Assessing Peanut Consumption in a Population of Mothers and Their Children in the UK

Validation Study of a Food Frequency Questionnaire

Aikaterini Sofianou-Katsoulis, MD, MRCPCH, MSc,[1] David Mesher, MSc,[2] Peter Sasieni, PhD,[2] George Du Toit, FRCPCH,[3] Adam T. Fox, FRCPCH,[3] and Gideon Lack, FRCPCH[3]

Background: Food frequency questionnaires (FFQs) are essential tools to investigate the relationship between peanut consumption and the development of peanut allergy. The aim was to validate a 50-item FFQ for use in peanut protein sensitization studies.

Methods: There were 38 mother-child pairs visiting a pediatric clinic of a London hospital included. Mothers recorded their own and their child's diet, using a 7 day food diary (7DFDR), completed prospectively over week. Six months later, they tried to recall the consumption of food items for the index week on a FFQ.

Results: Of these, 33 out of 38 mothers completed both the 7DFDR and the recall FFQ. Although there was considerable variation at the individual level between the 2 tools, there was extremely close agreement between the mean 7DFDR response and the FFQ when considering groups of fives with similar FFQ levels. Agreement was apparent on both peanut and other control foods consumption patterns.

Conclusion: The FFQ will reliably divide the population into groups with markedly different peanut consumption levels. It accurately reflects true adults and children peanut consumption, especially at low levels of peanut consumption, as it was validated against the gold standard, the 7DFDR. It also provides a good measure of other foods consumption.

Key Words: validation, food frequency questionnaire, recall, children

(*WAO Journal* 2011; 4:38–44)

The valid measurement of habitual food, energy or specific nutrient intake is required in studies that investigate the link between nutrition and disease outcomes. A major challenge in this field of research is the accurate determination of dietary intake.[1] In the absence of a validated biomarker, the use of 24 hours food diaries, particularly when performed more than 7 consecutive days, is considered to be by many, the best method for determining dietary intake. However, dietary records are labor intensive and require individuals to be followed-up prospectively and regularly. Hence, retrospective food frequency questionnaires (FFQs) have been used extensively in this field for the measurement of alcohol,[2] vitamins,[3] fatty acids,[4] and mineral consumption.[5] It is essential, therefore, that FFQs are validated against a gold standard, to verify that they reflect the accurate recall of consumption.[6]

The acceptability of an 'instrument' for measuring dietary intake will depend on the component of diet and the study design in which it is to be used. In the field of Food Allergy it is of interest to relate dietary intake (and in particular, the timing and quantification of food allergen exposure) to disease status. A common design is a case control study in which dietary questionnaires are given to children and their parents before allergy testing. The aim of the questionnaires is to divide the study population into groups with very low, low, medium, high, and very high exposure to a particular allergen.

The aim of this study was to validate the retrospective use of a 50 item semi-quantitative FFQ against a 7DFDR gold standard, for use in research on peanut allergy. The quantitative assessment of the association between peanut protein exposure and subsequent development of peanut allergy and the time this sensitization occurs are currently under research.

SUBJECTS AND METHODS

Dietary Record and FFQ Design

A. Food Frequency Questionnaire (FFQ)

The semi-quantitative food frequency questionnaire contained a predefined list of food items commonly consumed by families living in the United Kingdom. This FFQ had been validated previously for recall but has not been validated against a gold standard.[7] Eighteen high-peanut protein containing food items were also included. To make the latter list as accurate and complete as possible, we made use of both the pediatric dietitians' peanut avoidance diet

From the [1]Institute of Child Health, M.Asias 76, Gr-11527, Athens, Greece. St Mary's Hospital, Paediatric Department, QEQM Building, Praed Street, W2 1NY, London, UK; [2]Centre for Epidemiology, Mathematics and Statistics, Wolfson Institute for Preventive Medicine, Queen Mary University of London, Barts and The London School of Medicine and Dentistry, Charterhouse Square, London, EC1M 6BQ, UK; [3]King's College, London. MRC & Asthma UK Centre in Allergic Mechanisms of Asthma, Division of Asthma, Allergy and Lung Biology. Guy's and St. Thomas' NHS Foundation Trust, London. St Mary's Hospital, Paediatric Department, QEQM Building, Praed Street, W2 1NY, London, UK.

Correspondence to: Aikaterini Sofianou-Katsoulis, MD, Paediatrician, Research Fellow, Institute of Child Health, M.Asias 76, Gr-11527, Athens, Greece.

