Original Article

Measuring the dietary intake of Samoans living in New Zealand: Comparison of a food frequency questionnaire and a 7 day diet record

A Colin Bell MSc, Boyd A Swinburn MD, ChB, FRACP, Henga Amosa, Robert Scragg MB, BS, PhD and Susan J Sharpe MHSC

Public Health Nutrition Group, Department of Community Health, Faculty of Medicine and Health Science, University of Auckland, Auckland, New Zealand

The purpose of this study was to determine the accuracy of a quantitative food frequency questionnaire for measuring the usual dietary intake of Samoans living in New Zealand. We compared a self-administered 89 item quantitative food frequency questionnaire (FFQ) with a 7 day diet record (DR) in a sample of 55 Samoan adults aged 20 years and over. The FFQ asked people to report their dietary intake in frequency and amount and included photos of standard serving sizes. The DR was collected over non-consecutive three and four day periods, including two weekend days. Food weighing scales and measuring cups and spoons were provided to measure food portions. Correlations between the two methods were poor for both crude (range –0.03–0.48) and energy-adjusted (range –0.12–0.54) nutrient intakes. Approximately 29–53% of people fell into the same tertile when classified by the two methods and 9–22% of subjects were grossly misclassified into opposite tertiles. Agreement was also poor when the differences in energy, fat, protein and carbohydrate intake between the methods were plotted against mean intake. Relative to an estimate of energy expenditure, both methods underestimated usual energy intake; however, underestimation occurred to a greater extent with the DR. We conclude that agreement between the two dietary assessment methods was poor and we were unable to use the DR to calibrate the FFQ. In terms of total energy, the FFQ gave a better assessment of usual dietary intake than did the DR.

Key words: calibration, food frequency questionnaire, diet record, Samoan ethnic group, dietary intake, New Zealand.

Introduction

Pacific Islands people carry a heavier burden of heart disease and non-insulin dependant diabetes mellitus (NIDDM) than do other New Zealanders and dietary factors are likely to play a key role.[1–3] However, very little is known about the diets of Pacific Islands people in New Zealand and no dietary assessment methods have been validated for use in Pacific Islands communities.

Food frequency questionnaires (FFQ) are a useful tool for measuring dietary intake in communities because they are easy to administer and code, they are cost effective, and they can measure food consumption over long periods.[4] Two disadvantages of FFQ are that they rely on memory and estimates of serving size.[5] In order to determine the accuracy of FFQ, it is recommended that they are standardized against an independent method of dietary assessment in a sample of the population being surveyed.[6] Diet records (DR) collected over several days are typically used as the referent standard.[7,8] Depending on such factors as the length and form of the questionnaire and the population studied, most studies report modest correlations between FFQ and diet records that rarely exceed 0.6 and that are often highly variable.[9–11] Other methods of comparison include determining the proportion of subjects who fall into the same percentile range of energy (or nutrient) intake and calculating the mean difference and standard deviation of the differences.[6,12]

We assessed the usual dietary intake of 55 Samoan adults using a quantitative FFQ. In order to determine the accuracy of this questionnaire, a comparison was made with energy and nutrient intake data from a 7 day DR.

Methods

Participants

Participants in this study came from St Martins, Glen Eden, one of three Samoan churches participating in a community-based intervention project.[13] The data were collected at baseline before the interventions were introduced. This church was chosen because of strong links with the project coordinator (HA). Written consent was obtained from all participants and ethical approval was given by the University of Auckland Human Subjects Ethics Committee. All church members aged 20 years and over were invited to participate and a NZ$25 contribution was given to the church for each person who completed 7 days of diet records and the FFQ. Fifty-five people (24 men and 31 women) completed the records, representing 12% of those who participated in the

Correspondence address: Colin Bell, Department of Community Health, Faculty of Medicine and Health Science, University of Auckland, PO Box 92019, Auckland, New Zealand.
Tel: 64 9373 7599; Fax: 64 9373 7503.
Email: ac.bell@auckland.ac.nz
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wider community-based intervention ($n = 471$). Compared with the parent population, there were no significant differences ($P > 0.05$) in the proportion of male participants: 44% versus 41%; mean age ± SD, 43 ± 14 years versus 41 ± 14 years; mean weight, 97 ± 20 kg versus 93 ± 19 kg; or body mass index, 34.7 ± 6.3 kg/m^2 versus 34.1 ± 6.5 kg/m^2.

