**Assessing the relative validity of the Scottish Collaborative Group Food Frequency Questionnaire for measuring dietary intake in adults.**

**Abstract**

*Objective:* To assess the relative validity of the latest version of the Scottish Collaborative Group (SCG) Food Frequency Questionnaire (FFQ) (version 6.6) in adults living in Scotland.

*Design:* A cross-sectional validation study. Participants completed the self-administered, 169-item SCG FFQ followed by a 7-day, non-weighed food diary. Energy and energy-adjusted macronutrients and micronutrients were examined for relative validity through Spearman’s correlation, the percentage of subjects classified into thirds of intake, Cohen’s weighted kappa and Bland Altman analysis.

*Setting:* General population living in Scotland.

*Subjects:* Ninety-six adults aged 18-65 years.

*Results:* Spearman’s correlation coefficients ranged between 0.21 (retinol) to 0.71 (magnesium). A median of 52% of adults were correctly classified into thirds of intake (range: 42% (PUFA, MUFA and iron) to 64% (percentage energy from carbohydrates)), and 8% were grossly misclassified into opposite thirds of intake (range: 3% (carbohydrates, percentage energy from carbohydrates) to 19% (thiamin)). Weighted kappa values ranged between 0.2 (PUFA, beta-carotene) to 0.55 (percentage energy from carbohydrates). In the Bland Altman analysis, the smallest limits of agreement, when expressed as a percentage of the mean intake from the FFQ and food diary, were seen for the main macronutrients carbohydrates, fat and protein.

*Conclusions:* As in the previous validation study more than 10 years ago, the FFQ gave higher estimates of energy and most nutrients than the food diary, but after adjustment for energy intake the FFQ could be used in place of non-weighed food diaries for most macronutrients and many micronutrients in large-scale epidemiological studies.

*Key words:* Validation, dietary assessment, food frequency questionnaire, epidemiology

**Introduction**

Food frequency questionnaires (FFQ) are a feasible and cost-effective method of collecting dietary data in large-scale epidemiological research.([1](#_ENREF_1), [2](#_ENREF_2)) The Scottish Collaborative Group (SCG) FFQ (version 6.6) is a self-administered, 169-item, semi-quantitative FFQ originally developed from the FFQ used in the Scottish Heart Health Study and Monitoring Trends and Determinants in Cardiovascular Disease (MONICA) study.([3](#_ENREF_3)) The SCG FFQ has been continuously modified and updated for use in large-scale epidemiological studies.([4](#_ENREF_4), [5](#_ENREF_5)) A previous validation of the SCG FFQ (version 6.31)([6](#_ENREF_6)) with 4-day weighed food records in 41 men and 40 women from North East Scotland in 2003 showed significantly higher intakes of energy and macronutrients as assessed by the FFQ but no significant differences in macronutrient intake expressed as percentage energy. Spearman’s correlation coefficients were greater than 0.5 for energy-adjusted saturated fat, alcohol and non-starch polysaccharides (NSP) as well as many, though not all, micronutrients.([6](#_ENREF_6))

Refining the collection of dietary data through FFQs will provide more accurate estimates of dietary intake that can enhance our understanding of food and nutrients in the aetiology and prevention of disease.([7](#_ENREF_7)) Since the SCG FFQ was first developed in 1993, the composition and portion size data have been modified to reflect changes in the diet of the UK population. Since the previously validated SCG FFQ, numerous food items have been added and other items removed (Supplementary File 1). Subtle changes in the design of FFQs can affect the questionnaire’s performance, therefore it is essential to assess the validity of the revised FFQ.([1](#_ENREF_1)) As the degree to which data from one validation study can be generalised to other populations is unknown, repeating validation studies in different populations is important.([1](#_ENREF_1)) The aim of this study was to assess the current relative validity of the SCG FFQ (version 6.6) in healthy, free living adults across Scotland.