Copyright © 2011 by World Allergy Organization

Copyright © 2011 World Allergy Organization. Unauthorized reproduction of this article is prohibited

sheets (that lists common peanut-containing foods), and the Anaphylaxis Campaign (a charitable organization that offers support to the families of children with allergies) food lists. Given that refined peanut oils contain negligible quantities of protein, peanut oil containing foods were not included. Similarly, items that listed peanut either as a trace ingredient or as a possible contaminant were not placed on the questionnaire because of their minimal protein content.

The FFQ for peanut included 13 questions about peanut consumption combined with 37 questions on the consumption of other food groups so that mothers filling out the questionnaires would not realize that peanut was the focus of the study. Peanut items, however, were interspersed with other between a variety of other food items and different food categories were all mixed among each other, to prevent the mothers' attention being biased toward peanut consumption (Table 1). The questionnaire was also limited in size to allow for completion within ~10 minutes. We made use of 7 consecutive day food diaries, thereby recording consumption through all days of the week. Use of more than 7 food diaries has not shown to give a more efficient record of the true diet.[8] Quantities listed in both the FFQs and in the 7-day food diaries (7DFDR) were in portion sizes as recommended by the Ministry of Agriculture;[9] however, for prepacked snacks such as chocolates, the number of bars consumed was requested. The weight in grams of peanut protein in the relevant food items was provided by the manufacturers. The FFQ is identical to that used in the test–retest validation study[7] and in the epidemiological studies carried out by our group.[10,11]

B. Seven Days Food Diaries (7DFDR)

The 7DFDR included the same predefined list of food items and the same serving sizes as the food frequency questionnaires. Table 1 demonstrates the listed food items and portions used in both instruments. A total of 7 records for each 24 hour period during the index-week requested information on amount and times received for each food item listed and were obtained from each mother and her child reflecting the diet of a whole week.

Population Enrolment

The target population of the study was mothers of children aged 3 to 7 years. The mothers were visiting with their children either a General Pediatric clinic or a Pediatric Allergy clinic and they were enrolled consecutively between May and November 2005. These populations were targeted to recruit participants with both high and low peanut consumption diets. Mother-child pairs were excluded from the study if the main carer was not the mother, if the mother was pregnant or breast-feeding (at the time of the study UK government recommendations advised against peanut consumption during pregnancy and while breast-feeding, in atopic families), and if the mothers understanding of English language was poor. The mothers were given an information sheet at the end of the consultation to read at home. A few days later, Aikaterini Sofianou-Katsoulis (ASK) would contact them to ask if they agreed to participate. In case they did they were sent a pack contacting the FDFDR paperwork, a consent form and a prepaid envelope to return the 7DFDR. The population en-

TABLE 1. Original List of Food Items Included in Both DRs and FFQs and Portion Size

Apples	No of fruits
Orange	No of fruits
Cherries	Handfulls
Pears	No of fruits
Whole peanuts	Handfulls
Peanut butter on bread	Slices
Crunchy Nut Cornflakes	Bowls
Crunchy Nut Cornflakes Red	Bowls
Shoosh	Packets
Bamba	Packets
Cadbury's Star Bar	Bars
Cadbury's Fuse	Bars
Cadbury's Picnic	Bars
Revels	Bars
Satay sauce	Servings
Rowntree's Lion Bar	Bars
Tracker Roasted nut	Bars
Reese's Peanut Butter Cups	Cups
Snickers	Bars
Biscuits with peanuts	Teaspoons
Peanut M&Ms	Handful
Peanut brittle 'botnit'	Bars
Musli	Bowls
Bran flakes	Bowls
Corn flakes	Bowls
Coffee	Cup
Milk	Cup
White yogurt	Pots
Tea	Cup
White bread	No of slices
Cheddar	Slices
Mushrooms	Spoons
Margarine on bread	Slices
Butter on bread	Slices
Jam	Teaspoon
Fruit loaf	slice
Chips	Portion of ten
Pasta	Bowls
Tuna flakes	Spoons
Bounty	Bars
Chocolate muffins	Muffins
Milk chocolate	Bars
Soya sauce	Servings
Sweet and sour sauce	Servings
Curry sauce	Servings
Crisps	50 g pack
Salami	Slices
Crackers	Crackers
Custard	Bowls
Fromage frais	Pots

Peanut items were interspersed with other food items to prevent the mothers' attention being biased towards peanut consumption.

