A food frequency questionnaire for use in Chinese populations and its validation

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There is no gold standard in the assessment of individual dietary intake methodology. The choice of dietary method to estimate individual intake depends upon the study objectives for the assessment of individual intake. We adopted a food frequency questionnaire and modified it for use in a study of food habits and cardiovascular health status in adult Chinese living in Melbourne, Australia. This is a semi-quantitative questionnaire (MCHS-FFQ) and is designed to estimate past food intake. It consists of 220 foods and beverages. A reference portion is given to obtain a quantitative estimate of the usual intake portion. Various internal validation tests were performed. The MCHS-FFQ, being a food frequency dietary method, does not provide a good estimate of nutrients in foods which are not served in standard portions, such as sodium. The MCHS-FFQ offered a good estimate for potassium and protein intake when compared to estimates derived from a single 24-h urine collection. Finally, the MCHS-FFQ was predictive of plasma cholesterol levels. We conclude that the MCHS-FFQ is adequate for the assessment of individual usual food and nutrient intakes in a representative sample of adult Melbourne Chinese. For foods that are not served in a standard portion or quantifiable addition, an alternative more reliable method would be required for quantitative purposes. The method is, however, likely to be useful for the appraisal of overall food patterns in Chinese populations.

Introduction

Studies of food-health relationships require a dietary method with the capacity to estimate usual or past intake so as to make comparisons in time or to deal with the variability of dietary intake. On the other hand, current or short-term dietary methods may provide a better intake estimate in an intervention study where the compliance with dietary modification for a particular nutrient intake needs to be closely monitored over a short period[1].

There is no gold standard in the assessment of individual dietary intake methodology[2,3]. Up to the 1960s, food records for a few days or 24-h recalls were the two methods commonly used by researchers to estimate short-term or current food intake of individuals. These methods are expensive and unrepresentative of usual intake and therefore are not appropriate for the assessment of long-term or past food intake[4]. With the development of computer techniques for nutrient database management and statistical analysis, the food frequency questionnaire has become more widely used in large scale epidemiological studies[5]. Twenty-four recalls are still being used, with interest developing in their repeated application so that several days of information over an extended period of time can be obtained prospectively. The choice of dietary method to estimate individual intake thus depends upon the study objectives for the assessment of individual intake: particularly in reference to duration upon which intake estimates are based.

In the Melbourne Chinese Health Study, we are interested in relationships between food habits and cardiovascular health status in adult Chinese Australians living in Melbourne, Australia. In order to assess long-term food habits, we have adapted a food frequency questionnaire developed by Record and Baghurst[6] for use in Australian populations. We have modified this semi-quantitative questionnaire so that eating practices pertaining to Chinese food culture are embraced. We present here the development of a food frequency questionnaire for use in a Melbourne Chinese population, its application and potential for generalization.

Methods

We took the CSIRO food frequency questionnaire (FREQPAN)[6] as the basis for our modified Chinese food frequency questionnaire. The CSIRO FREQPAN questionnaire covered foods and beverages commonly used by Australians and was designed to assess usual intake rather than short-term intake. It consisted of 179

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Table 1. The Melbourne Chinese Health Study food frequency questionnaire: sample pages: Chinese text opposite English.

FOODS/BEVERAGES	Reference Portion	Usual time of day eaten	NUMBER OF TIMES EATEN: Per day (put a **number** in appropriate column)	Per week	Per month	Per year	Never or rarely (tick please)
Rice vermicelli/noodles	1 bowl						
Mungbean thread	1 bowl						
Gluten roll/ball	3 big 5 small						
Steak (grilled)	1 medium						
Steak (pan-fried)	1 medium						
Roast beef/veal	2 slices						
Crumbed veal/schnitzel (deep-fried)	1 large						
Lean beef/veal in other dishes (stir-fried)	5 cut pieces or 1/2 bowl						
Pork chop (grilled)	1 chop						
Pork chop (pan-fried)	1 chop						
Roast pork	2 slices						
Lean pork in other dishes (stir-fried)	5 cut pieces or 1/2 bowl						

B: Breakfast M: Morning L: Lunch A: Afternoon D: Dinner S: Supper

Table 1. English text opposite Chinese.

食物與飲料	參考用量	日常進食時間	進食次數					
			每天	每星期	每月	每年	不用/少用	
			請在適當的空格內寫下次數				請打✓	
米粉/河粉類	1 碗							
粉絲/冬粉	1 碗							
麵筋(球)	3 大 5 小							
炙燒牛扒(肉) 【火來自上方】	1 塊中							
油煎牛扒(肉) 【鍋放少許油】	1 塊中							
焙烤(烘)牛肉/ 牛仔肉【烤箱內】	2 切片							
炸沾粉牛仔肉	1 塊大							
炒瘦牛肉(柳)/ 牛仔肉	5 切塊 或半碗							
炙燒豬扒 【火來自上方】	1 扒							
油煎豬扒 【鍋放少許油】	1 扒							
焙烤(烘)豬肉 【烤箱內】	2 切片							
炒瘦豬肉	5 切塊 或半碗							

B: 早餐　M: 早茶　L: 午餐　A: 下午茶　D: 晚餐　S: 宵夜

Australian foods and beverages with identified standard portion size. Foods and beverages were expressed in serving sizes or natural units. Subjects were asked to select either per day, per week or per month as a denominator and then to enter frequency of use. Subjects could write down S alongside the frequency of use to indicate a seasonal use for that particular food. In addition, there was a comment column for usual serving size, if different from the questionnaire standard.

Food and beverage list. The main task in developing a food frequency questionnaire for use in an adult Melbourne Chinese population was to compile a food list that was cross-culturally robust. For the European type foods, the FREQPAN food list was used. The Chinese food list was compiled using information collected at various Chinese grocers, markets and restaurants. Foods were photographed at stores and Chinese kitchens to record the way in which food was prepared or served.

Denominators for frequencies. Subjects were asked to estimate the intake frequency for each food or beverage based upon one of the usual time frame, namely per day, per week, per month or per year. In doing so, subjects referred to our 'reference portion' listed alongside each food or beverage.

Reference portion. The Chinese rice bowl is a common household measure. It is used to serve rice, a staple in the traditional Chinese meal setting. For each food or beverage, we used a 'Chinese rice bowl (approximately 300 ml)' as a reference portion to estimate usual intake. Reference portion replaced the 'standard serving size (a correct and recommended amount for consumption)' in the Melbourne Chinese Health Study Food Frequency Questionnaire (MCHS-FFQ). Subjects referred to their consumption of each food item in the MCHS-FFQ in terms of a fraction of a rice bowl, eg 1/2 bowl of beer, 1/2 bowl of bean sprouts, etc. The identification of foods was facilitated with the use of colour food photographs at interview.

In a traditional Chinese meal setting, members of the family usually share *ts'ai* (dishes) from the centre of the dinner table, while *fan* (staple) is served in individual rice bowls. In such a setting, table manners emphasize taking food pieces 'equally amongst members', though men and young adults generally consume a greater portion than women and the aged. Perhaps, to facilitate the *ts'ai* sharing practices, Chinese dishes are usually diced, or sliced before they are cooked. Thus, in addition to 'portion of a rice bowl', food pieces were also used where appropriate as a reference portion. Rice bowl equivalents for food pieces were also used. For example, a 1/2 bowl of stir-fried chicken is equivalent to about 5 chicken (cut) pieces. There was also a need to use standard household measures like tea cups, glasses and spoons.

