

Using food intake records to estimate compliance with the Eatwell plate dietary guidelines

Stephen Whybrow¹, Jennie I. Macdiarmid¹, Leone C. A. Craig¹, Heather Clark² and Geraldine McNeill^{1,2}

1 Rowett Institute of Nutrition and Health, University of Aberdeen, Aberdeen, UK

2 Institute of Applied Health Services, University of Aberdeen, Aberdeen, UK,

Corresponding author:

Stephen Whybrow

Stephen.whybrow@abdn.ac.uk

Telephone +44 (0)1224 438041

Fax +44 (0)1224

Rowett Institute of Nutrition and Health,

University of Aberdeen,

Foresterhill,

Aberdeen,

AB25 2ZD

UK

Authors' contributions: The study was designed by G.M. S.W. and J.M. S.W., L.C. and H.C. were responsible for analysing the data. All authors contributed to the preparation of the manuscript. All authors critically reviewed the manuscript.

Acknowledgements: This work was supported by the Scottish Government's Rural and Environment Science and Analytical Services (RESAS) Division. The original studies, from which the current data were taken, were funded by the Food Standards Agency, UK, and the Biscuit, Cake, Chocolate and Confectionery Association, London, UK.

Conflict of interests: The authors declare that they have no conflicts of interest.

Abstract

Background: The UK's Eatwell plate is consumer based advice recommending the proportions of five food groups for a balanced diet: starchy foods, fruit and vegetables (F&V), dairy foods, non-dairy sources of protein (protein) and foods and drinks high in fat or sugar (HFHS).

Many foods comprise ingredients from several food groups and consumers need to consider how these fit with the proportions of the Eatwell plate. This involves disaggregating composite dishes into proportions of individual food components.

The present study aimed to match the diets of adults in Scotland to the Eatwell plate dietary recommendations and to describe the assumptions and methodological issues associated with estimating Eatwell plate proportions from dietary records.

Methods: Foods from weighed intake records of 161F and 151M were assigned to a single Eatwell group based on the main ingredient for composite foods, and the overall Eatwell plate proportions of each subject's diet calculated. Food group proportions were then recalculated after disaggregating composite foods.

Results: The F&V and starchy food groups consumed were significantly lower than recommended in the Eatwell plate, while the proportions of the protein and HFHS foods were significantly higher. Failing to disaggregate composite foods gave an inaccurate estimate of the food group composition of the diet.

Conclusions: Estimating Eatwell plate proportions from dietary records is not straightforward, and is reliant on methodological assumptions. These need to be standardized and disseminated to ensure consistent analysis.

Key words: Eatwell plate, food based dietary guidelines, disaggregation, food diaries

Introduction

The relationship between diet and health is complex, and the dietary factors associated with risk of developing, and protection from, many diseases are multiple, such as intakes of vegetables, fish, whole grains, alcohol and a Mediterranean style diet in the prevention of coronary heart disease ⁽¹⁾. National guidelines, such as the United Kingdom's Dietary Reference Values ⁽²⁾, have been developed from scientific evidence and recommend minimum and maximum average daily intakes of different nutrients to prevent develop of diseases. In-as-much as they do, consumers probably tend to think of their diet in terms of meals and foods rather than nutrients, and may have difficulty in translating nutrient-based recommendations into food-based amounts. In an attempt to overcome this, several countries have translated their national dietary targets into food-based visual representations, which suggest the proportions of food groups contributing to a healthy diet ⁽³⁾. Recently the United States Department of Agriculture Human Nutrition Information Service replaced their pyramid format with a plate format, "MyPlate"⁽⁴⁾, depicting food recommendations based on the Dietary Guidelines for Americans. Other countries have also adopted a plate format for food based dietary recommendations, including Australia ⁽⁵⁾, India ⁽⁶⁾, Finland ⁽⁷⁾ and the UK ⁽⁸⁾. In the UK, "The Balance of Good Health" ⁽⁹⁾ was developed with the aim of representing nutrient intake information in a picture format (the Eatwell plate) to make dietary recommendations easier for consumers to understand. The Eatwell Plate is a pie-chart diagram consisting of five food group segments, the proportions of which are based on the dietary reference values for the population ⁽¹⁰⁾. The five groups being: 1. bread, rice, potatoes, pasta and other starchy foods (starchy, which should make up around 33% of the diet), 2. fruit and vegetables (F&V, 33%), 3. milk and dairy foods (dairy, 15%), 4. meat, fish, eggs, beans and other non-dairy sources of protein (protein, 12%) and 5. foods and drinks that are high in fat or sugar, or both (HFHS, 8%) ⁽⁸⁾. The segments are based on the weight of the food ⁽¹¹⁾ and do not include frequency of servings or portion size, although additional guidance including eating five portion of fruits and vegetables a day, and two portions of fish a week (one of which should be oily) are part of wider government healthy eating messages. As many manufactured, and homemade, dishes typically comprise ingredients from several food groups (composite foods), consumers "...need to identify the main food items or ingredients in combination foods and think about how these fit with the proportions shown in the Eatwell Plate" ⁽¹⁰⁾. Pizza, for example, is made up from the starchy food group (the base), the F&V group (tomato sauce), the dairy group (cheese) and possibly the protein group depending on the topping. Failing to do so will distort the contributions of the food groups, potentially over-estimating meat intake and under-estimating fruit and vegetables ^(12; 13). The need to consider the proportions of composite dishes and manufactured ready meals is likely to present a difficulty for most consumers,