Copyright © 2011 World Allergy Organization. Unauthorized reproduction of this article is prohibited

rolled was not tested with a pilot questionnaire to assess their consumption before hand. We ultimately enrolled similar number of mothers from either the general Pediatric and the Allergy clinic (assuming that children from the Allergy clinic have often limited peanut consumption) and the 2 groups had similar drop out rate.

Ethics

Ethics Committee, and Hospital Trust, approval was obtained from Hillingdon Hospital (Uxbridge, Middlesex) and St. Mary's Research and Development Committee. Informed written consent was obtained from all mothers before participation.

Data Collection

Upon obtaining consent, 7 food diaries were issued. Mothers were asked to record their diet and their child's diet more than 7 consecutive days, starting any day of the week that was convenient for them. This week is referred to as 'index-week' for the remainder of this paper. Mothers were not made aware of the study's particular interest in peanut allergy. Mothers were advised to fill in the forms at the end of each day, reflecting the diet over the past 24 hours. It was also recorded if the index-week was a 'typical week,' for example, did the week include a holiday? A reminder (by telephone or text message) to complete the questionnaire was issued in the middle of the index-week. The 7DFDRs were returned in a prepaid envelope at the end of the index-week. All mothers were contacted by post 6 months later and asked to recall their diet for the index-week and the FFQ was separately completed for themselves and their child.

The amount of peanut protein consumption (in grams) reported in the food diaries and in the FFQs was gathered. Data regarding fruit (in portions), milk (cups), fat–namely butter and margarine (grams), and selected wheat items (grams) consumption were collected for use as control foods.

Statistical Analysis

Statistical analyses were performed using Stata version 10.0 (Stata Corp.)[12]. For each observed FFQ response, we calculated the mean of the diary responses based on individuals with the same or similar FFQ responses. This was done in Stata using a symmetric nearest neighbor running line smoother (moving average) based on 3, 5 or 7 observations.[13] In the absence of ties (individuals with same FFQ result), that would be the individual together with the 2 individuals with the closest smaller FFQ and the one, 2 or 3 with the closest larger FFQ responses, respectively. This smoothing method allows graphical representation of average values rather than the individual matched data and hence won't give undue influence to outliers. These smoothed lines together with the individual 7-day diaries were plotted against the FFQ responses separately for mothers and children and according to the type of food. An illustration of a smoothed line produced by this technique, relating to peanut consumption, is provided in Figure 1a and b.

FFQ responses were graded into 3 equal sized groups (whose size were as far as possible equal) for each food type, denoting low, moderate, and high consumption and for mother and children separately. The mean, the SE, and the upper and lower quartiles of the diaries were then calculated for each FFQ-group (Table 2).

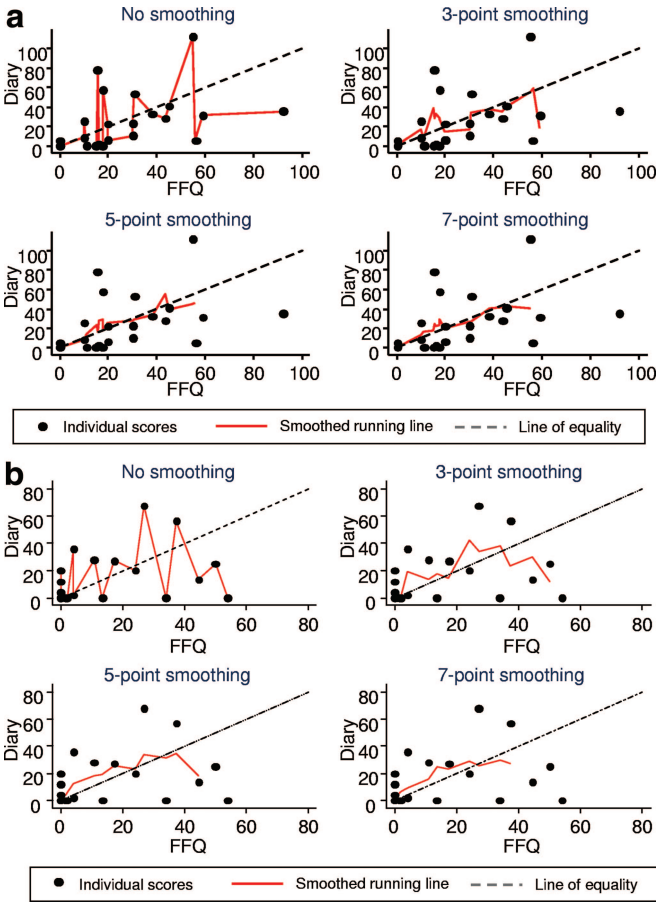

FIGURE 1. a and b, Comparison between FFQ and 7DFDR responses relating to maternal (a)/children's (b) weekly peanut consumption. When individual 7DFDR/FFQ responses are compared a greatly variable line is produced- upper left graph in both figures. When groups of 5 or 7 individuals with similar FFQ responses are gathered, the average of their 7DFDR responses produces a smoothed line (bottom charts). This line is closer to the equality line, that is, the line that would be produced assuming that FFQ-7DFDR responses in all individuals would be identical.