All food intake was ultimately expressed in numbers of Chinese rice bowls, pieces, or household measures. However, conversion factors allowed the intake of almost all items to be expressed in terms of rice bowl equivalents.

Time of intake (meal pattern). The usual times of the day for food/beverage consumption were also recorded.

Applications

One of the objectives of the development of the MCHS-FFQ was to assess an individual's usual intake in the 12 months prior to interview. Subjects were given descriptions of all parameters (eg the food and beverage list, frequency of intake, reference portion and time of intake) included in the questionnaire and instructions to fill out the questionnaire. MCHS-FFQ is bilingual (Chinese and English). Subjects were encouraged to report foods or beverages that were frequently consumed and not listed in the MCHS-FFQ. Extra spaces were provided for additional food items.

Self-administration. The MCHS-FFQ is a self-administered questionnaire with Chinese and English set side by side. A one-to-one interview could be arranged for those who were illiterate or less educated. The interview was conducted in the language spoken at home, which included Mandarin, Cantonese and Teochew dialects. Whether or not the subject needed a one-to-one interview was generally established prior to the interview.

Time taken. The self-administered questionnaire took about 45 min to one hour to complete. In the case where a one-to-one interview was required, interview would take up to 2½ hours.

Role of interviewer. Because the questionnaire was designed for self-administration, the role of interviewer was to ensure all food items in the questionnaire were answered. The interviewer would go through the questionnaire item by item and check at random the denominator for the frequency of use. The interviewer would also use the response to the 'usual time of day eaten' to verify 'portion size' or the 'frequency of use'. Although it rarely happened, the interviewer might decide to perform a one-to-one interview in light of doubts about the completeness of the questionnaire. Where the questionnaire as a whole appeared to be misunderstood, the interviewer would immediately offer another one-to-one interview or ask that the questionnaire be repeated. There were only a few subjects (less than five) who required the additional interview procedures.

Validation

We used several internal mechanisms to validate the MCHS-FFQ. These considered whether or not the questionnaire (1) covered foods likely to be consumed by the Melbourne Chinese, (2) adequately estimated the energy intake in terms of minimal energy requirement, (3) provided comparable nutrient intake estimates for appropriate biochemical markers, and (4) had ability to predict health outcomes.

Percentage of total food intake accounted for by the MCHS-FFQ. We classified food items into four categories: category 1 was food and beverages consumed by more than 75% of the study population (frequently consumed foods); category 2 was those consumed by 50 to 75% of the study population (commonly consumed foods); category 3 was foods and beverages consumed by 25 to 50% of the study population (less commonly consumed foods); category 4 was foods and beverages consumed by less than 25% of the study population (rarely consumed foods). We then calculated the number of foods and beverages in each category.

Additionally, for each subject, we calculated the percentage food items reported for intake during the 12-month period. This is called 'intake index' hereafter. Linear relationships between 'intake index' and estimates for daily total energy intake and daily intakes for protein, total carbohydrates and total fats were examined using simple regression analyses. The relationships between 'intake index' and the expected basal metabolic rates were also examined.

Nutrient intakes were estimated using the Australian Food Composition Table, 1990 edition[7]. Detailed methodology for nutrient conversion has been reported elsewhere[8].

Total energy intake and estimated BMR by weight. A dietary method is regarded as invalid if the population habitual energy intake is less than 1.4 times the expected basal metabolic rate (BMR)[9]. In other words, if the expected BMR accounted for more than 71.5% of the estimated energy intake, then the dietary method which produced the energy intake estimates would not likely be valid, discounting a 12.5% coefficient of variation in BMR.

Basal metabolic rate (BMR) is a measurement of the energy expended for maintenance of normal body functions and homeostasis, plus a component for activation of the sympathetic nervous system. BMR is the greatest contributor to total energy expenditure. Allowing for inter-individual variation and the effects of other component of energy expenditure, BMR accounts for 60 to 75% of total energy expenditure. The second largest component of energy expenditure is the thermic effect of exercise (TEE). TEE represents the cost of physical activity above basal levels and ranges from 15 to 30% of total energy requirements in a moderately active individual. It is highly variable. The thermic effect of food (TEF) is the result of energy expended to digest, transport, metabolize, and store food. It accounts for about 10% of daily energy expenditure[10]. BMR, TEE and TEF are major components of energy requirements. Energy expenditure may also be modulated by, or adapt to, for example, climatic change.

We used the Schofield equations to estimate BMR[11]. The equations employed body weight to estimate BMR for three age categories, ie (1) 18 to 30 years old, (2) 30 to 60 years old, and (3) 60 years. Assuming that 70% of the total energy intake is expended for BMR, we then calculated the expected energy intake. Student's *t*-test was performed to examine whether or not mean total energy intake estimated by the MCHS-FFQ was the same as that of the expected total energy intake.

Urinary sodium and potassium excretion. We collected single 24-h urine random specimens from 97 subjects. Urine specimens were collected using a cylinder sampler which exacts 1/50 portion of the voided urine. The 24-h volume was then estimated, multiplying the 1/50 specimens by 50. One ml was used to measure urinary sodium, potassium and creatinine concentrations. Urine specimens were analysed at Prince Henry's Hospital (now Monash Medical Centre), Department of Chemical Pathology (now Department of Clinical Biochemistry). Sodium and potassium excretion levels are products of urinary concentrations and volume estimated for 24 h.

The expected sodium intake was calculated based upon the urinary sodium excretion, allowing for 5% faecal and skin losses. Similarly, we assumed that 86% of the potassium intake was excreted through urine[12] and calculated the expected potassium intake. Student's *t*-test was performed to test whether the expected urinary sodium and potassium intakes were significantly different from estimates derived from the MCHS-FFQ.

Total nitrogen output. Urinary total nitrogen was analysed by the Kjeltec Kjeldahl technique[13]. Aliquots of urine specimens were stored in −20°C for two years prior to analysis. Single measurements were performed at the Monash Medical Centre, Department of Clinical Biochemistry.

We used estimates by Bingham and Cummings[14] that urine nitrogen accounted for 81% of the dietary nitrogen and calculated the expected nitrogen intake. The expected nitrogen intake was compared with the nitrogen intake estimates derived from the MCHS-FFQ, using Student's *t*-test.

Subjects were categorized into two groups; those whose nitrogen intake estimate derived from the MCHS-FFQ were higher than the expected value being derived from the urinary nitrogen, and those who had a lower estimate. Differences in total energy and nitrogen intakes, as derived from MCHS-FFQ, and the urinary nitrogen output were tested.

Ability to predict outcomes. One of the main objectives of our study was to identify changes in food habits in relation to cardiovascular risk factor prevalence in Melbourne Chinese. Multiple finger pricks were applied to collect capillary blood samples. Plasma total cholesterol and HDL-C were analysed using the KONE 'Progress' Selective Chemistry Analyser. LDL-C level was calculated based on the Friedewald formula[15]. We calculated Pearson's correlation coefficients to examine whether or not univariate relationships exist between nutrient intakes and plasma cholestrol levels. Plasma total cholestrol, high density lipoprotein cholesterol (HLD-C) and low density lipoprotein cholestrol (LDL-C) levels were examined and treated as outcomes.