which is an important issue considering an estimated 3.9 million people in the UK ate ready meals at least twice a week in 2013 ⁽¹⁴⁾.

Neither the Eatwell Plate or its forerunner the Balance of Good Health were intended as a comprehensive research tool to assess diet quality, but rather were intended to be used as guides for consumers using representative examples of foods to assist healthy food choices. The Eatwell plate has, however, been used by researchers as a reference to which the diets of different populations can be compared ^(15; 16; 17), for grouping foods in modelling the effects of increasing food prices on diet quality ⁽¹⁸⁾, and for designing “ideal” diets ^(19; 20). Furthermore, the ability to provide individuals with feedback on their diet, and how well it compares to the recommendations behind the Eatwell plate may be an additional health promotion use. All of these rely on being able to translate dietary intake data, however measured, into Eatwell plate proportions. This can be a complex process as there appears to be little published information on the disaggregation of composite foods into the Eatwell plate segments. Many of these issues are not unique to the UK’s Eatwell plate but apply also to other countries’ plate or pyramid based dietary recommendations, although the USDA’s MyPlate has information on portion sizes that are lacking in the Eatwell plate ⁽²¹⁾.

The primary aim of this study was to compare the diets of adults in Scotland to the Eatwell plate proportions. The secondary aim to identify the challenges involved in estimating the Eatwell plate proportions from weighed food diaries.

Materials and methods

Study design and subjects

Dietary data were taken from two existing datasets; 115 men and 125 women from a residential study ostensibly examining the relationships between diet and lifestyle ⁽²²⁾. A further 36 men and 36 women from a snacking intervention study ⁽²³⁾. Dietary data from both studies were taken from the baseline data collection when subjects were consuming their normal diet. Subjects were recruited from Aberdeen, Scotland by advertisements, and data collection took place between 1998 and 2001. Ethical approval for the original studies was approved by the Joint Ethical Committee of the Grampian Health Board and the University of Aberdeen.

Anthropometry

In both studies, height was measured by the investigator using a stadiometer (Holtain Ltd, Crymych, Dyfed, UK), and body weight by the investigator using calibrated scales (DIGI DS-410; CMS Weighing Equipment, London, UK), and corrected to nude. Body Mass Index (BMI) was calculated as weight (kg) / (height (m) * height (m)). Basal Metabolic Rate (BMR) was estimated using the equations of Schofield ⁽²⁴⁾.

Food diaries

Participants completed weighed food records for four, six or seven days following a standard protocol ⁽²⁵⁾. Food records were analyzed using Diet5 for Windows (Univation Ltd., Robert Gordon University, Aberdeen, Scotland), which uses U.K. food composition data ⁽²⁶⁾ to calculate nutrient composition. Mean daily energy intakes were calculated.

Eatwell Plate proportions.