To calculate a 50% prediction interval for the diary response for any given value of FFQ, we estimated the conditional mean DR for a given FFQ and the corresponding SD. The prediction interval is such that for a given value on the FFQ 50% of paired diary responses will be within the prediction intervals at that point (see Appendix for details of how these were produced) (Figure 2).

RESULTS

Completion of Follow-Up

There were 72 mothers initially approached and enrolled in the study. Out of this number, 21 were enrolled from the general Pediatric clinic and 20 from the Pediatric Allergy Clinic; 38 mothers finally consented to complete the study, 18

© 2011 World Allergy Organization

Copyright © 2011 World Allergy Organization. Unauthorized reproduction of this article is prohibited

TABLE 2. Comparison of FFQ Responses and Mean DR Consumptions FFQ Responses Grouping in Equal Sized Groups (Size is as Far as Possible Equal)

		Diary Response			
FFQ Response	No. of Individuals	Mean	SE	Lower Quartile	Upper Quartile
Mother (n = 32)					
Fruit (portions)					
None/low (0–<5)	10	3.05	1.11	0	4
Moderate (5–<8)	11	6.77	1.70	1.5	11
High (8+)	11	9.02	1.78	4.25	16
Peanut (g)					
None (0)	12	0.83	0.56	0	0
Low (0.01–<17.5)	6	18.85	12.44	0	25
Moderate (17.5–<35)	7	24.46	8.54	6	53
High (35+)	7	40.60	12.64	28	40.5
Wheat (g)					
None/low (0–<42)	11	23.13	5.88	12.6	25.8
Moderate (42–<60)	11	56.28	9.86	35.5	87.3
High (60+)	10	57.99	14.08	25.5	60.5
Milk (cups)					
None (0)	13	2.15	0.74	0	3
Low (0.01–<5)	7	0.71	0.36	0	2
Moderate (5–<10)	9	5.22	0.97	2	7
High (10+)	3	7.17	3.66	0	12
Fat (g)					
None/low (0–<14)	11	12.73	5.22	0	28
Moderate (14–<28)	10	25.60	10.03	4	40
High (28+)	11	32.73	7.45	16	52
Child (n = 33)					
Fruit (portions)					
None/low (0–<5)	11	2.68	0.75	1	3.5
Moderate (5–<7)	10	6.48	0.61	4	7
High (7+)	12	5.25	1.51	2	7.5
Peanut (g)					
None (0)	19	1.89	1.20	0	0
Low (0.01–<10)	4	9.53	8.84	0	19.05
Moderate (10–<30)	5	28.48	10.97	20	27.9
High (30+)	5	19.01	10.49	0	25
Wheat (g)					
None/low (0–<37)	11	35.75	10.06	3.5	48.6
Moderate (37–<65)	11	49.75	7.18	34.9	68
High (65+)	11	67.47	7.34	41.4	91
Milk (cups)					
None/low (0–<5)	10	5.15	1.11	2	7
Moderate (5–<7)	13	6.56	1.10	4	7.75
High (7+)	10	13.25	2.02	8	18
Fat (g)					
None/low (0–<12)	10	9.40	3.93	0	16
Moderate (12–<24)	10	26.90	4.67	20	40
High (24+)	13	32.31	7.62	16	44

Grouping is performed for each food type, denoting low/none, moderate, and high consumption and for mother and children separately. The mean, the SE and the upper and lower quartiles of the diaries are then calculated for each FFQ-group.

from the high consumption group and 20 from the low consumption group. Of these, 34 out of 38 (89.5%) of mothers completed both the Food Diaries and the recall FFQs at 6 months. The remaining 4 were contacted and asked to return their FFQs, but failed to do so. Another was excluded, because of erratic completion of the FFQ. One mother completed the FFQ relating to her child's consumption only; hence, there were data from 33 children and 32 mothers.