Stastical methods

All statistical procedures were performed using SAS (Statistical Analysis System)[16]. The significance level was set at 5%. Student's *t*-test was performed to assess differences between two population means and Pearson's correlation coefficient was calculated to test whether linear trends exist between two continuous variables. Population means and standard deviations (in parentheses) were reported where appropriate.

Results

The MCHS-FFQ

Table 1 gives sample pages selected from the Melbourne Chinese Health Study Food Frequency Questionnaire. This questionnaire begins with an introduction. Parameters required to estimate the frequency of usual food intake were stated. A stepwise instruction on how to fill out the questionnaire was also given. There were 220 foods and beverages, each in a reference portion attached to it. Denominators for the frequency of use were per day, per week, per month and per year. 'The usual time of day eaten' was also requested for each item.

The complete questionnaire can be obtained from the first author.

Validation

Percentage of total food intake accounted for by the MCHS-FFQ. We found that 48 (22%) items were reported for consumption by less than 25% of the study population (rarely consumed foods) and 44 (20%) items were reported for regular consumption by more than 75% of the population (frequently consumed foods) (Table 2).

Table 2. Foods and beverages reported for frequent and rare consumption in the 12 months prior to interviews.

Items frequently consumed	Items rarely consumed
Steamed rice	Raw bran
Sliced bread	Crumpet and muffin
Rice vermicelli	Gluton roll
Lean beef, stir-fried	Schnitzel
Lean pork, stir-fried	Dried pork
BBQ pork	Lamb chop, pan-fried
Spare ribs	Lamb, stir-fried
Boiled chicken	Pigeon
Chicken breast, stir-fried	Pork sausages, pan-fried
Chinese sausages	Beef sausages, grilled
Fried egg	Beef sausages, pan-fried
Fresh fish	Salami and mettworst
Crab, prawns and lobster	Cottage cheese
Abalone and scallops	Pure cream
Dried shrimps	Yoghurt
Lettuce	Boiled quail egg
Cabbage	Eel
Spinach	Skimmed milk
Broccoli	Flavoured milk
Celery	Milk shake
Cauliflower	Thick shake
Chinese cabbage	Canned carrots
B.ai-choi	Dried Chinese radish
Choi-sum	Mashed potato
Fried onion	Potato packet
Cucumber	Broad beans
Tomato	Tau-miu
Fresh carrots	Soybeans
Green peas	Papayas
Snow peas	Fruit fritters
Beancurd	Preserved plums
Bean sprouts	Olives
Chinese dried mushrooms	Gherkins
Orange, mandarin and grapefruits	Hamburger without bun
	Meat pie – homemade
Apple and pear	Savoury pies and pastries
Banana	Packet soup
Watermelon	Ginseng tea
Mango and nectarines	Cider
Fresh grapes	Walnut shortcake and biscuits
Dim sim – steamed varieties	
Curry	Rice pudding
Homemade soup	Milk pudding
Chinese tea	Custard
Water	Vegemite
	Thick sauces
	Sherry
	Port
	Light beer

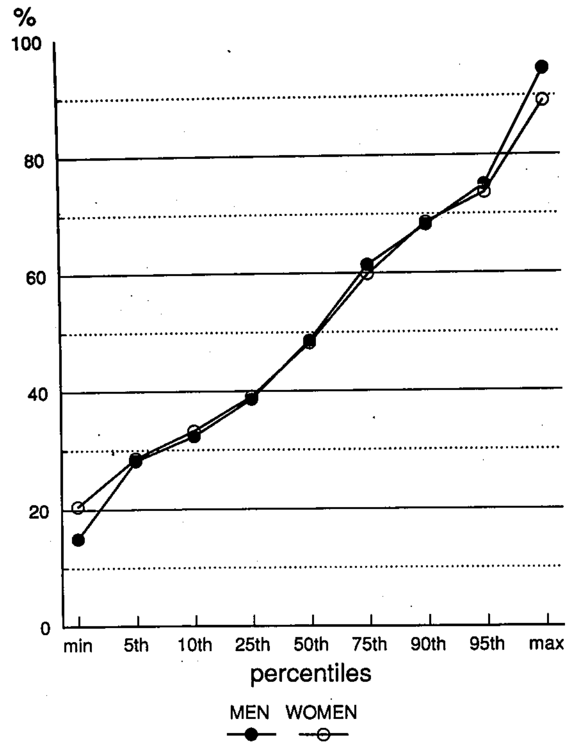

Fig. 1. Percentile distribution for total food intake index, by gender.

On average, responses were obtained for 110 items in the MCHS-FFQ, ranging from 33 items to 208 items. Figure 1 shows percentiles for 'intake index' in men and women. There is no difference in intake index between men and woman.

Figure 2 shows macro-nutrient intake estimates by tertiles of the intake index. Macro-nutrient intake estimates were significantly higher among those in the higher tertiles compared to the lowest. There was a positive linear trend between macro-nutrient intake estimates and intake indices, expect for total carbohydrates in men. Similarly, there was a positive linear trend between total energy intake estimates and intake indices. The same trend was not significant for the estimate BMR. (Figure 3).

Total energy intake and estimated BMR. The mean expected total energy intake from BMR was 9.37 (±1.13) MJ/d for men and 7.49 (±0.51) MJ/d for women. The expected total energy intakes derived from BMR did not differ from those estimated from the MCHS-FFQ [9.21 (±2.90) MJ for men and 7.57 (±2.37) MJ for women] (Figure 4).

Urinary sodium excretion. On average, the urinary sodium excretion was 181 (±86) mmol/d for men and 154 (±74) mmol/d for women. This was equivalent to 10.6 g/d of salt intake for men and 9.0 g/d for women. The expected sodium intake [191 (±91) mmol/d for men and 162 (±74) mmol/d for women] was significantly higher than the estimate derived from the MCHS-FFQ. The mean sodium intake for those who collected the urine sample did not differ from the population mean (Figure 5).

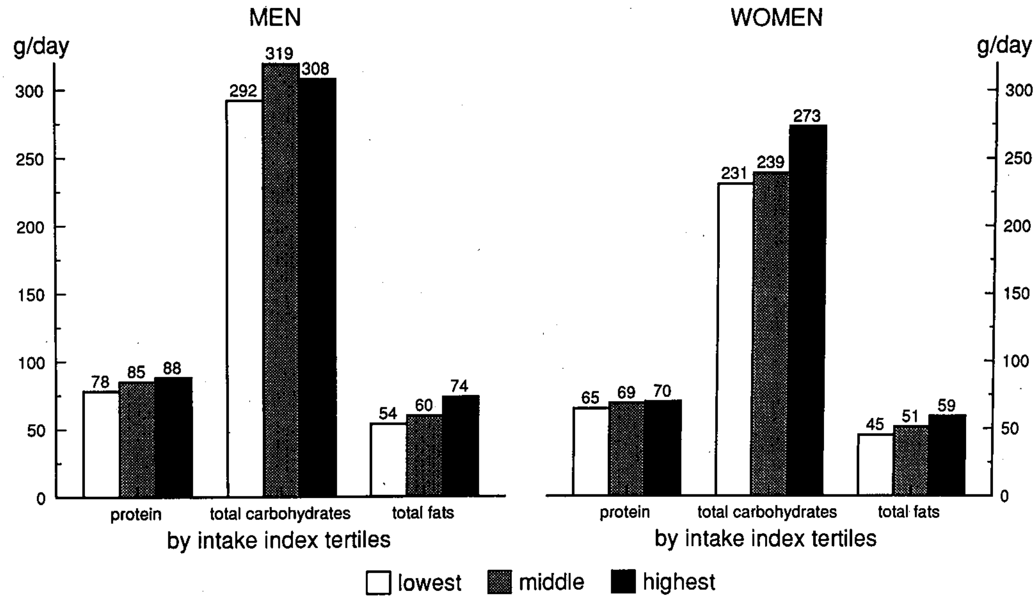

Fig. 2. Macro-nutrient intake estimates by tertiles of the intake index, by gender.