Instruments and protocol

The FFQ was collected from participants in January 1996. The DR was collected over the following 3 months. Each DR was collected over three consecutive days in week one, and four consecutive days in week two. The days were selected to include every day of the week. On the first day of each period, a recall technique was used to collect the previous days intake. By using this technique we hoped to demonstrate how to complete the record booklets, encourage adherence to usual eating practices, and aid compliance. Participants were then asked to fill in the remaining two or three days of the record collection. Each participant was given a record booklet, a standardized measuring cup and a set of spoons (Hartlin International, CA, USA) and a set of electronic food scales accurate to ±2 g (Salter Electronic-Elite 3001, Tonbridge, England). Instruction was available in Samoan. The booklets were collected and checked for completeness at the end of each period.

The FFQ was designed to record, in frequency and amount, usual dietary intake during the past year. The selection of food items for the questionnaire followed the basic plan of the shortened questionnaire of Willett.[14] This was then adapted for use in New Zealand and expanded to include 89 items.[15] Samoan foods such as green bananas were added. The questionnaire consisted of two sections. The first asked how often a food was eaten based on seven categories: never; < 1 occasion a month; 1–3 times a month; 1–2 times a week; 3–4 times a week; 5–6 times a week; and every day. The second section included the list of food items and a black and white scanned picture of a standard serving size. The standard serve sizes were taken from lists of average serve sizes developed by local dietitians from ongoing dietary assessments. Four response categories (half the pictured serve size, the same size, two-fold the size, or three-fold the size) were included to cover a wide range of serve sizes. The FFQ was self-administered although instruction was available if required.

Analysis and statistics

Nutrient and energy data from both questionnaires were calculated using Nutritionist IV software (version 2 for IBM and compatible computers; N-Squared Computing, Salem, OR, USA) and the New Zealand Food Composition Database.[16] This database was supplemented with data from the Pacific Islands Food Composition Database.[17] One person (CB) was responsible for all data entry.

A number of statistical tests were used to determine the relationship between the two methods.[14] Firstly, means and standard deviations were calculated to explore differences or similarities between the methods. Secondly, crude and energy-adjusted Spearman correlation coefficients were calculated. A non-parametric test was used because most nutrient intake distributions were skewed toward higher values. Energy was adjusted for by replacing nutrient values with their respective residuals from a regression model with nutrient intake as the dependent variable and energy intake as the independent variable.[18]

Thirdly, the proportion of participants who fell into the same and opposite tertiles was reported for each nutrient. If there was no agreement at all between the methods, by chance, 33% of people would fall into identical tertiles, 44% into adjacent tertiles and 22% into opposite tertiles. If there was perfect agreement between the methods the percentage of people in each of these categories would be 100, 0 and 0%, respectively. Finally, agreement tests recommended by Bland and Altman were carried out for energy and nutrient intakes.[12] Dietary data for men and women were analysed together as there was no reason to believe they would respond differently to the questionnaires.

In order to determine the accuracy of mean energy intake (EI) from each method, an estimate of energy expenditure was calculated for males and females. Resting metabolic rate (RMR) was calculated from equations appropriate for Samoans, based on weight, age and fat free mass.[19,20] Resting metabolic rate was then multiplied by activity factors obtained from the literature.[21,22]

All analyses were performed using SAS, version 6.10 for Windows (SAS Institute Inc, Cary, NC, USA). Statistical significance was accepted at $P < 0.05$.

Results

Comparisons between the two methods

Mean intakes, cross-classification of participants by intake tertiles and correlations between intakes from both methods are presented in Table 1 for energy, macronutrients and cholesterol. Table 2 gives the same information for vitamin and mineral intakes. Mean energy intake was higher when measured by the FFQ (+2.2 MJ). Mean macro- and micronutrient intakes were also higher when assessed by the FFQ. In the tertile classifications, the percentage of people classified into the same tertile was not greatly different from the percentage expected by chance for the nutrients examined (range 29–53%). Also, high percentages of people were grossly misclassified into opposite tertiles of intake by the two methods (range 9–22%).