Validity of FFQ

Table 2 shows the relationship between Food Diary and FFQ for each of the food types. It is seen, that in almost all cases, the questionnaires reliably identify groups with different levels of consumption. With a few exceptions, individuals in the lowest consumption group on the FFQ, had a much lower mean diary score than did those in the middle FFQ-group; the middle group, in turn, had a much lower mean diary score than did the group with the highest FFQ responses. In all cases, there is a clear distinction between the no/low and high consumption groups.

When FFQ responses are matched to individual 7DFDR responses, a great variation is observed (see plots showing no smoothing within Fig. 1a and b, other food types not shown). When this line is smoothed, we show reasonable agreement for mothers and children's 7DFDR response when compared with FFQ response, when groups 5 or 7 individuals with similar FFQ responses are averaged (Fig. 1a and b).

Figure 2 shows the relationship between the mean food diary value at a given level of FFQ and also provide 50% prediction bands for food diary responses given the FFQ level. These bands are such that 50% of individual diary values will fall within the bands for any given FFQ level. The prediction bands get wider as the FFQ increases. Consequently, their prediction value is limited at higher levels of reported consumption. When considering all food types in this study, for both mothers and children, the FFQ was generally seen to be unbiased in the low and normal range of food consumption, but to slightly underestimate consumption at high levels.

DISCUSSION

The prevalence of IgE-mediated food allergy appears to have increased over the recent past with ~3–6% of children in the developed world being affected.[14] The increase in food allergy is, however, best described for peanut allergy.[15–17] For example, in the UK, 3 sequential studies (cohorts born 1989–2000) demonstrate an increase in the prevalence of peanut allergy from 0.6 to 1.8% over the last 10 years.[16,19] Peanut Allergy is considered a public health concern as the condition is associated with significant morbidity and occasional mortality.[18] Studies into the etiology of food allergies in general, and peanut allergy in particular, rely on the accurate determination of disease outcome and food allergen exposure (route of exposure, timing, and quantification).[19] The FFQ is an essential tool for research in this area, but requires validation before use.

The FFQ that has been validated in this study, has previously been validated for retrospective recall of peanut consumption, where a high degree of correlation (R = 0.95)

Copyright © 2011 World Allergy Organization. Unauthorized reproduction of this article is prohibited