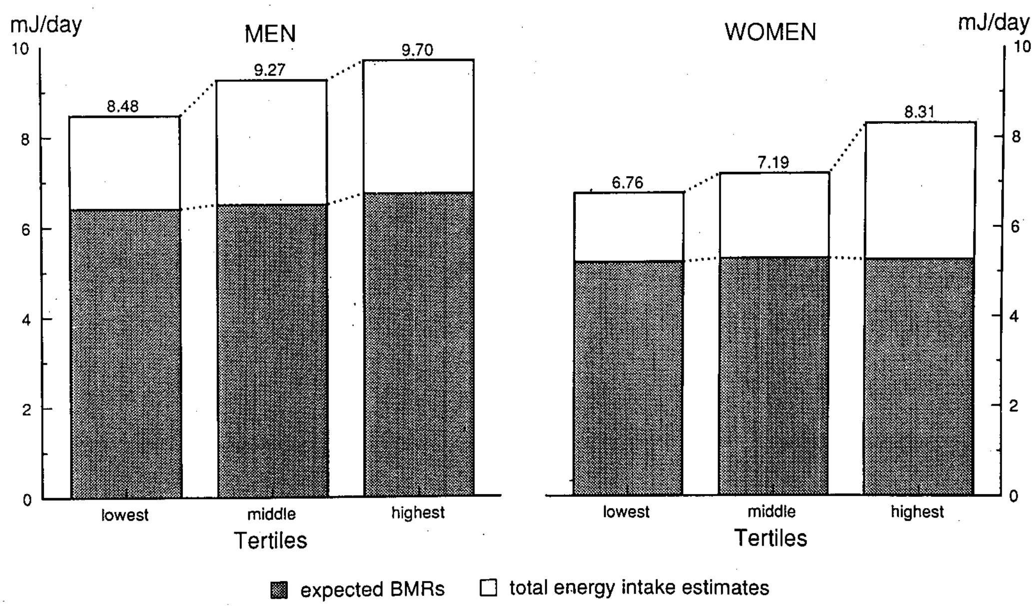

Fig. 3. Total energy intake estimates and the expected basal metabolic rates by tertiles of the intake index, by gender.

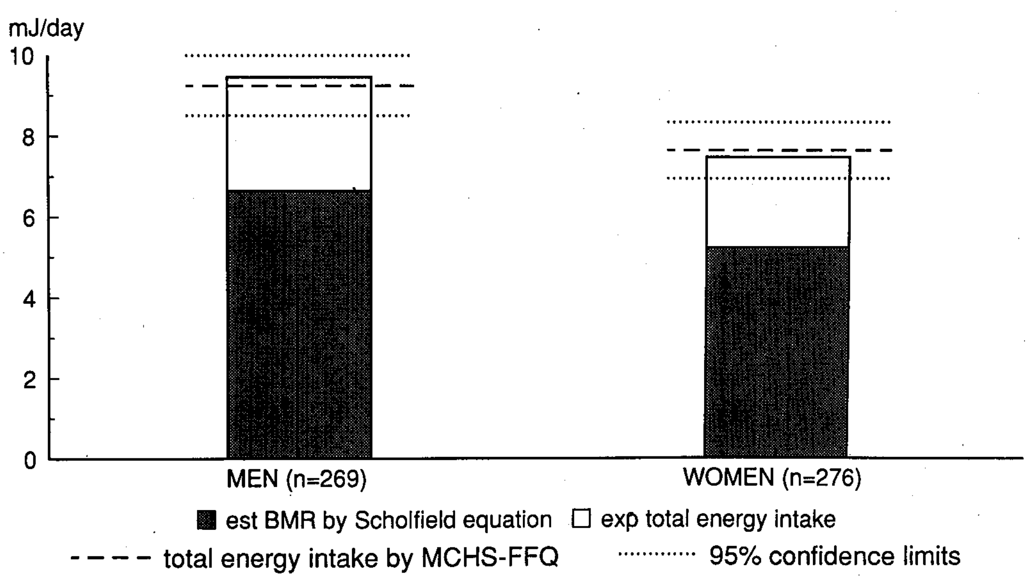

Fig. 4. The expected total energy intake derived from the estimated BMR and the mean and 95% confidence limits for total energy intake derived from MCHS-FFQ.

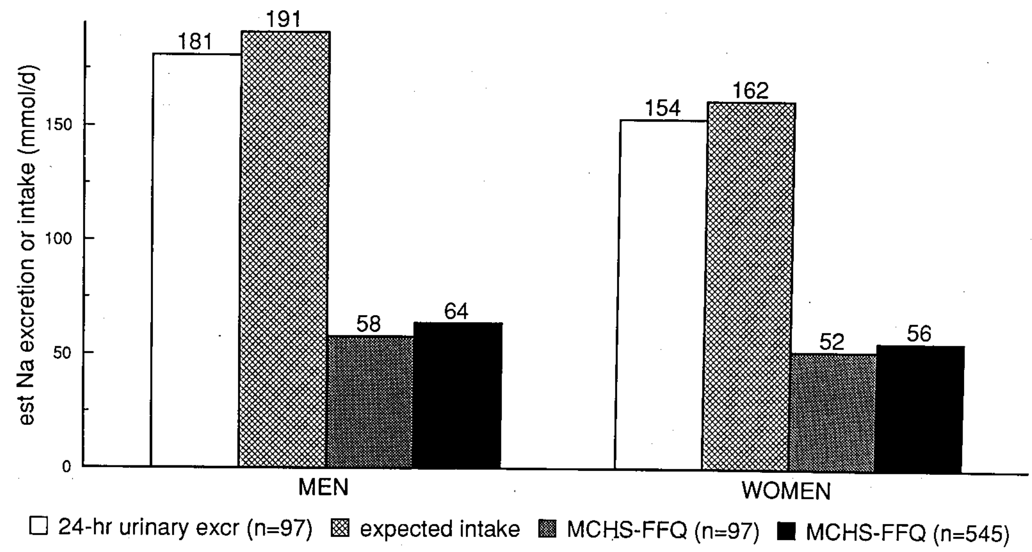

Fig. 5. Average single 24-h urinary sodium excretion, expected daily sodium intake estimated by 24-h urinary excretion, average daily sodium intake estimated by MCHS-FFQ for those who collected a 24-h urine sample (n+97) and the total population (n+545).