The correlation coefficients for crude nutrient intakes were low (range –0.03–0.48), particularly for thiamin, folate, vitamin A and fibre where the coefficients were less than 0.1. The correlation coefficient for alcohol intake was $r = 0.43$, $P < 0.001$ (data not shown). Most of the nutrients examined in the study were highly correlated with energy. Thus, to limit the variability caused by differences in energy intake between the two methods, nutrient intakes were energy adjusted. The correlations for energy-adjusted nutrient intakes covered a wider range of values (range –0.12–0.54) but were generally lower than those for the crude comparison. The lowest correlations were observed for vitamin B6 ($r = –0.12$), mono-unsaturated fat ($r = –0.05$), and thiamin ($r = –0.01$). The highest was observed for calcium ($r = 0.54$).

Table 3 gives the mean differences in energy and macronutrient intakes between the two methods. While most participants (>90%) fell within ±2 standard deviations, the mean differences were large, the limits of agreement were wide and the confidence intervals about the limits were also wide. Agreement was equally poor for the other nutrients looked at and for macronutrients expressed as percentages of energy.

In order to test our assumption that sex differences were unlikely to influence agreement between the methods, Bland and Altman tests were conducted separately for men and women (data not shown). While mean differences for energy and nutrients were generally smaller for men, agreement was poor for both sexes. Also, Student's *t*-tests of mean differences in energy and nutrient intakes by sex showed the differences were not significant.

Comparisons with estimated energy expenditure

Table 4 presents the average weight, calculated fat free mass (FFM), and RMR of the participants. It also presents the ratio of EI to RMR. For comparison, the EI/RMR ratio expected for a sedentary individual (from WHO) and physiological minimum EI/RMR ratios (from Goldberg *et al*.), based on 7 days (DR) and 28 days (FFQ) of data collection, are included.[3,22] It can be seen that EI/RMR ratios were higher for women than for men and the ratios were higher where EI was measured using the FFQ. However, only women had an EI/RMR ratio above 1.55, and only for the FFQ. Most ratios were well below the physiological minimums. This suggests that the vast majority of participants underestimated their EI regardless of which dietary assessment method was used.

Energy intake appeared to be positively related to body mass index for both males and females (Figs 1,2). The figures include regression lines (solid for FFQ, dotted for DR), showing non-significant but positive relationships between EI and BMI for males. The relationships for females were positive and statistically significant. The figures also indicate the difference in energy intake between the methods for each individual. Four or five men and women reported very high energy intakes using the FFQ. These outliers will have influenced the mean energy and nutrient intakes from the FFQ. However, a substantial difference in mean energy intake (DR mean = 8.8 MJ, FFQ mean = 10.2 MJ) persisted between the two methods when they were removed.

Discussion

To date, no studies have been done that look specifically at the diets of Samoan communities in New Zealand, although

Table 1. Mean intake (SD) of macronutrients measured by diet record (DR) and food frequency questionnaire (FFQ) ($n = 55$): Cross-classification of individuals into tertiles and Spearman correlation coefficients (r)

Nutrient	DR		FFQ		Tertile (%)		*r*	*r*
	Mean	SD	Mean	SD	Same	Opposite	Crude	Adjusted*
Energy, kcal (MJ)	2141 (8.9)	570	2683 (11.2)	1241	45	18	0.21	–
Carbohydrate, g (%)	265 (47)	74	332 (47)	156	33	16	0.16	0.12
Protein, g (%)	93 (18)	25	126 (19)	63	44	11	0.30	0.14
Fat, g (%)	85 (35)	27	101 (33)	52	49	14	0.30	0.06
SAFA, g (%)	35 (14)	13	43 (14)	23	44	16	0.27	0.14
MUFA, g (%)	28 (12)	10	36 (12)	19	45	14	0.34	–0.05
PUFA, g	8 (3)	3	12 (4)	6	45	14	0.16	0.12
Fibre, g	17	6	27	14	31	22	0.06	0.23
Sugar, g	85	38	114	69	53	14	0.32	0.28
Cholesterol, mg	356	111	432	244	44	13	0.35	0.14

*Adjusted for energy by the residual method.[18] SAFA, saturated fat; MUFA, monounsaturated fat; PUFA, polyunsaturated fat.