**Methods**

The study was carried out using data from an existing study conducted between September 2013 and June 2014. Participants were recruited from the 2010 Scottish Health Survey (SHeS) sample. The SHeS assesses a nationally representative sample of the general population living in Scottish households. In 2010, 8,473 adults were randomly selected to participate in the SHeS using postcode address files (response rate=55%).([8](#_ENREF_8)) The SHeS team provided names and addresses of 1,600 SHeS participants (800 male, 800 female) who had consented to be contacted for follow-up research; were aged 18-65 years old; and had complete data for sex, age, height, weight and Scottish Index of Multiple Deprivation (SIMD). An invitation letter, consent form, and freepost return envelope were mailed to potential participants.

***Measures***

Participants completed the SCG FFQ followed by a 7-day non-weighed food diary. Dietary data from the study were linked with data collected during the 2010 SHeS including demographic characteristics (e.g. age, sex), height, weight and body mass index (BMI). Data entry was double checked to maximise accuracy. Basal Metabolic Rate (BMR) was calculated using the Henry equations ([9](#_ENREF_9)) to assess reported energy intake relative to estimated energy requirements.

The SCG FFQ (version 6.6) ([10](#_ENREF_10)) assessed each participant’s habitual diet over the preceding two to three months. Participants completed the paper-based questionnaire and were asked to return the SCG FFQ in a Freepost envelope within one week. FFQs were checked for missing or unclear responses. Participants with >10 missing responses were telephoned to provide missing information, and FFQs with >10 missing responses after telephone contact attempts were excluded. Responses were entered using a purpose-built web based data entry system. FFQ data were analysed using the UK food composition tables.([11](#_ENREF_11))

Participants completed the 7-day non-weighed food diary over consecutive days. The food diary and a Freepost return envelope were mailed to participants following receipt of the FFQ. The diaries contained photographs of standard portion sizes to assist participants to describe the amount of foods and beverages consumed (including food prepared at home).([12](#_ENREF_12)) Participants could also report weights from packaged food if appropriate. Participants were asked to provide brands names of commercial products, and identify if ‘low-fat’, ‘low sugar’, ‘low calorie’, or ‘diet’ products were used, which aided with identifying the correct food item (or closest substitute) in the food composition tables. Foods that were prepared from ingredients were analysed using representative recipes from the food composition tables, or from internet sources. Food diary data were analysed with WISP 4.0 (Tinuviel Software 2013) using the UK food composition tables (McCance and Widdowson's The Composition of Foods 6th Edition (2002).([11](#_ENREF_11))

***Statistical analysis***

Data were analysed using SPSS Version 22 (SPSS/IBM Corp, Armonk, New York, NY). The crude medians (interquartile ranges) were reported, and relative differences between the FFQ and food diary for each nutrient were calculated. Intakes fromthe FFQ were compared to the food diary for energy, percentage energy from macronutrients, macronutrients, and 16 micronutrients. Energy-adjusted nutrient values were used to control for energy intake, as recommended for investigating diet-disease relationships.([13](#_ENREF_13)) Energy-adjusted intakes were calculated by adding the mean nutrient intake to the residual from the linear regression model. Participants who reported FFQ energy intakes at the highest and lowest 2.5% of the sample were excluded, in line with the current SCG FFQ standard operating procedures.

Three statistical methods were used to assess relative validity; 1) Spearman rank correlation coefficient and 95% confidence intervals were used to examine the correlation between the SCG FFQ and food diary; 2) the percentage of subjects classified into the same and opposite thirds of intake and Cohen’s weighted kappa statistic were used to assess agreement in ranking into thirds, and 3) Bland Altman analysis was used to assess mean difference and 95% limits of agreement between the SCG FFQ and food diary ([14](#_ENREF_14)).

**Results**

One-hundred and fifty individuals agreed to participate in the study (response rate=9%). A total of 101 participants completed the study (67%; 49 participants failed to complete both the SCG FFQ and food diary) and 96 participants (56 female) were included in the analysis (lowest and highest 2.5% of the sample were removed). Eleven participants were re-contacted as more than 10 FFQ questions had been missed. The final sample had a mean (SD) age of 51.4 (11.1) years, and BMI of 27.1 (4.9) kg/m2 (Table 1). The median (interquartile range) energy and nutrient intakes calculated from the FFQ and food diary are reported in Table 2. One-percent and 35% of participants reported an energy intake lower than their estimated BMR, as measured by the SCG FFQ and food diary, respectively.