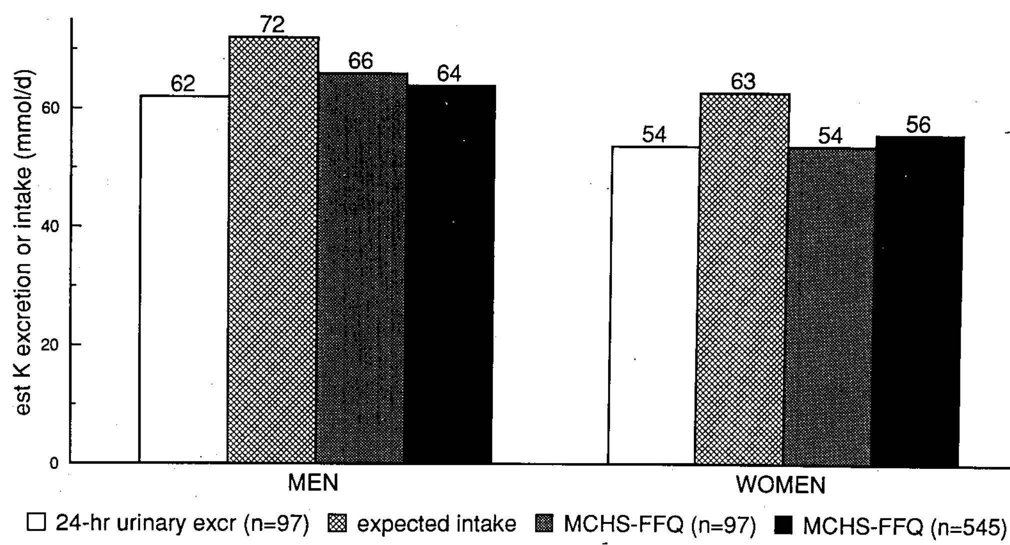

Fig. 6. Average single 24-h urinary potassium excretion, the expected potassium intake estimated by 24-h urinary excretion, the average daily potassium intake estimated by MCHS-FFQ for those who collected a 24-h urine sample (n+97) and the total population (n+545).

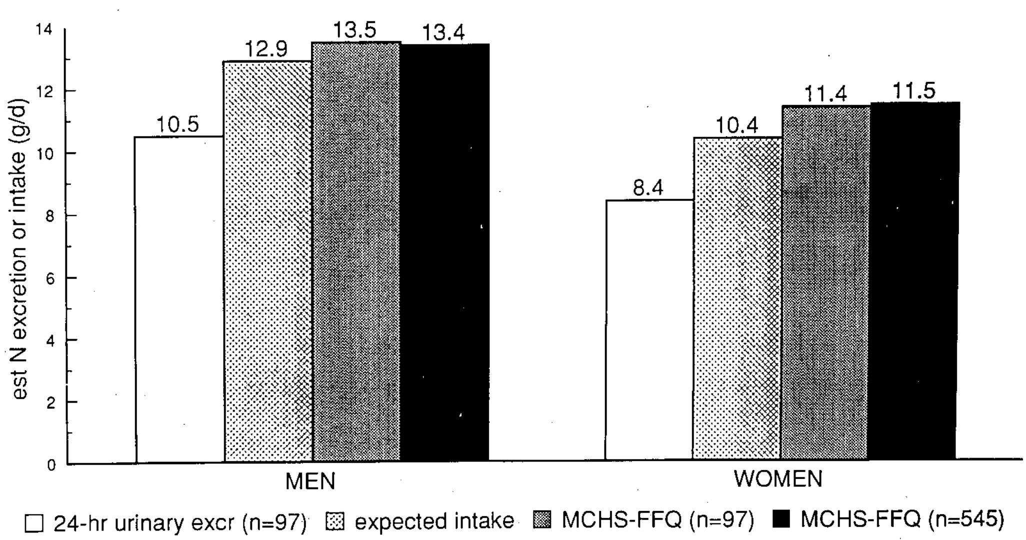

Fig. 7. Average single 24-h urinary nitrogen output, the expected daily nitrogen intake estimated by 24-h urinary excretion, the average daily nitrogen intake estimated by MCHS-FFQ for those who collected a 24-h urine sample (n+97) and the total population (n+545).

Urinary potassium excretion. Figure 6 shows mean urinary potassium excretion [62 (±24) mmol/d for men and 54 (±32) mmol/d for women], the expected potassium intake (72 (±28) mmol/d for men and 63 (±38) mmol/d for women] and the potassium intake estimate from MCHS-FFQ [66 (±23) mmol/d for men and 54 (±23) mmol/d for women]. No differences were found between the potassium intake calculated from the urinary excretion and that estimated from the MCHS-FFQ, for those who collected the urine sample and for the entire population.

Total nitrogen output and protein intake. The expected mean nitrogen intake level was 12.9 (±6.2) g/d for men and 10.4 (±4.6) g/d for women. Figure 7 shows that there was no differences between the expected nitrogen intake and the estimates derived from the MCHS-FFQ [13.5 (±4.1) g/d for men and 11.4 (±4.1) g/d for women].

There was no linear relationship between the log-transformed urinary total nitrogen output and log-transformed nitrogen intake estimated from the MCHS-FFQ for the entire study population. However, positive associations were found when separate analyses were performed in those who had a nitrogen intake derived from the MCHS-FFQ below or above the expected intake derived from the urinary excretion. The log-transformed urinary nitrogen output was positively and significantly related to the log-transformed nitrogen intake from MCHS-FFQ in three of the four separate analyses. No linear relationship was found in women whose MCHS-FFQ estimated nitrogen intake was greater than the expected intake (Figure 8).

Figure 9 shows that individuals who had an MCHS-FFQ nitrogen intake estimate above the expected value had a lower total energy and nitrogen intake estimate compared to their counterparts. These comparisons were statistically significant for women only.

Ability to predict plasma cholesterol levels. Table 3 shows Pearson's correlation coefficients for univariate relationships between plasma cholesterol levels and nutrient intakes derived from the MCHS-FFQ. Positive relationships were found between total fat intake or the percentage energy intake from total fat, as derived from the MCHS-FFQ, and plasma total or LDL cholesterol levels in men, but not women. Total energy intake, for women, and total carbohydrate or the percentage energy intake from total carbohydrate for men and women predicted plasma total and LDL cholesterol levels in a favourable fashion.

Table 3. Significant univariate associations between nutrient intakes and plasma cholesterol variables.

Nutrients	*r*	*P*-value
Total Cholesterol (mmol/l)		
MEN		
Fat (%kJ)	0.14	0.0178
Carbohydrate (%kJ)	−0.16	0.0087
WOMEN		
Total energy (kJ/d)	−0.14	0.0227
Total carbohydrate (g/d)	−0.16	0.0080
HDL-C (mmol/l)		
MEN		
Alcohol (g/d)	0.20	0.0010
Alcohol (%kJ)	0.23	0.0002
WOMEN		
Total energy (kJ/d)	0.13	0.0321
Total fat (g/d)	0.16	0.0067
SFAs (g/d)	0.18	0.0028
MUFAs (g/d)	0.14	0.0209
PUFAs (g/d)	0.14	0.0203
Dietary cholesterol (g/d)	0.13	0.0375
Sodium (mg/d)	0.14	0.0191
Calcium (mg/d)	0.16	0.0065
Phosphorus (mg/d)	0.13	0.0310
Iron (mg/d)	0.14	0.0191
Riboflavin (mg/d)	0.14	0.0195
SFAs (%kJ)	0.18	0.0033
Fat (%kJ)	0.15	0.0156
M/S ratio	−0.13	0.0321
LDL-C (mmol/l)		
MEN		
Total fat (g/d)	0.14	0.0209
SAFs (g/d)	0.16	0.0087
MUFAs (g/d)	0.13	0.0316
Fat (%kJ)	0.20	0.0010
Carbohydrate (%kJ)	−0.17	0.0057
WOMEN		
Total energy (kJ/d)	−0.15	0.0116
Total carbohydrate (g/d)	−0.18	0.0031
Calcium (mg/d)	−0.13	0.0277
Retinol (mg/d)	−0.13	0.0285
Retinol equivalents (mg/d)	−1.13	0.0298

%kJ, percentage energy intake of; SFAs, saturated fatty acids; MUFAs, mono-unsaturated fatty acids; PUFAs, poly-unsaturated fatty acids; M/S ratio, MUFA to SFA intake ratio.