Table 2. Mean intake (SD) of micronutrients measured by diet record (DR) and food frequency questionnaire (FFQ) ($n = 55$): Cross-classification of individuals into tertiles and Spearman correlation coefficients (r)

Vitamin/Mineral	DR		FFQ		Tertile (%)		*r*	*r*
	Mean	SD	Mean	SD	Same	Opposite	Crude	Adjusted*
Thiamin (mg)	1.1	0.4	1.4	0.7	38	22	–0.03	–0.01
Riboflavin (mg)	1.3	0.4	1.9	0.9	40	13	0.21	0.38
Niacin (mg)	19.25	5.3	25.6	12.5	34	11	0.26	0.15
B6 (mg)	1.4	0.4	2.0	0.9	33	16	0.15	–0.12
Pantothenic acid (mg)	5.1	1.9	5.8	2.7	38	14	0.26	0.06
B12 (μg)	7.2	4.2	12.8	9.3	40	9	0.48	0.53
Folate (μg)	181.0	56.5	271.4	119.6	29	16	0.07	0.15
Biotin (μg)	27.3	8.1	42.9	20.5	44	20	0.10	0.03
Vitamin A (μg)	756.5	392.6	1231.7	772.9	31	18	0.08	0.10
β-Carotene (μg)	2484.9	1884.8	4576.7	3155.4	38	18	0.17	0.17
Vitamin C (μg)	95.2	38.4	138.5	73.5	29	13	0.14	0.26
Vitamin E (μg)	8.3	2.8	9.7	4.2	38	18	0.19	0.38
Iron (mg)	12.9	3.8	19.5	10.1	38	11	0.32	0.42
Calcium (mg)	476.4	216.1	693.6	425.7	36	9	0.27	0.54
Zinc (mg)	14.1	4.4	17.7	8.8	44	20	0.24	0.13
Sodium (mg)	3617	1158	3953	1998	36	16	0.21	0.19
Potassium (mg)	3399	931	4391	1914	36	16	0.15	0.18
Selenium (mg)	0.06	0.02	0.08	0.04	49	11	0.37	0.42

*Adjusted for energy by the residual method.[18]

Table 3. Mean difference in energy and macronutrient intake between the diet record and food frequency questionnaire (n = 55) with lower (–2 standard deviations) and upper (+2 standard deviations) limits of agreement and 95% confidence intervals (CI)

	Mean difference (CI)	Lower limit –2 SD (CI)	Upper limit +2 SD (CI)
Energy (kcal)	–543	–2918	1833
	(–862, –224)	(–3473, –2363)	(1279, 2389)
Carbohydrate (g)	–68	–380	245
	(–109, –27)	(–452, –306)	(172, 318)
Fat (g)	–17	–115	82
	(–30, –4)	(–138, –92)	(59, 105)
Protein (g)	–33	–151	85
	(–49, –17)	(–179, –124)	(58, 113)

developing an accurate tool for assessing diet is a important first step. While the aim of this study was to see how well a FFQ performed against a DR, the accuracy of the DR was also called into question.

Correlation coefficients between FFQ and DR in other studies have generally been higher than those reported here. The same FFQ used with a Caucasian population in New Zealand gave correlation coefficients ranging from 0.39 to 0.74.[15] Bingham *et al*. reported correlation coefficients in the order of 0.4–0.6 and 0.3–0.4 in two versions of a 131-item FFQ.[23] Moreover, correlation coefficients from the studies of Willett *et al*., Rimm *et al*. and Block *et al*. were all higher than those reported in this study.[7,10,24] Adjusting for energy intake did not improve the correlations.

The cross-classification of individuals into broad categories of intake, in this case tertiles, did not differ enough from chance to conclude that there was good agreement between the methods. Other studies have used quintiles, rather than tertiles as the basis of classification.[23] Tertiles were chosen in this study because the numbers were small enough that cross-classification of intake levels by quintiles would probably have spread the data too thinly and produced less meaningful results.