Foods shown in the Eatwell plate ⁽⁸⁾ suggest that the proportions are based on raw foods, or as purchased. Recommendations for nutrients, however, are for food as eaten and would relate to amounts, or weights, of foods after allowing for cooking weight changes and food preparation losses. The UK Dietary Reference Values ⁽²⁾ are given for intakes, and although not specifically a part of the Eatwell plate, the recommended maximum amount of red meat of 70g/day is based on cooked weight ⁽²⁷⁾. Some foods, and especially recipe components, were recorded by subjects as raw weights. These were converted to “as eaten” by adjusting for weight changes during cooking (e.g. weight increase on cooking of rice), and for food preparation waste (e.g. banana skins) using

an edible portion conversion factor⁽²⁶⁾ and cooking weight changes where foods were recorded as their raw, uncooked or unprepared form⁽²⁸⁾.

Many foods clearly belonged to just one food group in the Eatwell plate, such as apples to the F&V group, chocolate confectionery to the HFHS group, and bread and boiled potatoes to the starchy group. For composite foods it was less clear. There is little published information or guidance detailing to which of the five Eatwell food groups composite, or indeed many, foods belong. To allow the contribution of composite dishes and foods to be distributed across the five Eatwell plate food groups, five factors representing the proportion of the food in the composite dishes that was allocated to each of the groups were estimated. These factors were used subsequently in calculating the Eatwell plate proportions of the total diet. For composite dishes and foods the individual factors representing the food group proportions were estimated using representative recipes from food composition tables⁽²⁶⁾, from similar foods and dishes, or from internet sources. As an example, the Eatwell Plate proportions for macaroni cheese were calculated as 39% starchy (macaroni and flour), 58% dairy (milk and cheese) and 3% HFHS (margarine). Estimates from the list of ingredients were used where a suitable recipe could not be found. Alcoholic drinks and miscellaneous food such as sauces, pickles, tea and coffee are not included in the Eatwell Plate and are assigned to a sixth group (miscellaneous) for completeness but were not included in these analyses.

As recommended, weights of liquids such as milk, fruit juices and soups were halved because of their high water content (and therefore weight), which would have a disproportionate effect on the Eatwell plate proportions⁽¹¹⁾. Similarly, following existing recommendations, sugar sweetened soft drinks were included as their sugar content only, and assigned to the HFHS group⁽¹¹⁾. The Eatwell Plate proportions calculated here represented the proportions of foods in the form in which they would be consumed, and after adjustment of the weights of milk, soups and beverages. To assess the effects of disaggregation, Eatwell plate amounts and proportions were also calculated without applying the disaggregation factors, by assigning each composite food to single Eatwell food group as described elsewhere⁽¹⁵⁾. The total weight of meat based dishes were considered to belong to the protein food group, for example.

Analysis

Student's t-tests were used to test for differences between the amounts and proportions of the Eatwell Plate food groups as calculated with and without the disaggregation of composite foods. T-tests were also used to test for differences between the Eatwell Plate proportions of subjects' diets and the Eatwell Plate recommended proportions. All analyses were carried out using SPSS Statistics package, version 20.0.0 (SPSS/IBM, Armonk, New York, NY).

Results

Mean (SD) subject characteristics were: age 41 (12) years, BMI 25.7 (4.0) kg/m², energy intake 10.3 (2.9) MJ/d and energy intake/BMR 1.52 (0.33).

The effect of disaggregating composite foods on the apparent composition of the diet is shown in table 1. Disaggregation altered the amounts (g/d) of F&V, protein and HFHS foods and the proportion of all but the dairy food groups. Failing to disaggregate composite foods resulted in the aggregated starchy and aggregated HFHS food groups appearing to be closer to the Eatwell Plate recommendations, but the aggregated F&V and aggregated protein food groups further from the recommendations. The amount of disaggregated F&V reported was greater than 400g/d (which would be equivalent to five portions per day). Overall the proportion of the disaggregated F&V and disaggregated starchy food groups were lower (both $p < 0.001$), and the proportion of the disaggregated protein and disaggregated HFHS food group higher (both $p < 0.001$) than recommended. The proportions of the disaggregated dairy food group was similar (N.S.) to the Eatwell plate recommendations.

Discussion

This study is, as far as we are aware, the first to report the Eatwell Plate proportions of the diets of adults in Scotland, and to describe the necessary assumptions and methodologies in calculating the Eatwell Plate proportions from weighed food records.