Discussion

Characteristics of the MCHS-FFQ

In the course of developing a dietary method for use in a Melbourne Chinese population, we considered several dietary methods[4,17-21] and attempted to adopt and improve an existing method that would measure individual usual intakes in Chinese Australians living in Melbourne. Additionally, we were interested in a less expensive method which would take advantage of newer computer technology.

The CSIRO FREQPAN[6] had been used in a large dietary survey in the state of Victoria, Australia, from which our study population was drawn. The questionnaire had been tested and developed for computerized processes. It was suitable for estimation of the assessment of individual usual intakes. For these reasons, the food frequency questionnaire, rather than any other dietary intake method, was used.

We have also considered the need to develop a reference portion so that food intake can be quantified in a manner that was culturally relevant. The way in which a Chinese family conducts its meal setting was considered and the traditional Chinese rice bowl was used as a reference portion for most foods. Because different type of foods are usually served in accordance with meal setting we have used the 'usual time of the day eaten' for internal validity at the interview.

Approaches in validation

Various approaches have been used to evaluate the performance of food frequency questionnaires. One common approach is to compare nutrient intake estimates of individuals in the study, using correlation coefficients to evaluate the agreement, with those

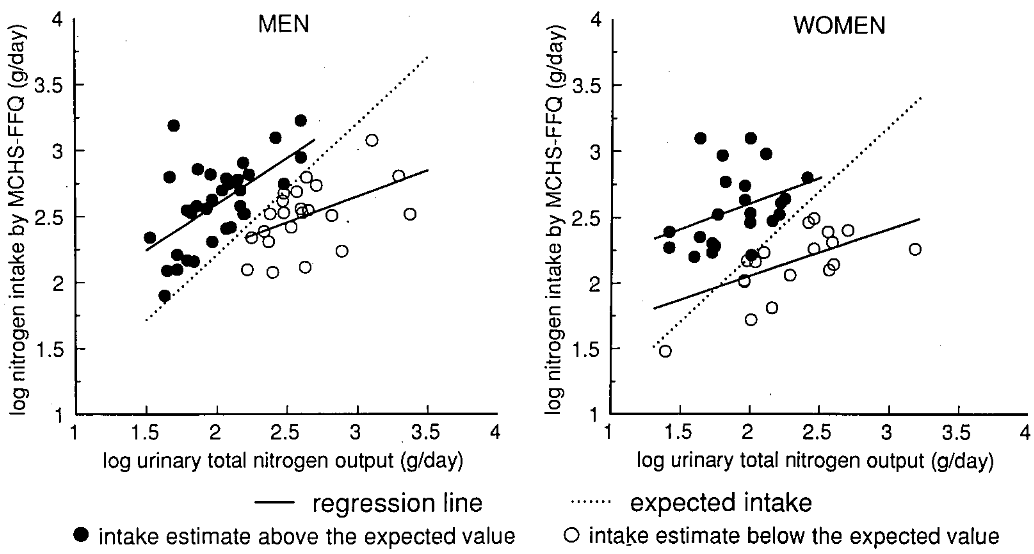

Fig. 8. Relationships between nitrogen intake estimates (log-transformed) and single 24-h urinary total nitrogen output (log-transformed) for individuals with an MCHS-FFQ estimate above or below the expected intake estimate being derived from urinary excretion.

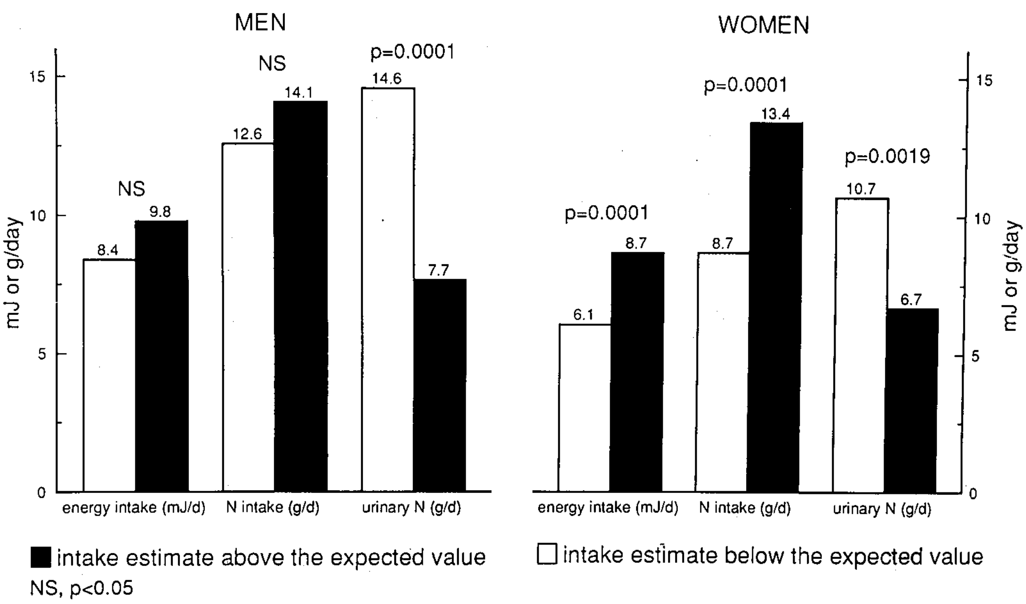

Fig. 9. Total energy and nitrogen intake estimates by MCHS-FFQ and 24-h urinary total nitrogen for individuals with an MCHS-FFQ estimate above or below the expected intake estimate being derived from urinary excretion.

derived from an independent standard[4,21–26]. Because there is no gold standard method for dietary assessment, and the nature and/or major sources of error produced by an alternative dietary method are often fairly similar to the one to be validated [2,4,27], the choice of an independent standard for the validation of a dietary assessment methodology may therefore introduce a validity problem in itself. Comparisons of group means of intake estimates are also questionable as a validity exercise. A serious concern is that such comparisons disregard possible differences in nutrient intake among individuals and the same amount of food, or the same nutrient intakes, across population groups[4].

The reproducibility of individual nutrient intakes has also been widely used to validate a dietary method[28]. This approach differs from previous approaches, in that research investigators use the same dietary method repeatedly over a range of time intervals and assess the agreement in individual nutrient intakes. There is, however, a fundamental problem in the interpretation of reproducibility and validity of a dietary method.[4]. As individual dietary intake is highly variable, a low agreement in estimates between time intervals may simply reflect changing eating practices of individuals. This is particularly important in the study of migrant health, as in our study. Individual dietary change is often considered a major determinant of changing disease patterns. We used internal validation so that various nutrient 'intake indices' derived from the 220-item food frequency questionnaire could be assessed.