Bland and Altman consider the use of correlation coefficients to be misleading, because they measure the strength of relationship between two variables rather than agreement between them.[12] For this reason, their test for agreement was also applied to energy and nutrient intakes from the FFQ and DR. However, this test also pointed to poor agreement between the methods. The limits of agreement were wide and we could not put confidence in the precision of the limits.

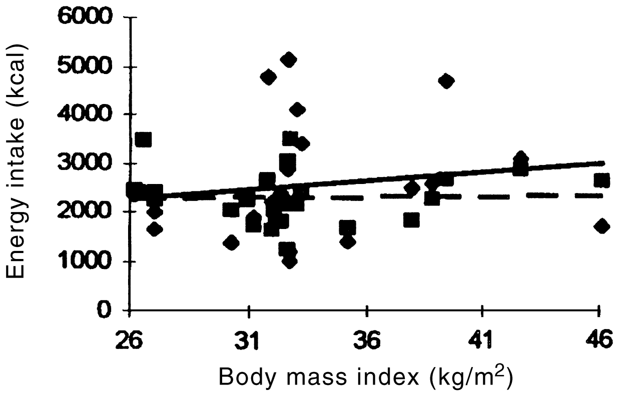

Figure 1. Relationship between energy intake and body mass index for males (n = 24). Food frequency questionnaire (♦) regression equation (—) y = 40.029x + 1230.3, r = 0.16, P = 0.427. Diet record (■) regression equation (----) y = 7.4409x = 2064.6, r = 0.06, P = 0.768.

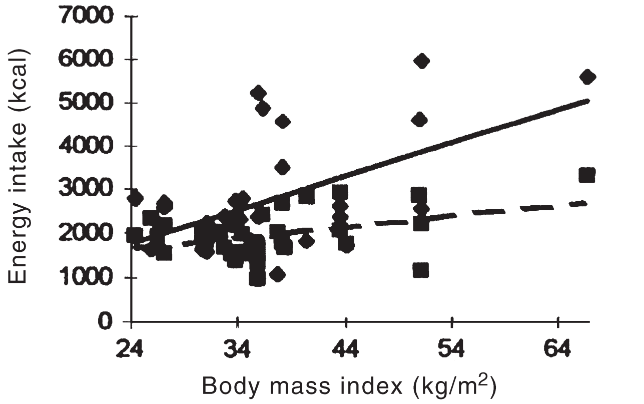

Figure 2. Relationship between energy intake and body mass index for females (n = 24). Food frequency questionnaire (♦) regression equation (—) y = 77.515x – 84.262, r = 0.52, P = 0.002. Diet record (■) regression equation (----) y = 26.342x + 1035.7, r = 0.42, P = 0.01.

There are several likely reasons for the lack of agreement. The small sample size will have contributed to the variability about the means and increased numbers would have stabilized the estimates of mean energy and nutrient intakes. Underestimation of intake by the DR is also likely to be a critical factor. Underestimation may have occurred at several stages in the dietary data collection and analysis process. Firstly, subjects may have forgotten to include certain foods, such as snacks, and it was clear that a number of participants had not used the food scales or standardized cup and spoon set to measure their food. Also, long periods of recording dietary data have been associated with the potential to alter dietary habits, boredom and declining accuracy.[25,26] We tried to overcome this by reducing the number of consecutive days

Table 4. Ratio of energy intake (EI) over resting metabolic rate (RMR) ± SD, using a 7 day diet record (DR) or food frequency questionnaire (FFQ) to estimate EI

Sex	*N*	Wt	FFM[*]	RMR[†]	Record		FFQ		WHO[§]	Goldberg[‡]	
					EI kcal (MJ)	EI/RMR	EI kcal (MJ)	EI/RMR		7 days	28 days
All	*55*	97.9	61.9	1901	2141 (8.9)	1.13±0.26	2684 (11.2)	1.41±0.58	1.55	1.48	1.48
Male	*24*	97.2	70.5	2097	2312 (9.7)	1.10±0.26	2560 (10.7)	1.21±0.51	1.55	1.45	1.46
Female	*31*	98.6	55.3	1749	2009 (8.4)	1.15±0.27	2780 (11.6)	1.56±0.60	1.56	1.46	1.46

[*]Calculated fat free mass for Samoan males (FFM = 36.93 + 0.4121 × wt + 0.1424 × age) and females (FFM = 22.35 + 0.3858 × wt + 0.1252 × age). [†]Calculated resting metabolic rate: RMR = 22.8 × FFM + 489.[20] [§]Mean standard for sedentary lifestyle.[21] [‡]Cut-off 2 for diet record (7 days) and FFQ (28 days).[22]

of recording and by using a recall technique on 2 out of the 7 days. However, it is possible that the gap between data collection periods (up to a week) caused similar problems. Questionnaires were a new concept for many of the participants we surveyed and this may also have contributed to a lack of accuracy.