The Eatwell plate proportions in the current study, calculated from the disaggregated composite foods, are similar to those estimated by us from the UK wide National Diet and Nutrition Survey ⁽¹⁵⁾. The major differences being the higher contribution of fruits and vegetables and lower contribution of the protein food group in the Scottish sample (30% vs. 23% and 13% vs. 22% respectively). These differences are at least partly due to a difference in how the dietary data were analysed as it was not possible to disaggregate the amount of meat from the composite dishes in the 2000/2001 National Diet and Nutrition Survey. The most recent National Diet and Nutrition Survey rolling programme shows that failure to disaggregate composite dishes results in an overestimation of the amount of meat (protein Eatwell food group) in the diets ⁽¹²⁾ and an underestimation of the amounts of vegetables ⁽¹⁵⁾.

The main challenge was dealing with composite dishes where the ingredients contribute to several of the Eatwell plate segments, and the lack of clarity for where some food should be placed, e.g. whether cream should be considered a dairy product or a high-fat food. As this study illustrates, misclassification of foods or not disaggregating composite food makes a significant difference in the Eatwell proportions, affecting all but the dairy food group.

One of the methodological issues was the classification of F&V in the Eatwell plate compared with the recommended five portions a day. The weight of the F&V food group, and therefore the contribution to the Eatwell plate proportions, was higher than expected, and higher than reported elsewhere ⁽²⁹⁾. Barton and Wrieden ⁽²⁹⁾ reported 259g/d for estimated intakes of fruits and vegetables in 2001 (compared to 419g/d in the current study) using data from the Living Costs and Food Survey. A similar value of around three portions (240g) per day was reported for adults in the Scottish Health Survey ⁽³⁰⁾.

Fruit juices and smoothies currently contribute towards the five-a-day recommendations for fruit and vegetables intakes, but only up to a maximum of one portion per day, or two portions per day for some fruit smoothies. The Eatwell plate method does not, however, limit the contribution of these foods to the F&V food group, other than halving the weight of fruit juices. For this reason the weight of fruits and vegetables eaten as reported in the current study is likely to be higher than if calculated using the five-a-day method. However, the overestimate will be partly balanced by a lower contribution from pluses and beans that contribute to five-a-day intakes of fruits and vegetables but are assigned to the protein food group of the Eatwell plate. Recalculating F&V

intakes using the five-a-day method resulted in a mean F&V intake of 377g per person per day – which is still higher than reported elsewhere.

The Eatwell plate is designed to illustrate a healthy diet, but not all food and drinks are included. Alcoholic drinks and miscellaneous food such as sauces, pickles, tea and coffee are not included. Many of these make only minor contributions to the diet (at least for energy, nutrients – especially salt and sugars - and weight), but beverages have a high water content, and therefore weight. The Eatwell Plate is represented as proportions of the diet, and as the proportion of one group increases the proportions of the other groups will necessarily decrease. It does not take account of the amount of food consumed, therefore increasing F&V intakes, for example, will reduce the proportion of all of the other food groups - but not as a result of a reduction in consumption of these food groups. This is simply a consequence of expressing food or nutrient intakes as percentages or proportions ^(31; 32).

Foods shown in Eatwell Plate were chosen because they were consistent with the key characteristics of each of the segments ⁽¹¹⁾. The number of foods illustrated in the Eatwell plate has increased to show important alternative foods, such as soya milk as an alternative to dairy milk, and the recently published guide to the Eatwell plate lists additional foods that fit into each of the segments ⁽³³⁾. The assignment of some foods to the relevant segment requires some consideration as they can appear contrary to beliefs about healthy eating. Sausages and beef burgers can have relatively high fat contents, but are included in the protein segment ⁽³³⁾ because they also meet the key characteristics of the protein group, being major sources of protein, B vitamins, iron and other minerals ⁽¹¹⁾. Other products, for which there is no guidance such as pâté, which can have a considerably higher fat content than sausages, will need consideration about the segment to which they belong to be consistent with the principle of the Eatwell plate. Additional advice on meat and meat products includes “... not to eat too many sausages, meat pies and salami, because these are often high in fat” ⁽³³⁾, to choose leaner cuts of meat, and to limit the consumption of red and processed meat to 70g a day.