The need for a comprehensive food and beverage list

Foods and beverages frequently consumed by the population were mostly traditional Chinese foods or foods in abundant supply. On the other hand, traditional Chinese foods that are less accessible in general food supply, snacks and non-traditional Chinese foods were rarely consumed by the Melbourne Chinese (Table 2).

This implied that the food consumption pattern of Melbourne Chinese remains traditionally Chinese and limited to accessible foods. It is equally appropriate to consider food intake patterns associated with food acculturation with a shift toward the Australian way of eating and its related health outcomes. Thus the inclusion of foods and beverages rarely consumed by the study population should not be seen as being redundant in this particular study.

Macro-nutrient intakes

Where a complete food list is provided, one would expect to observe a positive relationship between 'intake index' and either total energy intake or the expected basal metabolic rate, and positive relationships between intake index and some macro-nutrients. We observed increases in major macro-nutrient intake as intake index increased, except for total carbohydrate intake in men (Figure 2). Additionally, increases in total energy intake with intake index were accounted for by intakes in excess of the expected BMR (Figure 3). In other words, individuals responding to a higher percentage of foods in the questionnaire had a higher energy intake which was independent of BMR. Our result also suggests that the total energy intake was adequately estimated using the MCHS-FFQ (Figure 4), so that the minimal energy requirement is met[29].

Sodium and potassium intake estimates

The food frequency questionnaire depends upon portion-size estimation of quantitative intake. As a result of this, foods which are not served in standard portion are likely to be under-estimated[8]. In this study, a 1 day sodium intake was estimated from a 24-h urinary sodium excretion. Urinary sodium excretion over 1 day may not be representative of a year-long Chinese diet probed by the food frequency questionnaire. Nevertheless, if the assumption is made that urinary sodium intake is correct, it is clear that the food frequency questionnaire would have under-estimated true sodium intake (Figure 5). The agreement between potassium intake estimated from a urinary excretion and the MCHS-FFQ (Figure 6) suggests that the MCHS-FFQ has the ability to estimate daily potassium intake similar to that of single 24-h urine sample. This implied that potassium balance may fluctuate less than sodium balance across a year and/or there is less problem with unmeasured potassium additions in a Chinese diet than sodium additions. Sources of added sodium intake in a Chinese diet are soysauce, salt, mono-sodium glutamate (MSG) and stock[8].

Urinary nitrogen output and protein intake

There was no difference in population mean nitrogen level estimated from the 24-h urinary nitrogen output and the MCHS-FFQ (Figure 7). Our results did not support an intra-individual relationship between estimates derived from the two independent methods for the entire population (Figure 8). This is probably due to daily variation in dietary intake and marked daily fluctuations in daily nitrogen balance. Bingham and Cummings[14] showed that single 24-h urine collection can be substantially in error. In healthy individuals with normal western diets, an 8-day 24-h urine nitrogen collection would verify its completeness and a dietary assessment from 18 days of records or 24-h recalls would minimize reporting errors from such methods.

When considered separately for those who had a nitrogen intake estimate by MCHS-FFQ higher or lower than the expected nitrogen intake, as derived from the single 24-h urinary nitrogen output, our data confirmed intra-individual relationships between urinary total nitrogen output and nitrogen intake estimated by MCHS-FFQ. In all cases, slopes were attenuated for both men and women and the linear relationships were less pronounced in women (Figure 8). This indicates that the lack of one-to-one relationships between the 24-h urinary nitrogen output and the MCHS-FFQ estimated nitrogen intake may depend upon the level of true protein intake. Individuals with a higher protein intake have been shown to have a lower urinary nitrogen output than expected[14,30]. This is confirmed in our study, particularly in women (Figure 9). The gender differences in the significance levels further suggest that a higher total energy intake in men, as estimated by MCHS-FFQ, have resulted in a lower urinary nitrogen output.

In summary, single 24-h urinary nitrogen output is not appropriate for the individual validation of protein intake because the steady state condition is rarely achieved in free-living individuals and large day-to-day fluctuations in protein intake exist. The single 24-h urinary nitrogen output, however, provides a good ball-park figure for the validation of population mean protein intake in the case where urinary nitrogen does not exceed the estimate of dietary intake over a short period of time[14]. The MCHS-FFQ thus gives a reasonable estimate of the population mean protein intake.

Predictive power of the MCHS-FFQ

One of the most important expectations for a dietary method is that it should predict outcome variables. A method cannot be claimed as valid or reliable if it fails to demonstrate the ability to predict what it is supposed to. The emphasis in tackling problems associated with various dietary methods has been on external validation against an independent method or on internal reliability tests over a time[2,3,31]. Neither approach has taken into account the possibility of errors associated either with the methods themselves or the use of alternative methods to validate them. The predictive power of a dietary method has rarely featured, however, in the considerations.

Nutrient estimates derived from the MCHS-FFQ are capable of predicting health outcomes (Table 3). Although Table 3 shows univariate associations, similar results were found in the multivariate models[8]. Positive relationships between fat intake and plasma cholesterol and coronary heart disease are well established. To mention a few, the same predicitve power of dietary fat intake, particularly saturated fatty acids and the percentage energy of fat intake, for 4-year coronary incidence has been reported in the young Framingham cohort[32] and in the 10-year coronary mortality in Japanese men living in Hawaii[33]. Less evidence is avilable in the cross-sectional studies. A cross-sectional relationship between fat intake, particularly saturated fatty acid intake, and plasma cholesterol has however been reported in a coloured population in South Africa[34]. As cross-sectional relationships are likely to be attenuated due to cohort effect, such relationships when

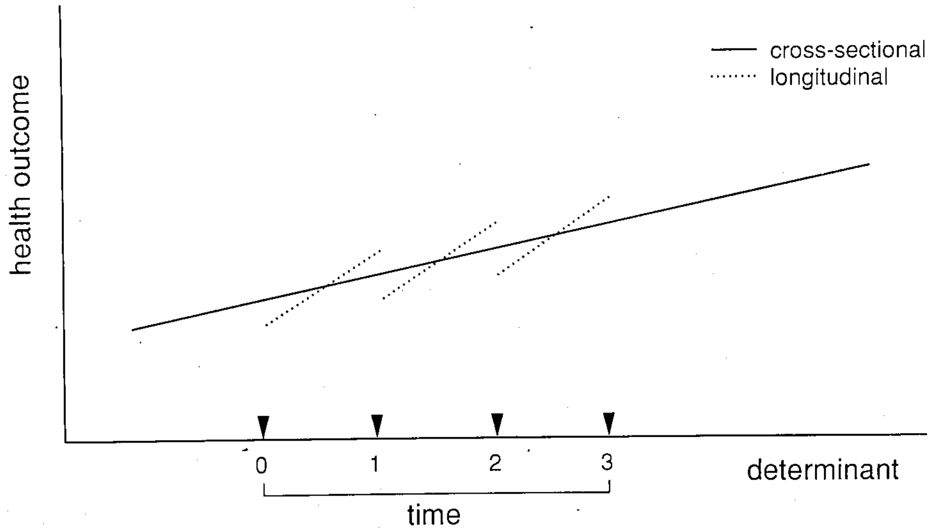

Fig. 10. Cross-sectional *vs* longitudinal relationships between health outcome and its determinants.

identified would be better appreciated in a longitudinal study (Figure 10). Thus, the validity of MCHS-FFQ is appropriate insofar as the predictive power of plasma cholesterol and other health outcomes is concerned.