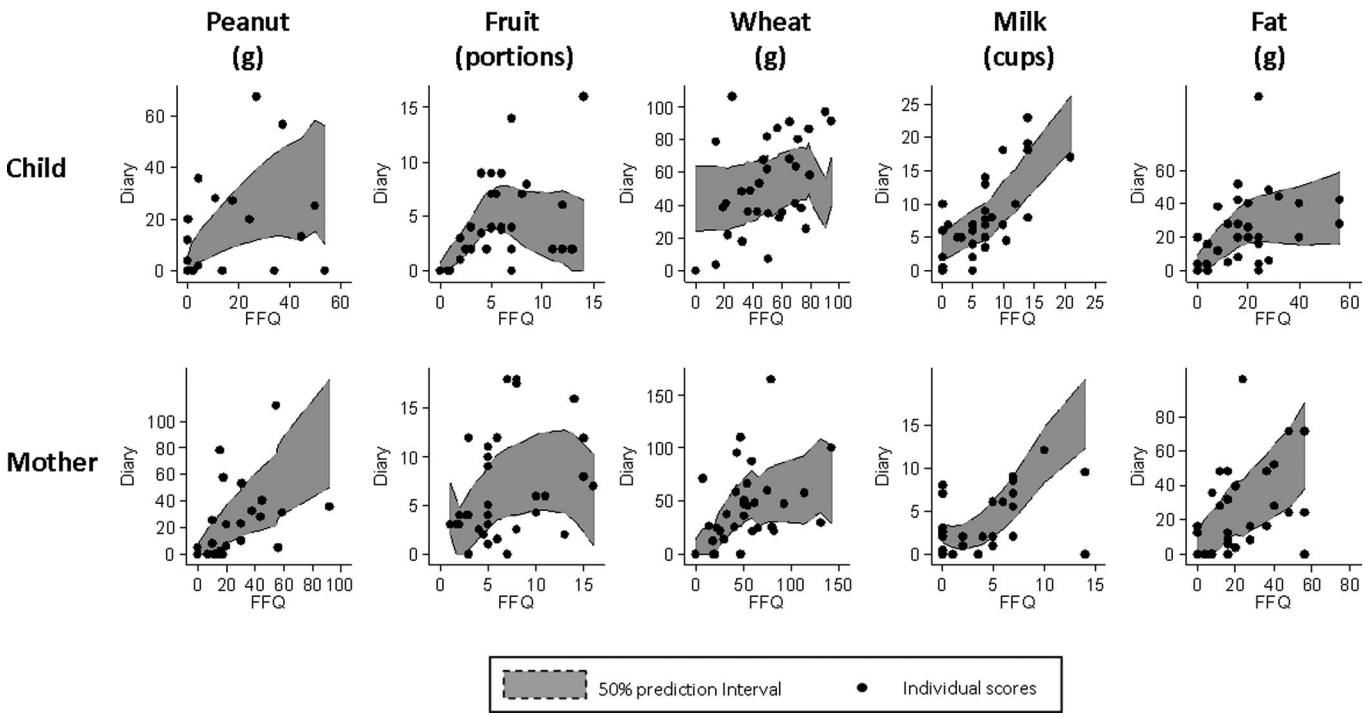

FIGURE 2. 50% Prediction Bands for smoothed points. They demonstrate that 50% of individual diary values will fall within the bands for any given FFQ level. The prediction bands get wider as the FFQ increases, hence their prediction value is limited at higher levels of reported consumption.

was demonstrated.[7] Recently it has been employed in 2 published studies[10,11] looking at the relationship between exposure to peanut and the development of peanut allergy. However, to date, this FFQ had not been validated against a gold standard for peanut consumption. Therefore, we tried to validate our FFQ against a well accepted gold standard, the 7-day food diary.

The results of this study demonstrate a good agreement between the FFQ responses and the Food Diaries especially at low and normal levels of consumption for peanut protein, fats (butter and margarine), selected wheat products, fruit portions, and milk cups weekly intake. The recalled consumption pattern was very similar at these levels for peanut, milk, fats, and fruit consumption. This demonstrates that the participants' answers were not biased by the fact that consumption of a specific allergenic food stuff's consumption was examined. At high levels of consumption the peanut protein consumption was slightly underestimated by the FFQs for mothers and children. This FFQ does not hence, accurately distinguish between different levels consumption at the highly consuming group especially among children. This FFQ, however, appears to be a valid and useful tool at differentiating between low, medium, and high range of consumption both in mothers and children.

One of the main strengths of this study is its prospective design that allowed for the recruitment of participating mother-child pairs who were naive to the precise nutritional focus of the study, that is, peanut consumption. By including children aged 3–7 years, we hoped to target a population that was not subject to DoH peanut avoidance recommendations at that time.

Prospective enrolment, from different pediatric clinics, allowed for the inclusion of both low and high peanut consuming families. Participation of both high and low peanut consumers in this study allowed for assessment of the FFQ at all levels of consumption. We prevented recall bias concerning peanut consumption (that is widely known culprit for food allergies) by interspersing peanut items between other food items.

The children target group was 3–7 year olds. The majority of children in this age group would either be with the parents or at school, where peanut containing food items are not widely consumed in the UK. We believe that this consumption would be true for this age group. It may have been less accurate for teenagers, who spend more time out of the house. In the latter age group this FFQ may not be an accurate tool in terms of reflecting true diet and would need further validation for that population.

The questionnaire was limited in size to allow for completion within ~10 minutes. We made use of 7 consecutive day food diaries, thereby recording consumption through all days of the week. Use of less than 7 food (ie, 5 or 3 day food diaries) has been proven by other studies to miss important variations in an individual's diet that can occur between weekdays and the weekend. Conversely, longer than 7DFDR have not proven to give a more efficient record of the true diet.[6]

Regular contact with the mothers was provided to ensure that the food diaries were properly completed and that any queries were promptly resolved. Participating mothers

 © 2011 World Allergy Organization

Copyright © 2011 World Allergy Organization. Unauthorized reproduction of this article is prohibited

were also contacted if questions were illegibly or incompletely answered.

Despite its careful design and the vigorous follow up this study has a few limitations. The original number of women asked to participate in the study was 72. Just over half of them finally agreed to complete the paperwork and 34 of them remained on the follow up stage. A significant number of mothers withdrew after receipt of the 7DFDR pack. Others were not able to cope (because of increased workload), often had younger children to look after, or had a subsequent pregnancy. Despite the large number who failed to complete the study, however, we were left with 2 groups (high and low level) of peanut protein consumers of similar size.

One could argue that no biomarkers of consumption were not used to validate consumption. Use of such Biomarkers is considered by many researchers to reflect more accurately true diet.[6] To our knowledge there are no specific biomarkers that distinguish between peanut, wheat, fat, and milk consumption.