***Relative agreement in energy and energy-adjusted nutrient intakes***

Correlation coefficients ranged between 0.21 for retinol and 0.71 for magnesium (Table 3). All macronutrients expressed as percentage energy had a correlation coefficient above 0.5. Correlation coefficients were above 0.5 for energy-adjusted saturated fat, carbohydrates, sugar, starch, NSP, alcohol, riboflavin, vitamin B6, vitamin C, niacin equivalents, magnesium and potassium. Correlations were lowest for thiamin and retinol at less than 0.3. At least 50% of participants were correctly classified into the same third of intake for 21 of the 31 nutrients. For all nutrients, a median of 52% of adults were correctly classified, ranging from 42% for PUFA, MUFA and iron to 64% for percentage energy from carbohydrates. Ten per cent or more of participants were grossly misclassified into the opposite third of intake for 11 nutrients. The median percentage of participants who were grossly misclassified was 8%, ranging from 3% for carbohydrates and percent energy from carbohydrates to 19% grossly misclassified for thiamin. The weighted kappa ranged from -0.08 (thiamin) to 0.55 (percent energy from carbohydrates). Weighted kappa values were above 0.4 (indicating moderate agreement) for 10 of the 31 nutrients. The mean agreement and 95% limits of agreement for intake by the two methods is shown for each nutrient in Table 4. The smallest limits of agreement, when expressed as a percentage of the mean intake from the FFQ and food diary, were seen for the main macronutrients carbohydrates, fat and protein. Bland-Altman plots to assess relative agreement for percentage energy from protein, fat and carbohydrates showed good agreement (Figure 1).

The relative agreement between the SCG FFQ and food diary are reported separately by sex (Supplementary File 2 and 3) and showed that although validation findings were consistent across many nutrients (e.g. percentage energy from carbohydrates, carbohydrates, NSP, magnesium, potassium) there were some differences according to sex. For example, measurement of percentage energy from fat, starch, alcohol and niacin equivalents was superior in women; and SFA, PUFA, MUFA, sugars, and vitamin B6 superior in men. Bland Altman plots to assess relative agreement for percentage energy from protein, fat and carbohydrates showed good agreement for both sexes (Supplementary File 4).

**Discussion**

The study aimed to assess the relative validity of the SCG FFQ (version 6.6) in healthy, free living adults aged 18-65 years old. While the study showed higher intakes of energy and macronutrients by the FFQ, macronutrient intakes expressed as percentage of energy between the FFQ and food diary were highly correlated. These findings were similar to the previous SCG FFQ validation study ([6](#_ENREF_6)) (see Supplementary File 5) and other validation studies in adults.([15](#_ENREF_15), [16](#_ENREF_16)) It has been suggested that correlation coefficients >0.5, >50% of participants correctly classified and <10% of subjects grossly misclassified into the appropriate third of intake, and weighted kappa values >0.4 are desirable if the possibility of false-negative associations between diet and disease in epidemiological studies is to be minimised.([6](#_ENREF_6)) Based on these criteria, percentage energy from protein and carbohydrates, and energy-adjusted carbohydrates, sugars, NSP, alcohol, vitamin B6, vitamin C, magnesium and potassium could be assessed with equal validity using the SCG FFQ or a seven day unweighed food diary method.