In conclusion, the MCHS-FFQ is a simple and valid method in the assessment of usual food intake in a representative adult Chinese living in Melbourne. Australia. The method, when carefully applied, provides a reasonable estimate of all macro-nutrients and has the ability to predict the major health outcomes we explored. The method, however, is not appropriate for estimation of foods not served in a standard portion or as quantifiable additions. Where such foods or food sources of nutrient are of importance to the study outcomes, an alternative or supplementary method will be required to remove these sources of error.

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References

1 Elmer PJ. Dietary methods in cardiovascular diesease critique. Vital Hlth Stat [4] 1992; 27:32–4.
2 Bingham SA. Limitations of the various methods for collecting dietary intake data. Ann Nutr Metab 1991; 35:117–27.
3 Block G. A review of validations of dietary assessment methods. AM J Epidemiol 1982; 115:492–505.
4 Willett W. Nutritional epidemiology. New York: Oxford University Press, 1990.
5 Medlin C Skinner JD. Individual dietary intake methodology: a 50-year review of progress. J Am Diet Ass 1988; 88:1250–7.
6 Record S, Baghurst K. Dietary assessment by computer: User's manual. Adelaide: CSIRO Division of Human Nutrition, 1987.
7 Commonwealth of Australia. Composition of foods, Australia, 1990. Canberra: Australian Government Publishing Services, 1990.
8 Hage, BH-H. Food habits and cardiovascular health status in adult Melbourne Chinese. Thesis, Monash University, Department of Medicine, 1992.
9 Bingham SA. The dietary assessment of individuals; methods, accuracy, new techniques and recommendations. Nutrition Abstracts and Review 1987; 57:724–7.
10 Devlin JT, Horton ES. Energy requirements. In: Brown ML (ed). Present knowledge in nutrition. International Life Sciences Institute, Nutrition Foundation, Washington DC, 1990.
11 Schofield MN. Predicting basal metabolic rate, new standards and review of previous work. Hum Nutr: Clin Nutr 1985; 39C (Suppl 1):5–41.
12 Schachter J, Harper PH, Radin ME, Caggiula AW, McDonal RH Diven WF. Comparison of sodium and potassium intake with excretion. Hypertension 1980; 2:695–9.
13 Tecator Ltd. Cooper Road, Thornbury, Bristol, England BS12 2UP.
14 Bingham SA, Cummings JH. Urine nitrogen as an independent validatory measure of dietary intake: a study of nitrogen balance in individuals consuming their normal diet. AM J Clin Nutr 1985; 42:1276–89.
15 Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem 1972; 18:499–502.
16 SAS Institute Inc. SAS/STAT User's Guide, Release 6.03 edition. Cary: SAS Institute Inc, 1988.
17 Burke BS. The dietary history as a tool in research. J Am Diet Ass 1947; 23:1041–6.
18 Stefanik PA, Trulson MF. Determining the frequency of foods in large group studies. Am J Clin Nutr 1962; 11:335–43.
19 Balogh M, Medalie JH, Smith H, Groen JJ. The development of a dietary questionnaire for an ischaemic heart disease survey. Israel J Med Sci 1968; 4:195–203.
20 Balogh M, Kahn HA, Medalie JH. Random repeat 24-hour dietary recalls. Am J Clin Nutr 1971; 24:304–10.
21 Borrelli R, Cole TJ, Di Biase G, Contaldo F. Some stastical considerations on dietary assessment methods. Eur J Clin Nutr 1989; 43:453–63.
21 Marr JW. Individual dietary surveys: Purposes and methods. Wld Rev Nutr Diet 1971; 13:105–64.
22 Eck LH, Klesges RC, Hanson CL, Slawson D, Portis L, Lavasque ME. Measuring short-term dietary intake: development and testing of a 1-week food frequency

questionnaire. J Am Diet Assc 1991; 91:940–5.
23 Jenner DA, Neylon K, Croft S, Beilin LJ, Vandongen R. A comparison of methods of dietary assessment in Australian children aged 11–12 years. Eur J Clin Nutr 1989; 43:663–73.
24 Posner BM, Martin-Munley SS, Smigelski C, Cupples LA. Cobb JL, Schaefer E, Miller DR, D'Agostino RB. Comparison of techniques for estimating nutrient intake: the Framingham Study. Epidemiology 1992; 3:171–7.
25 Stein AD, Shea S, Basch CE, Contento IR, Zybert P. Consistency of the Willett semiquantitative food frequency questionannire and 24-hour dietary recalls in estimating nutrient intakes of pre-school children. Am J Epidemiol 1992; 135:667–77.
26 Suitor CJ, Gardner J, Willett WC. A comparison of food frequency and diet recall methods in studies of nutrient intake of low-income pregnant women. J Am Diet Assc. 1989; 89:1786–94.
27 Hebert JR, Miller DR. The inappropriateness of conventional use of correlation coefficient in assessing validity and reliability of dietary assessment methods. Eur J Epidemiol 1991; 7:339–43.
28 Bloemberg BP, Kromhout D, Obermann-De Boer GL, Van Kampen-Donker M. The reproducibility of dietary intake data assessed with the cross-check dietary history method. Am J Epidemiol 1989; 130:1047–56.
29 James WPT. Comments on the new equations. Human Nutr: Clin Nutr 1985; 39C (Suppl 1):92–6.
30 Alpers DH, Clouse RE, Stenson WF. Manual of nutritional therapeutics. Boston, Mass: Little Brown, 1983, pp 101.
31 Block G. Human dietary assessment: methods and issues. Preven Med 1989; 18:653–60.
32 Posner BM, Cobb JL, Belanger AJ, Cupples LA, D'Agostino RB, Stokes J 3d. Dietary lipid predictors of coronary heart disease in men. The Framingham Study. Arch Intern Med 1991; 151(6):1181–7.
33 McGee D, Reed D, Stemmerman G, Rhoads G, Yano K, Feinleib M. The relationship of dietary fat and cholesterol to mortality in 10 years: the Honolulu Heart Program. Int J Epidemiol 1985; 14(1):97–105.
34 Steyn K, Langenhoven ML, Joubert G, Chalton DO, Benade AJ, Rossouw JE. The relationship between dietary factors and serum cholesterol values in the coloured population of the Cape Peninsula. S Afr Med J 1990; 78(2):63–7.

A food frequency questionnaire for us in Chinese populations and its validation

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摘要

爲中式膳食習慣所設計的問卷：

個人膳食之評估沒有一定基準。其選擇原則通常以研究方案之目標爲準。爲要瞭解在澳洲墨爾本華人的膳食習慣與心血管病之關係，我們採用現存之膳食習慣問卷加以改善。這個問卷屬"類似量"的分析方法，其設計強調過去膳食習慣. 本問卷有 220 項食品和飲料，每一項目有一攝食量，作爲過去進食計量參考之用。本問卷採膳食習慣評估方法，因此無法有效地評估某些營養成分，尤其是添加物之類食品，如食鹽，醬油等所含之鈉質。和24小時尿液磷和氮質分析結果作比較，本問卷可準確地評估此兩項營養素。本問卷並可預測營養攝取值和血液膽固醇之關係。

因此，本問卷適合用於過去膳食計量之評估，尤其是住在澳洲墨爾本之華人。雖然，本問卷無法準確地評估營養素取自食品添加物，就華人膳食之瞭解而言，確有相當價值。