The responses for the diary-FFQ show some variation between subjects peanut consumption, both for mothers and children that can be seen in Figure 1a and b. Variability is also noted for other 'control foods' suggesting that, on an individual basis, the FFQ may not always reflect the diet originally recorded on the 7 day diaries.

The statistical analysis, however, shows that when diary responses are grouped in small numbers, hence allowing for a smoothing statistical effect, the FFQ responses are then very close to the diet monitored by the diaries. Hence, the FFQ is fairly unbiased in terms of predicting the mean peanut consumption in small groups, for example, 3, 5, or 7, of mothers or children. The smoothing technique yields a line very close to the 'full fit line,' although on some occasions, consumption reported by the FFQ is lower compared with the food diary answers; this is particularly evident for maternal fruit consumption. The food diaries were giving a much lower consumption in some individuals compared with their FFQ responses. On some occasions FFQs were reporting a fruit consumption equal to the universally recommended fruit and vegetable consumption of 5 per day. Similarly, milk was under-recorded on the FFQs, when some individuals failed to put the amount of milk consumed with cereal. Wheat consumption was often underreported either on FFQ or DRs especially in children. Many participants, for instance, failed to tick against bread on their lists, when they were reporting bread or margarine consumption on the bread.

The use of 50% prediction bands is another way of looking at how FFQs perform, the discrepancy between FFQ and DRs seems to be smaller in subjects with lower consumptions, for both peanut protein and the control foods, where in most cases the FFQ responses fall within 50% prediction bands for all foods.

Unlike some other components of diet (eg, total energy intake) a substantial proportion of the population will have zero consumption of peanut protein at a time. Additionally, the majority of peanut protein consumed is in discrete portions that contain ~3.5 g of peanut protein (this is roughly the amount in 1 Snickers bar, 1 peanut-butter sandwich, 1 handful of peanuts, or 1 packet of Bamba). Thus, the problem of measuring peanut consumption is in several ways different from that of measuring consumption of some other food items (eg, wheat, milk, fish, egg protein), that are eaten on weekly basis.

The first interpretation of this discrepancy is that the FFQ is unable to accurately reflect what the individual ate during the week, when the food diaries were completed, 6 month previously. The second interpretation is that the subject filling out the FFQ is not remembering, what she ate eating exactly 6 months ago. She is recalling what she ate in a typical week 'some 6 months' ago. Given that the purpose of the diary was unknown to the mother and that all food item categories were interspersed, it is extremely unlikely that she could accurately remember what she recorded eating that specific week.

The second explanation points to the different roles of food diaries and FFQs in the evaluation of diet. A food diary although it is the gold standard for accurate record of food consumption in a given week, it is not necessarily the most representative picture of what an individual eats in general. An FFQ yields retrospective information that may be less accurate for consumption in a precise given week, but maybe more representative of a typical week.

Our findings that both instruments agree with each other, when groups of individuals are compared, provides cross validation of both questionnaires and further insight into the potential advantages and limitations of both instruments.

CONCLUSIONS

Our statistical analysis shows that this FFQ is generally free of bias; and is particularly accurate in reflecting actual peanut consumption at low levels for either peanut protein or control foods. However, we do observe a tendency to overreport consumption (of select food items) at the higher end especially for peanut protein containing items.

There is variability between individuals in the level of agreement between food diaries and FFQs for peanut and control food consumption. Hence, the FFQ cannot confidently predict an individual's actual consumption, as recorded on DRs. The predicting value of the FFQ, however, improves considerably if the results are grouped. When 5 individuals have the same (or similar) FFQ this accurately predicts their mean DR at low or moderate consumption levels.

We conclude that this FFQ can be used to predict mean peanut consumption from small groups of mothers or children, even when the questionnaire refers to past consumption at a 6 month time lag. Our findings that both instruments agree with each other, when groups of individuals are compared, provides cross validation of both questionnaires and further insight into the potential advantages and limitations of both instruments.

REFERENCES

1. Acheson KJ, Campbell IT, Edholm OG, Miller DS, Stock MJ. The Measurement of Food and Energy intake in a man-an evaluation of some techniques. *Am J Clin Nutr.* 1980;May:1147–1154.
2. Khani BR, Weimin Y, Terry P, Wolk A. Reproducibility and validity of major dietary patterns among Swedish women assessed with a Food Frequency Questionnaire. *J Nutr.* 2004;134:1541–1545.