Secondly, at the data entry stage, where portion sizes were not specified (i.e. cups, spoons or scales not used), published serve sizes, as discussed in the methods, were used. These serve sizes were based on the eating habits of predominantly Caucasian New Zealanders and therefore may underestimate Samoan serve sizes. This problem was overcome in the FFQ by offering a range of serving size options. Finally, the food composition tables did not have a complete list of Samoan foods and food substitution may have led to lower fat foods being included in the diets.

Food frequency questionnaires often record energy and nutrient intakes that are higher than those recorded for diet diaries.[23,27] Some participants in this study overestimated their energy intake using the FFQ and several outliers were observed. However, the difference in EI between the methods remained, even when these outliers were excluded and if anything, intakes from the FFQ were lower, not higher, than expected. This may be because the method relies on memory or because, by design, the FFQ clusters similar foods together. In so doing, foods which are important contributors to the energy and nutrient intakes of Samoan people may have been left out. Lastly, there is evidence that the food composition tables may underestimate the fat content of meats typically eaten by Samoan communities, lowering estimates of fat intake from both methods. An analysis of corned beef commissioned by the National Heart Foundation found that the composition tables may underestimate the fat content of this food by 10–20 g per 100 g (Iutita Rusk, pers. comm., 1995).

The comparisons of EI with estimates of energy expenditure confirmed our earlier observation that dietary intake was underestimated by the DR. They also revealed that, on average, energy intake was underestimated by the FFQ as well, but to a lesser extent. Energy efficiency/RMR ratios of the levels described in this study were well below the minimum limits and are unlikely to represent habitual intake, particularly in a population that is maintaining or gaining weight.

In studies of European populations, there is an inverse relation between BMI and EI, suggesting that obese subjects under-report to a greater extent than leaner subjects.[28,29] In this study, the mean BMI was 34.7 kg/m^2 and at least half were clinically obese (BMI > 30 kg/m^2). However, for both the DR and the FFQ, there was a positive relationship between EI and BMI for males and females. Therefore, body size is an unlikely reason for underestimating dietary intake. This may be because of the important place food has in Samoan culture.[30] For instance, there is not the stigma associated with eating large amounts of food or being overweight as there is in European cultures. Also, there is some evidence that Polynesian women may have lower metabolic rates than European women and therefore burn less of their energy intake.[31]

Obtaining good quality data on diet is essential when studying diet–disease relationships in epidemiological studies.[29] However, it is also one of the most difficult problems to be faced.[32] This calibration study has highlighted problems associated with using dietary records as a 'gold standard' method. Problems of approximate measurements and interpretation of dietary descriptions have been realised for a long time.[33] Recent studies using doubly labelled water to measure energy expenditure have highlighted the problem of under-reporting.[22,31]

In Samoan communities, where so little is known about dietary intake, several issues relating to the accuracy of measurement need to be addressed. There is the question of how to best collect dietary data from Samoan communities. Collecting supermarket dockets may be a useful method of measuring food intake at a family level as a first step. Standard serving sizes should be developed specifically for Pacific Islands peoples if they are to be used at all. The Pacific Islands Food Composition Tables need to be expanded to avoid food substitution and checked to ensure the nutrient content of the foods included reflects the nutrient content of foods that Pacific Islands people actually eat. Finally, there is a need to conduct external evaluations of dietary intake in Pacific Islands communities using biological markers such as doubly labelled water estimates of energy expenditure.

In conclusion, the DR and the FFQ used in this study did not compare well and we were unable to overcome an anticipated lack of accuracy in the FFQ. In fact, based on an estimate of energy expenditure, we considered that the FFQ gave a better estimation of true EI in this group of people.

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