Comparing the previous SCG FFQ ([6](#_ENREF_6)) and the current validation study (and using the above mentioned criteria) there were similar results for NSP, alcohol, magnesium and potassium. The curent study showed greater validity for percentage energy from protein and carbohydrates, and energy-adjusted carbohydrates, sugars, vitamin B6 and vitamin C, but slightly lower validity for iron. Correlation coefficients for thiamin and retinol were low and had poorer agreement. This was relatively consistent with findings from the previous validation study ([6](#_ENREF_6)). The poor agreement for retinol may reflect the fact that retinol is found in high concentration in infrequently eaten products (e.g. liver/liver products) so habitual intake at the individual level is not measured so well by short-term recording methods such as diaries. This could also be an explanation for the lower correlation coefficients for thiamin which is found in high concentration in yeast extract. In future studies, multiple food diaries may be needed to assess habitual intake of nutrients with large day-to-day variation within individuals. ([17](#_ENREF_17))

This paper reports the updated validation results of the SCG FFQ, 10 years after the previous validation study was published ([6](#_ENREF_6)), and in a wider population. Multiple statistical approaches have been used to examine the performance of the SCG FFQ against unweighed food records because there is no single superior method for relating a proxy measure to the reference measure, and future epidemiological studies that use the SCG FFQ will require the FFQ to be validated in the nutrients of interest through different methods (i.e. continuous or categorical data) depending on the study methods.([1](#_ENREF_1), [6](#_ENREF_6)) The residual method of energy adjustment was used as it has been recommended for validating nutrients used to investigate diet-disease relationships.([13](#_ENREF_13)) Sex specific validation values should be taken into account for single sex studies.

The limitations of this study need to be acknowledged. Food diaries, as with all dietary assessment measures, rely on self-reported data and could be influenced by participant misreporting or a social desirability bias.([18](#_ENREF_18), [19](#_ENREF_19)) A postal estimated weighed food diary (used as the reference method) without an interview may be considered less of a ‘gold standard’ than a weighed food diary, or a food diary with an interview, to check details and enable estimation of portion size. We could not estimate intake of free sugars as this was not available in the UK nutrient composition database. Multiple comparisons may be an issue due to the number of statistical tests and range of variables examined. The subjects were recruited from the SHeS sample in an attempt to obtain a representative sample of the population. However, a 9% response rate from a group who had agreed to be contacted for future health-related research will likely be a highly selected sample, and may be more educated and motivated to complete the assessment methods than those who would be recruited to an epidemiological study.

**Conclusion**

As in the previous validation study in 2003, the SCG FFQ gave higher estimates of energy and most nutrients than the food diary, but after adjustment for energy intake the SCG FFQ could be used in place of non-weighed food diaries to estimate percentage energy from protein and carbohydrates, and energy-adjusted carbohydrates, sugars, NSP, alcohol, vitamin B6, vitamin C, magnesium and potassium in large-scale epidemiological studies but should be used with caution for other nutrients. The similarity of results over 10 years provides reassurance that performance over time remains relatively stable.

**References**

1. Willett WC (2012) Nutritional Epidemiology. 3rd ed, New York: Oxford University Press.

2. Willett WC. (1994) Future directions in the development of food-frequency questionnaires. *Am J Clin Nutr* **59**, 171S-4S.

3. Scottish Collaborative Group. Scottish Collaborative Group Food Frequency Questionnaire. <http://www.foodfrequency.org/> (accessed 5th May 2015).

4. Smith WCS, Crombie IC, Tavendale R et al. (1987) The Scottish Heart Health Survey - objectives and development of methods. *Health Bulletin* **45**, 211-7.

5. Allan KM, Prabhu N, Craig LC et al. (2015) Maternal vitamin D and E intakes during pregnancy are associated with asthma in children. *Eur Respir J* **45**, 1027-36.

6. Theodoratou E, Farrington SM, Tenesa A et al. (2014) Associations between dietary and lifestyle risk factors and colorectal cancer in the Scottish population. *Eur J Cancer Prev* **23**, 8-17.

7. Masson LF, McNeill G, Tomany JO et al. (2003) Statistical approaches for assessing the relative validity of a food-frequency questionnaire: use of correlation coefficients and the kappa statistic. *Public Health Nutr* **6**, 313-21.

8. Subar AF, Thompson FE, Kipnis V et al. (2001) Comparative validation of the Block, Willett, and National Cancer Institute food frequency questionnaires : the Eating at America's Table Study. *Am J Epidemiol* **154**, 1089-99.

