of all patients with coeliac disease having  
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45 the opportunity for dietary review with a suitably experienced dietitian on a  
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47 **regular** basis for advice on foods to achieve a balanced diet or appropriate  
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49 dietary supplementation.  
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**Table 1 Characteristics of gluten-free diet survey participants (n=70)**

	Men	Women
Mean BMI (SD)	25.4 (4.0) n=25	25.5 (3.9) n=45
BMI range (kg/m <sup>2</sup> )*	17.8-33.6	18.4-35.1
BMI <20	3	2
BMI 20-24.9	8	19
BMI 25-29.9	11	20
BMI 30-34.9	3	3
BMI> 35	0	1
Mean age (years)	56 (15) n=31	53 (13) n=62
Median age (years)	63	53
Mean duration of GFD (years)	8.43	11.28
Median duration of GFD (range)	6.71 (0.29-31.35)	9.52 (0.52-33.45)

\*38 participants had a BMI>25; 24 females (38.7%) and 14 males (45.2%)

Of these 7 participants had a BMI >30; 4 females, 3 males.

**Table 2 Average daily energy and nutrient intakes in 62 female participants consuming a gluten-free diet**

	Units	GFD		NDNS Northern (n=256)			UKWCS (n=708)		
		Mean	SD	Mean	SD	P value (vs GFD)	Mean	SD	P value (vs GFD)
Energy	kJ	7945	1792	6770	1840	<0.01*	7666	1695	0.22
Protein	g	74.1	16.8	63.1	18.4	<0.01*	70.5	17.8	0.13
Fat	g	68.4	23.0	58.6	21.4	<0.01*	68.1	23.5	0.92
Carbohydrate	g	240.7	58.6	202	58	<0.01*	229.3	56.6	0.13
Alcohol	g	9.4	10.6				9.3	11.8	0.99
Starch Intake	g	79.6	31.5				116.9	34.3	<0.01*
Total sugars	g	106.7	34.7				107.5	36.0	0.87
Starch and intrinsic sugar	g	168.8	41.5	152	NA				
Extrinsic sugar	g	71.9	26.9	51	46	<0.01*			
Non-starch polysaccharides	g	13.7	4.5	12.4	5.2	0.07	17.3	6.1	<0.01*
Calcium	mg	888.3	346.7	786	285.8	0.02*	869.5	286.5	0.63
Vitamin D	ug	2.6	2.0				2.6	2.1	1.00
Magnesium	mg	253.0	86.2	228	71	0.02*	318.9	86.6	<0.01*
Manganese	mg	2.8	1.3	2.6	1.1	0.22	3.9	1.5	<0.01*
Iron	mg	10.7	3.2	9.9	4.1	0.15	12.5	3.8	<0.01*
Zinc	mg	7.7	2.5	7.3	2.2	0.21	8.5	2.6	0.02*
Selenium	ug	39.2	16.9				58.0	40.0	<0.01*
Folate	ug	264.3	92.1	249	95	0.25	291.5	102.3	0.04*

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47**Table 3 Average daily energy and nutrient intakes in 31 male participants consuming a gluten-free diet**

	Units	GFD		NDNS Northern (n=195)		
		Mean	Std. Deviation	Mean	SD	P value (vs GFD)
Energy	kJ	10462	3000	9450	2230	0.03*
Protein	g	92.7	24.9	86.7	24.73	0.21
Fat	g	93.2	36.6	81.7	25.39	0.03*
Carbohydrate	g	315.6	98.5	266	70	<0.01*
Alcohol	g	12.0	14.4			
Starch and intrinsic sugar	g	220.9	72.1	196	NA	
Extrinsic sugar	g	94.7	36.0	77	42.2	0.03*
Non-starch polysaccharides	g	13.7	5.3	14.3	5.44	0.57
Calcium	mg	1090.7	459.2	993	348.2	0.17
Vitamin D	ug	3.1	3.1			
Magnesium	mg	266.5	98.8	303	96.9	0.05
Manganese	mg	2.7	1.1	3.14	1.242	0.06
Iron	mg	13.8	5.4	12.6	4.46	0.18
Zinc	mg	10.1	3.7	10.1	3.04	1.00
Selenium	ug	46.3	38.3			
Folate	ug	310.0	101.6	332	116	0.32

**Table 4** N (%) of patients on GFD meeting RNI for micronutrients and macronutrients from dietary sources

	RNI males/females	n (%) meeting RNI				
		Males (n=31)		Females on GFD (n=62)		UKWCS (n=708)
Folate	200/200µg	28 (90)		49 (79)		610 (86)
Calcium	700/700mg	23 (74)		42 (68)		500 (71)
Calcium (coeliac)	1000mg <=55yrs 1200mg >55 yrs	n=13; 7 (54) n=18; 7 (39)		n=34; 11 (32) n=28; 5 (18)		
Magnesium	300/270mg	7 (23)		19 (31)		500 (71)
Zinc	9.5/7mg	17 (55)		37 (60)		498 (70)
Iron	8.7/8.7-14.8mg	25 (81)		aged 18-54 RNI=14.8mg: N=31 aged 55-74 RNI=8.7mg : N=27	3(10) 20(74)	606 (86)
Selenium	75/60ug	2 (6)		7 (11)		247 (35)
Manganese	2.3/1.8mg	15 (48)		47 (76)		678 (96)
Protein	55.5-53.3/45- 46.5g	aged 18-50 RNI =55.5g: N=11 aged 50-74 RNI=53.3g: N=20	11(100) 20 (100)	aged 18-50 RNI =45g: N=27 aged 50-74 RNI=46.5g: N=35	26(96) 35(100)	
Energy as Fat	<33%/<33%	17 (55)		33 (53)		376 (53)
Energy as CHO	>47%/>47%	13 (42)		26 (42)		338 (48)
Energy as Extrinsic Sugar	<10%/<10%	8 (26)		15 (24)		

**Table 5 Daily Calcium Intake in those on a Gluten-Free Diet**

	N	Minimum	Maximum	Mean	Std. Deviation
Males $\leq$ 55yrs	13	619.1	2269.7	1160.3	496.8
Males >55yrs	18	455.0	2005.3	1040.5	437.6
Females $\leq$ 55yrs	34	259.1	1716.8	862.2	374.4
Females >55yrs	28	334.8	1970.8	920.1	313.4

Calcium intakes (mg/day) from diet only. Daily recommended intakes for calcium in adults with coeliac disease <sup>11</sup> are 1000mg/day (1200mg/day for postmenopausal women and men over 55 years of age).

As we did not record menopausal status for the female cohort, 55 years of age has been used for the purpose of this analysis.

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