© 2011 World Allergy Organization

Copyright © 2011 World Allergy Organization. Unauthorized reproduction of this article is prohibited

3. Martin- Moreno JM, Boyle P, Gorgojo L, Maisonneuve P, Fernandez-Rodriguez JC, Salvini S, Willett W. Development and validation of a Food Frequency Questionnaire in Spain. *Int. J Epidemiol.* 1993;22(3): 512–519.
4. Broadfield E, McKeever T, Fogarty A, Britton J. Measuring dietary fatty acid intake: validation of a food frequency questionnaire against 7d weighed records. *Br J Nutr*. 2003;90:215–220.
5. Rockett HR, Breitenbach RD, Frazier L, Witschi J, Wolf AM, Field AE, Colditz GA. Validation of a youth/adolescent Food Frequency Questionnaire. *Preventive Med.* 1997;26:808–816.
6. Cade J, Thompson R, Burley V, Warm D. Development, validation and utilisation of food frequency questionnaires: a review. *Public Health Nutr.* 2002;5(4):567–587.
7. Fox AT, Meyer R, DuToit G, Syed H, Sasieni P, Lack G. Retrospective recall of maternal peanut consumption using a multiple food-frequency questionnaire. *S African J Clin Nutr.* 2006;19(4):154–160.
8. Stram DO, Longnecker MP, Shames L, Kolonel LN, Wilkens LR, et al. Efficient design of a diet validation study. *American Journal of Epidemiology.* 1995;142(3):353–360.
9. Helen C. (Ed). *Food Portion Sizes*. 2nd ed. London: Ministry of Agriculture, Fisheries & Food, The Stationery Office Books; 1994.
10. Du Toit G, Katz Y, Sasieni-Mesher D, Maleki SJ, Fisher HR, Fox AT, Turcanu V, et al. Early consumption of peanuts in infancy is associated with a low prevalence of peanut allergy. *J Allergy Clin Immunol.* 2008;122(5):984–991.
11. Fox AT, Sasieni P, du Toit G, Syed H, Lack G. Household Peanut Consumption as a Risk Factor for the Development of Peanut Allergy. *J Allergy Clin Immunol.* 2009;123(2):417–423.
12. Stata version 10.0 (Stata Corporation).
13. Sasieni P. sed9: Symmetric nearest neighbor linear smoothers. *Stata Technical Bulletin* 24:10–14. In *Stata Technical Bulletin Reprints*, 4:97–101. College Station, TX: Stata Press; 1995.
14. Sicherer SH, Sampson HA. 9. Food allergy. *J Allergy Clin Immunol.* 2006;117:S470–S475.
15. Grundy J, Matthews S, Bateman B, Dean T, Arshad SH. Rising prevalence of allergy to peanut in children: data from 2 sequential cohorts. *J Allergy Clin Immunol.* 2002;110:784–789.
16. Hourihane JO, Aiken R, Briggs R, Gudegeon LA, Grimshaw KE, et al. The impact of government advice to pregnant mothers regarding peanut avoidance on the prevalence of peanut allergy in United Kingdom children at school entry. *J Allergy Clin Immunol.* 2007;119:1197–1202.
17. Sicherer SH, Munoz-Furlong A, Sampson HA. Prevalence of peanut and tree nut allergy in the United States determined by means of a random digit dial telephone survey: a 5-year follow-up study. *J Allergy*.
18. Warner JO. Peanut allergy: a major public health issue. *PAI* 1999;10: 14–20.
19. Lack G, Fox D, Northstone K, Golding J, Avon Longitudinal Study of Parents and Children Study Team. Factors associated with the development of peanut allergy in childhood. *N Engl J Med.* 2003;348:977–985.

APPENDIX

Creation of 50% Prediction Bands for Figure 2

To calculate a 50% prediction interval for the diary response for any given value of FFQ, we estimated the conditional mean DR for a given FFQ and the corresponding SD. Formally, the bands are given by: $f(FFQ) \pm z_{\alpha}S(FFQ)$, where f(FFQ) is a smooth function estimating the mean and S(FFQ) is a linear function estimating the SD of DR given FFQ. The smooth f was obtained as a local linear regression for 19 symmetric nearest neighbor diary responses and constrained to be greater than or equal to zero. S(FFQ) was obtained by a linear regression of the square root of the smoothed squared residuals against FFQ. The mean $\pm$ 0.675*SD gives a 50% prediction interval.

© 2011 World Allergy Organization

Copyright © 2011 World Allergy Organization. Unauthorized reproduction of this article is prohibited