9. The Scottish Government. The Scottish Health Survey 2010 Volume 2: Technical Report. 2010.

10. Henry CJ. (2005) Basal metabolic rate studies in humans: measurement and development of new equations. *Public Health Nutr* **8**, 1133-52.

11. Food Standards Agency (2002) McCance and Widdowson's The Composition of Foods Integrated Dataset 6th Edition, Cambridge Royal Society of Chemistry.

12. Nelson M, Atkinson M, Meyer J Food Portion Sizes: A Users Guide to the Photographic Atlas: Nutritional Epidemiology Group UK, Food Standards Agency.

13. 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**, S73-85.

14. Bland JM, Altman DG (1986) Statistical methods for assessing agreement between two methods of clinical measurement. *Lancet* **1**, 307-10.

15. Boucher B, Cotterchio M, Kreiger N et al. (2006) Validity and reliability of the Block98 food-frequency questionnaire in a sample of Canadian women. *Public Health Nutr* **9**, 84-93.

16. Lassale C, Guilbert C, Keogh J et al. (2009) Estimating food intakes in Australia: validation of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) food frequency questionnaire against weighed dietary intakes. *J Hum Nutr Diet* **22**, 559-66.

17. Henriquez-Sanchez P, Sanchez-Villegas A, Doreste-Alonso J et al. (2009) Dietary assessment methods for micronutrient intake: a systematic review on vitamins. *Br J Nutr* **102**, S10-37.

18. van de Mortel TF. (2008) Faking it: social desirability response bias in self-report research. *Australian Journal of Advanced Nursing* **25**, 40.

19. Winkler JT. (2005) The fundamental flaw in obesity research. *Obes Rev* **6**, 199-202.

20. Altman DG (1991) Practical Statistics for Medical Research, London: Chapman and Hall.

**Table 1.** Demographic characteristics of the 96 participants included in the study.

|  |  |  |  |
| --- | --- | --- | --- |
| **Demographic characteristics** | | | **Mean (SD)** |
| Age (years) | | | 51.4 (11.1) |
| BMI (kg/m2) ^ | | | 27.1 (4.9) |
|  | | **Number (n)** | **Percentage (%)** |
| Sex | Male | 40 | 42 % |
| Female | 56 | 58 % |
| Residence | Large urban areas | 29 | 30 % |
|  | Other urban areas | 27 | 28 % |
|  | Accessible small towns | 6 | 6 % |
|  | Remote small towns | 10 | 10 % |
|  | Accessible rural areas | 7 | 7 % |
|  | Remote rural areas | 17 | 18 % |
| SIMD | Quintile 1 *(most deprived)* | 10 | 10% |
| Quintile 2 | 11 | 12% |
| Quintile 3 | 28 | 29 % |
| Quintile 4 | 25 | 26 % |
| Quintile 5 *(least deprived)* | 22 | 23 % |

Abbreviations: Body Mass Index (BMI), Scottish Index of Multiple Deprivation (SIMD), Standard Deviation (SD).

^ BMI was calculated based on weight and height measurements taken at the time of the 2010 Scottish Health Survey.

**Table 2.** Median daily energy and nutrient intakes in 96 participants (40 men and 56 women), and relative differences between the SCG FFQ and food diary.