Not all dairy products are included in the milk and dairy segment of the plate; butter, cream and ice-cream are included in the HFHS segment because they are considered to be mainly sources of fat and energy ⁽¹¹⁾. This could be confusing for many consumers as these are often seen as dairy products. For some dairy foods the distinction is less clear, such as full-fat, sugar-sweetened yogurts, where the cut-point between the HFHS and dairy groups is not objectively defined, or subjectively obvious. Thus, higher-fat foods are assigned differently depending on their composition, their other nutritional properties, the way they tend to be consumed, and subjective judgement, rather than their fat content *per se*. Composite foods (e.g. sandwiches) present further classification problems, and there is less guidance on these.

The Eatwell plate is based on a food grouping system and composite foods do not fit directly into this ⁽¹¹⁾. Consumers need to estimate the relative contribution of foods that contribute to composite dishes ^(11; 33). Whether consumers are able to do this sufficiently well does not appear to have been evaluated, despite the need for this being suggested previously ⁽¹¹⁾. It is also difficult to know the degree of disaggregation that is appropriate. Lasagne, for example, contains portions of the starchy (pasta), F&V (tomato sauce), dairy (cheese and white sauce) and protein (meat) groups. But it could also be considered as having some HFHS foods if a white sauce is also disaggregated. One compromise for including composite foods into the Eatwell Plate might be to include additional guidance, as has been done for choosing lower-fat alternatives of foods, with average proportions of a few representative composite foods. Ideally several different values would need to be calculated or estimated for different versions of foods - possibly one for homemade dishes and one for manufactured dishes. Alternatively, average values could be used for different groups of products, although the effects of such assumptions would need to be evaluated.

Foods in the National Diet and Nutrition Survey have been disaggregated to an extent, in that only five food components were used: meat, fish, vegetables, fruit and cheese ⁽³⁴⁾ resulting in some of the weight of composite foods being unaccounted for. Corned beef hash, for example, is disaggregated to 30% of the processed red meat component, but the remaining 70% (potatoes) is unaccounted for. There are also some differences in the food categories; beans and pulses are included in the vegetable component of the National Diet and Nutrition Survey, but categorized to the protein food group of the Eatwell plate. Consequently, the disaggregation factors derived for the National Diet and Nutrition Survey database are not ideally suited for estimating Eatwell plate proportions.

The composition of the UK's diet has changed since the development work that led to the Eatwell Plate was done in the 1990s. The UK market for ready meals has grown considerably, with the biggest increase being in the chilled ready meals market ⁽³⁵⁾. These may have different compositions to frozen ready meals. The Eatwell Plate needs to be updated to reflect these changes in food availability and supply.

Limitations

An aim of this study was to compare the diets of adults in Scotland against the recommended Eatwell Plate proportions. Data used for these analyses were collected between 1998 and 2001 and there have been changes in the foods that we eat and their contribution to the diet over the last 15 years, such as an increase in the amounts of ready meals consumed ⁽³⁵⁾. However, some changes in the average diet since 2001 appear to have been small, such as a small increase in the amount of

fruit and vegetables eaten⁽³⁶⁾. Participants in both of the original studies had volunteered to take part in nutritional research and may therefore not be representative of the Scottish population. Average self-reported energy intake relative to estimated energy requirement for the group was higher than is usually reported^(37; 38), and intakes of fruit and vegetables appear to be higher than found elsewhere, which would increase the apparent proportion of the F&V food group and decrease the proportions of the other food groups. Food group proportions of composite foods were estimated from matching to similar foods or recipes from food composition tables, and there will have been some errors introduced in the matching of foods. In addition recipes in the latest version of the food composition tables have recently been updated⁽³⁹⁾. However, none of these changes are likely to have had an impact on the secondary aim of the study, which was to identify the methodological issues of estimating Eatwell Plate proportions.

Conclusions

The present study suggests that it is possible to estimate Eatwell plate proportions of diets from weighed food records, but that methodological issues in assigning foods to Eatwell food groups, and in disaggregating composite foods make this complex. The research suggests several areas in which standardization of the method would be beneficial, and areas for future research.