|  |  |  |  |
| --- | --- | --- | --- |
| **Nutrient** | **SCG FFQ** | **Food diary** | **Relative difference (%)** |
| **Median (P25-P75)** | **Median (P25-P75)** | **Median (P25-P75)** |
| Energy (kJ) | 9317 (7738, 11691) | 6828 (5471, 8136) | 44 (14, 68) |
| Fat (g) | 85.8 (67.3, 108.0) | 61.5 (47.8, 79.5) | 34.6 (8.0, 87.3) |
| % energy from fat | 32.7 (30.9, 36.2) | 33.4 (29.6, 38.0) | -1.4 (-10.7, 12.6) |
| SFA (g) | 32.9 (26.3, 42.9) | 22.3 (15.7, 27.0) | 56.4 (15.5, 105.6) |
| % energy from SFA | 13.1 (11.7, 14.3) | 11.8 (10.0, 13.9) | 10.9 (-6.3, 27.7) |
| PUFA (g) | 13.8 (10.9, 17.8) | 9.4 (7.0, 13.1) | 47.9 (1.7, 102.1) |
| MUFA (g) | 29.4 (22.9, 37.5) | 20.1 (15.3, 27.1) | 45.9 (8.3, 83.9) |
| Protein (g) | 89.7 (76.9, 114.8) | 63.6 (53.9, 77.8) | 40.2 (10.7, 79.3) |
| % energy from protein | 16.9 (15.1, 18.5) | 16.5 (14.5, 18.5) | 0.7 (-5.2, 12.6) |
| CHO (g) | 266.4 (217.2, 330.6) | 196.7 (159.3, 226.0) | 44.7 (11.8, 73.4) |
| % energy from CHO | 45.6 (42.3, 50.0) | 45.2 (40.8, 51.5) | -0.8 (-8.9, 9.7) |
| Starch (g) | 134.5 (113.3, 173.5) | 102.3 (81.9, 118.8) | 43.6 (13.1, 74.7) |
| Total sugars (g) | 124.3 (96.9, 153.6) | 83.0 (65.0, 104.6) | 47.8 (19.2, 78.7) |
| NSP (g) | 19.5 (15.6, 25.9) | 15.6 (12.7, 19.5) | 28.3 (0.5, 63.6) |
| Alcohol (g) | 8.8 (3.3, 19.9) | 5.8 (0.0, 15.8) | 22.0 (-7.2, 141.9) |
| Retinol (µg) | 393.0 (292.5, 559.8) | 249.5 (176.8, 361.8) | 69.4 (10.2, 143.3) |
| β-carotene (µg) | 3943.0 (2628.3, 5951.8) | 2215.5 (1240.0, 3191.5) | 114.8 (34.7, 244.3) |
| Vit D (µg) | 3.6 (2.1, 5.8) | 1.6 (1.1, 2.4) | 123.8 (39.8, 207.5) |
| Vit E (mg) | 10.9 (8.4, 14.0) | 6.2 (5.0, 8.5) | 65.7 (29.1, 125.3) |
| Thiamin (mg) | 1.8 (1.4, 2.3) | 1.3 (1.1, 1.5) | 44.9 (20.5, 87.1) |
| Riboflavin (mg) | 2.1 (1.7, 2.7) | 1.4 (1.2, 1.8) | 50.2 (28.5, 95.4) |
| Vit B6 (mg) | 2.5 (2.0, 3.1) | 1.6 (1.3, 1.9) | 62.3 (23.5, 101.1) |
| Vit B12 (µg) | 6.4 (4.4, 9.6) | 3.4 (2.6, 4.7) | 90.8 (24.4, 174.6) |
| Vit C (mg) | 127.5 (89.0, 180.8) | 75.0 (45.8, 102.8) | 68.8 (15.3, 142.9) |
| Folate (µg) | 308.0 (261.5, 401.3) | 201.5 (164.3, 243.5) | 59.5 (28.2, 107.7) |
| Niacin equivalents (mg) | 42.7 (34.5, 52.5) | 29.6 (24.7, 34.7) | 44.1 (19.1, 81.2) |
| Iron (mg) | 14.2 (12.2, 19.0) | 9.6 (8.1, 11.5) | 51.6 (24.5, 83.3) |
| Calcium (mg) | 1191.5 (950.3, 1548.3) | 771.5 (612.0, 934.8) | 56.3 (33.0, 95.0) |
| Magnesium (mg) | 369.5 (299.5, 460.8) | 255.5 (201.3, 305.5) | 46.8 (17.3, 80.4) |
| Potassium (mg) | 3903.0 (3330.3, 4888.3) | 2661.0 (2283.8, 3167.8) | 44.8 (20.0, 81.5) |
| Zinc (mg) | 11.3 (10.1, 15.0) | 7.6 (6.3, 9.4) | 46.0 (27.9, 89.6) |

SFA, saturated fatty acids; PUFA, polyunsaturated fatty acids; MUFA, monounsaturated fatty acids; NSP, non-starch polysaccharides; CHO, carbohydrates.