- A comprehensive published list of foods and beverages, such as those included the UK composition of foods tables, allocated to their respective Eatwell plate segments.
- A published list of the disaggregation factors for common composite foods and dishes.
- A standardized protocol for disaggregating composite foods and estimating their Eatwell plate proportions.
- Guidelines need to be drawn up to update the Eatwell Plate to accommodate convenience foods, ready meals and composite dishes.
- Development of a simplified dietary assessment tool that is user-friendly, and requires minimal nutritional knowledge, that would enable consumers to estimate the Eatwell plate proportions of their diet.
- Research to evaluate whether consumers are sufficiently able to disaggregate composite foods.

Table 1. Mean daily absolute amounts (g) and proportions of the Eatwell plate food groups before and after disaggregation of composite foods.

	Eatwell Starchy	Eatwell F&V	Eatwell Dairy	Eatwell Protein	Eatwell HFHS
Before disaggregation (g/d)	372	409	203	212	171
After disaggregation (g/d)	335	419	212	177	216
P	0.177	0.029	0.535	<0.001	<0.001
Recommended proportion (%)	33	33	15	12	8
Before disaggregation (%)	27.5	29.1	14.4	15.8	13.2
After disaggregation (%)	25.0	30.0	15.2	13.3	16.6
P	0.008	0.006	0.584	<0.001	<0.001

F&V – fruit and vegetables. HFHS – High-fat/high-sugar

References

1. Mente A, de Koning L, Shannon HS *et al.* (2009) A systematic review of the evidence supporting a causal link between dietary factors and coronary heart disease. *Arch Intern Med* **169**, 659-669.
2. Department of Health (1991) *Dietary reference values for food energy and nutrients for the United Kingdom*. London: HMSO.
3. Painter J, Rah J-H, Lee Y-K (2002) Comparison of International Food Guide Pictorial Representations. *J Am Diet Assoc* **102**, 483-489.
4. United States Department of Agriculture Human Nutrition Information Service ChooseMyPlate. www.choosemyplate.gov (accessed 25 March 2014)
5. Smith A, Kellet E, Schmerlaib Y (1998) *Australian Guide to Healthy Eating*. Canberra: Commonwealth Department of Health and Family Services.
6. National Institute of Nutrition (2010) *Dietary Guidelines for Indians-A Manual*. Hyderabad: National Institute of Nutrition.
7. National Nutrition Council (2014) Finnish Nutrition Recommendations. <http://www.ravitsemusneuvottelukunta.fi/portal/en/nutrition+recommendations/> (accessed 1 March 2015)
8. Food Standards Agency (2010) The Eatwell Plate. <http://tna.europarchive.org/20100929190231/http://www.eatwell.gov.uk/healthydiet/eatwellplate/> (accessed 25 March 2014)
9. Hunt P, Rayner M, Gatenby S (1995) A national food guide for the UK? Background and development. *J Hum Nutr Diet* **8**, 315-322.
10. Food Standards Agency (2011) Guidelines for use and reproduction of the eatwell plate model. <http://www.food.gov.uk/scotland/scotnut/eatwellplate/guidelines> (accessed 25 March 2014)
11. Gatenby SJ, Hunt P, Rayner M (1995) The National Food Guide: development of dietetic criteria and nutritional characteristics. *J Hum Nutr Diet* **8**, 323-334.
12. Cosgrove M, Flynn A, Kiely M (2005) Impact of disaggregation of composite foods on estimates of intakes of meat and meat products in Irish adults. *Public Health Nutr* **8**, 327-337.