Relative Difference: ((FFQ - food diary)/food diary) x 100

**Table 3.** Spearman rs correlation coefficients, percentages of subjects classified into the same and opposite third of intake, and weighted kappa (Kw) in 96 adults (40 men and 56 women) living in Scotland using energy, percent-energy from macronutrients and energy-adjusted nutrient intakes.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Nutrient** | **Spearman Correlation** | | | **Percentage classified in** | | **Kw** |
| **r**s | **95% CI** | **p** | **Same third** | **Opposite third** |
| Energy (kJ) | 0.37 | 0.19, 0.53 | <0.001 | 45.8 | 12.5 | 0.25 |
| Fat (g) | 0.48 | 0.31, 0.62 | <0.001 | 54.2 | 8.3 | 0.39 |
| % E from Fat | 0.53 | 0.36, 0.66 | <0.001 | 49.0 | 7.3 | 0.34 |
| SFA (g) | 0.52 | 0.36, 0.66 | <0.001 | 54.2 | 8.3 | 0.39 |
| % E from SFA | 0.55 | 0.39, 0.68 | <0.001 | 50.0 | 6.3 | 0.37 |
| PUFA (g) | 0.35 | 0.17, 0.52 | <0.001 | 41.7 | 12.5 | 0.20 |
| MUFA (g) | 0.42 | 0.25, 0.58 | <0.001 | 41.7 | 8.3 | 0.25 |
| Protein (g) | 0.47 | 0.30, 0.62 | <0.001 | 53.1 | 9.4 | 0.37 |
| % E from Protein | 0.55 | 0.40, 0.68 | <0.001 | 58.3 | 6.3 | 0.46 |
| CHO (g) | 0.67 | 0.54, 0.77 | <0.001 | 57.3 | 3.1 | 0.48 |
| % E from CHO | 0.69 | 0.57, 0.78 | <0.001 | 63.5 | 3.1 | 0.55 |
| Total sugars (g) | 0.62 | 0.49, 0.73 | <0.001 | 55.2 | 5.2 | 0.44 |
| Starch (g) | 0.52 | 0.35, 0.65 | <0.001 | 52.1 | 8.3 | 0.37 |
| NSP (g) | 0.59 | 0.44, 0.71 | <0.001 | 60.4 | 8.3 | 0.46 |
| Alcohol (g) | 0.65 | 0.52, 0.75 | <0.001 | 60.4 | 4.2 | 0.51 |
| Retinol (µg) | 0.21 | 0.01, 0.40 | 0.037 | 51.0 | 15.6 | 0.27 |
| β-carotene (µg) | 0.45 | 0.28, 0.60 | <0.001 | 42.7 | 13.5 | 0.20 |
| Vit D (µg) | 0.32 | 0.13, 0.49 | 0.001 | 44.8 | 11.5 | 0.25 |
| Vit E (mg) | 0.33 | 0.14, 0.50 | 0.001 | 44.8 | 11.5 | 0.25 |
| Thiamin (mg) | 0.26 | 0.06, 0.44 | 0.011 | 54.2 | 18.8 | 0.27 |
| Riboflavin (mg) | 0.61 | 0.47, 0.72 | <0.001 | 52.1 | 6.3 | 0.39 |
| Vit B6 (mg) | 0.63 | 0.49, 0.74 | <0.001 | 56.3 | 8.3 | 0.41 |
| Vit B12 (µg) | 0.45 | 0.27, 0.60 | <0.001 | 43.8 | 6.3 | 0.30 |
| Vit C (mg) | 0.55 | 0.39, 0.67 | <0.001 | 55.2 | 5.2 | 0.44 |
| Folate (µg) | 0.48 | 0.31, 0.62 | <0.001 | 54.2 | 12.5 | 0.34 |
| Niacin Equivalents (mg) | 0.52 | 0.35, 0.65 | <0.001 | 51.0 | 9.4 | 0.34 |
| Iron (mg) | 0.42 | 0.24, 0.57 | <0.001 | 41.7 | 10.4 | 0.23 |
| Calcium (mg) | 0.38 | 0.19, 0.54 | <0.001 | 50.0 | 14.6 | 0.27 |
| Magnesium (mg) | 0.71 | 0.59, 0.79 | <0.001 | 58.3 | 4.2 | 0.48 |
| Potassium (mg) | 0.64 | 0.50, 0.74 | <0.001 | 59.4 | 5.2 | 0.48 |
| Zinc (mg) | 0.41 | 0.23, 0.56 | <0.001 | 43.8 | 12.5 | 0.23 |

SFA, saturated fatty acids; PUFA, polyunsaturated fatty acids; MUFA, monounsaturated fatty acids; NSP, non-starch polysaccharides; CHO, carbohydrates.

Values of weighted kappa greater than 0.60 indicate good agreement, between 0.41–0.60 moderate agreement, 0.21–0.40 fair agreement, and less than or equal to 0.20 poor agreement ([20](#_ENREF_20)).

**Table 4.** Bland Altman calculations of mean difference between the FFQ and diary and limits of agreement for energy, percent-energy from macronutrients and energy-adjusted nutrient intakes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Nutrient** | **Mean difference between FFQ and diary** | **Standard Deviation** | **95% limits of agreement** | |
| **Upper limit** | **Lower limit** |
| Energy (kJ) | 3004.8 | 3010.6 | 8905.6 | -2896.0 |
| Fat (g) | 27.1 | 11.0 | 48.7 | 5.5 |
| % energy from fat | -0.9 | 5.2 | 9.3 | -11.1 |
| SFA (g) | 12.8 | 7.0 | 26.5 | -0.9 |
| % energy from SFA | 1.1 | 2.7 | 6.4 | -4.2 |
| PUFA (g) | 4.4 | 4.2 | 12.6 | -3.8 |
| MUFA (g) | 9.8 | 4.9 | 19.4 | 0.2 |
| Protein (g) | 32.6 | 16.0 | 64.0 | 1.2 |
| % energy from protein | 0.23 | 2.8 | 5.72 | -5.25 |
| CHO (g) | 85.0 | 27.7 | 139.3 | 30.7 |
| % energy from CHO | -0.15 | 5.1 | 9.85 | -10.15 |
| Starch (g) | 44.8 | 26.5 | 96.7 | -7.1 |
| Total sugars (g) | 40.8 | 24.5 | 88.8 | -7.2 |
| NSP (g) | 5.1 | 5.9 | 16.7 | -6.5 |
| Alcohol (g) | 2.9 | 10.3 | 23.1 | -17.3 |
| Retinol (µg) | 170.6 | 453.0 | 1058.5 | -717.3 |
| β-carotene (µg) | 2852.2 | 3449.5 | 9613.2 | -3908.8 |
| Vit D (µg) | 2.6 | 2.8 | 8.1 | -2.9 |
| Vit E (mg) | 4.6 | 3.4 | 11.3 | -2.06 |
| Thiamin (mg) | 0.7 | 0.5 | 1.7 | -0.3 |
| Riboflavin (mg) | 0.8 | 0.5 | 1.8 | -0.2 |
| Vit B6 (mg) | 1.1 | 0.5 | 2.1 | 0.1 |
| Vit B12 (µg) | 3.8 | 3.2 | 10.1 | -2.5 |
| Vit C (mg) | 63.3 | 66.6 | 193.8 | -67.2 |
| Folate (µg) | 137.3 | 85.8 | 305.5 | -30.9 |
| Niacin equivalents (mg) | 14.4 | 7.1 | 28.3 | 0.5 |
| Iron (mg) | 5.6 | 2.6 | 10.7 | 0.5 |
| Calcium (mg) | 504.7 | 316.6 | 1125.2 | -115.8 |
| Magnesium (mg) | 132.2 | 52.8 | 235.7 | 28.7 |
| Potassium (mg) | 1461.7 | 615.1 | 2667.3 | 256.1 |
| Zinc (mg) | 4.7 | 2.2 | 9.0 | 0.4 |