13. Prynne CJ, Wagemakers JJMF, Stephen AM *et al.* (2008) Meat consumption after disaggregation of meat dishes in a cohort of British adults in 1989 and 1999 in relation to diet quality. *Eur J Clin Nutr* **63**, 660-666.
14. Statista (2015) Number of people using ready meals (chilled or frozen) in the United Kingdom (UK) in 2013, by frequency of use (in 1,000 people). <http://www.statista.com/statistics/301779/ready-meal-usage-frequency-in-the-uk/> (accessed 2 February 2015)
15. Macdiarmid JJ, Kyle J, Horgan GW *et al.* (2011) *Livewell: a balance of healthy and sustainable food choices.* . Godalming, UK: WWF-UK.
16. Harland JJ, Buttriss J, Gibson S (2012) Achieving eatwell plate recommendations: is this a route to improving both sustainability and healthy eating? *Nutrition Bulletin* **37**, 324-343.
17. DEFRA (2014) *Family Food 2013*. Department for Environment, Food and Rural Affairs.
18. Jones NRV, Conklin AI, Suhrcke M *et al.* (2014) The Growing Price Gap between More and Less Healthy Foods: Analysis of a Novel Longitudinal UK Dataset. *PLoS ONE* **9**.
19. Banks J, Williams J, Cumberlidge T *et al.* (2012) Is healthy eating for obese children necessarily more costly for families? *Brit J Gen Pract* **62**, e1-e5.
20. Leslie WS, Comrie F, Lean ME *et al.* (2012) Designing the eatwell week: the application of eatwell plate advice to weekly food intake. *Public Health Nutr* **16**, 795-802.
21. United States Department of Agriculture Human Nutrition Information Service ChooseMyPlate. www.choosemyplate.gov/food-groups/protein-foods (accessed 02 February 2015)
22. Stubbs RJ, O'Reilly LM, Whybrow S *et al.* (2014) Measuring the difference between actual and reported food intake in the context of energy balance under laboratory conditions. *Br J Nutr* **111**, 2032 - 2043.
23. Whybrow S, Mayer C, Kirk TR *et al.* (2007) Effects of two-weeks' mandatory snack consumption on energy intake and energy balance. *Obes Res* **15**, 673-685.
24. Schofield WN (1985) Predicting Basal Metabolic Rate, new standards and review of previous work. *Hum Nutr Clin Nutr* **39**, 5-41.
25. Bingham SA (1987) The dietary assessment of individuals; methods, accuracy, new techniques and recommendations. *Nutr Abstr Rev* **57**, 705-742.
26. Holland B, Welch AA, Unwin ID *et al.* (1991) *The Composition of Foods*. 5 ed. Cambridge: The Royal Society of Chemistry and Ministry of Agriculture, Fisheries and Food.

27. World Cancer Research Fund / American Institute for Cancer Research (2007) *Food, nutrition, physical activity, and the prevention of cancer: a global perspective*. Washington DC.
28. Food Standards Agency (2002) McCance and Widdowson's Composition of Foods integrated dataset (CoF IDS): Food Standards Agency. Crown copyright.
29. Barton K, Wrieden W (2012) Estimation of Food and Nutrient Intakes from Food Survey data in Scotland 2001-2009: Food Standards Agency in Scotland.
30. Bromley C, Dowling S, Gray L *et al.* (2013) *The Scottish Health Survey 2012 Edition: Volume 1 – Main Report*. Edinburgh: The Scottish Government.
31. Macdiarmid JI, Cade JE, Blundell JE (1995) Extrinsic sugar as vehicle for dietary fat. In *Lancet*, vol. 346, pp. 696-697.
32. Horgan GW, Whybrow S (2012) Associations between fat, sugar and other macronutrient intakes in the National Diet and Nutrition Survey. *Nutrition Bulletin* **37**, 213-223.
33. Public Health England (2014) Your guide to eatwell plate: helping you eat a healthier diet: Public Health England in association with the Welsh Government, the Scottish Government and the Food Standards Agency in Northern Ireland.
34. Fitt E, Mak TN, Stephen AM *et al.* (2010) Disaggregating composite food codes in the UK National Diet and Nutrition Survey food composition databank. *Eur J Clin Nutr* **64**, S32-S36.
35. Food Standards Agency (2009) The Ready Meals Market. <http://www.food.gov.uk/news/newsarchive/2003/jun/readymealsmarket> (accessed 1 March 2015)
36. Wrieden WL, Armstrong J, Sherriff A *et al.* (2013) Slow pace of dietary change in Scotland: 2001–9. **109**, 1892-1902.
37. Poslusna K, Ruprich J, de Vries JH *et al.* (2009) Misreporting of energy and micronutrient intake estimated by food records and 24 hour recalls, control and adjustment methods in practice. *Br J Nutr* **101 Suppl 2**, S73-85.
38. Black AE, Goldberg GR, Jebb SA *et al.* (1991) Critical-evaluation of energy-intake data using fundamental principles of energy physiology. 2. Evaluating the results of published surveys. *Eur J Clin Nutr* **45**, 583-599.
39. Finglas PM, Roe MA, Pinchen HM *et al.* (2015) *McCance and Widdowson's The Composition of Foods, 7th summary edition*. Cambridge The Royal Society of Chemistry.