The Development and Validation of a Three Day Food Frequency Recall

by

Joyce Metka

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A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of

MASTER OF SCIENCE

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ABSTRACT

A link between diet and a variety of diseases has been established, however a causal relationship is difficult to prove. One of the challenges facing nutrition epidemiologists is the ability to accurately define what people eat. Several valid dietary assessment methods have been developed, yet most are expensive and time consuming. Food frequency questionnaires are less costly and can be completed in as little as fifteen minutes. Unfortunately, their use is limited to assessment of group intakes.

This research developed and attempted to validate a food frequency recall (FFR) which assesses diet 3 days in the past. The FFR food list had 101 items and subjects were required to respond according to 4 meal patterns: breakfast, lunch, supper and snacks. As well, a reference portion was provided for each food, and respondents indicated their usual portion size at each meal in relation to the reference portion, i.e., a multiple or fraction.

Eighty-two first year university students completed two FFRs one week apart. Both were compared to a 3-day record completed for the same 3 days as the second FFR (FFR2).

Pearson correlation coefficients for comparison of FFR1 with the record varied between 0.16 for alcohol and 0.61 for protein. For comparison of FFR2 with the record, a low of 0.66 was observed for % protein with a high value of 0.91 for % alcohol. The higher values found between the record and

FFR2 is partly due to no within-person variability being present, as both methods cover the same time period.

Similar group means were not consistently found between the two methods. The FFR appeared to underestimate intake. The FFR showed no bias at high or low intakes. FFR1 classified an average of 77% of respondents in the same or next quartile as the record. An average of 89% were classified in the same or next quartile by FFR2. Only two respondents had intake estimates greater than 4500 kilocalories per day with FFR1 while there were no 'outliers' with FFR2.

The FFR displayed similar and perhaps even better correlation coefficients than those found in the literature. However, it does not exhibit a high enough level of accuracy to assess individual quantitative intakes.

Where estimates differed between FFR2 and the record, it was respondents forgetting foods from FFR2 that contributed the most to that difference. This suggests that enabling people to better remember specific foods will lead to greater accuracy when estimating intakes with the FFR.

The FFR is useful for assessing short-term dietary intake or change. It is an appropriate dietary assessment method for classifying or ranking individuals according to nutrient intakes. This is important in epidemiological studies attempting to compare nutrient intake estimates to an established risk ratio. Further research is warranted to determine if the FFR could achieve greater accuracy if administered by an interviewer.

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Chapter I

INTRODUCTION

The contribution of dietary risk factors has become more important in the study of chronic disease. This health-related behavior has captured the interest of both the scientific community and lay public. While several large-scale prospective studies have demonstrated a link between diet and disease, a causal relationship is difficult to prove. Part of the problem is the ability to define accurately what people eat. Epidemiological and clinical studies alike make use of several types of dietary assessment methodologies, including diet histories, estimated or weighed food records, food frequency questionnaires and 24-hour recalls. The objectives of the proposed research often dictate which method will be used, however each is not without its liabilities. Aside from inherent methodological problems, time, cost and respondent burden are also factors to be considered. In particular, nutrition epidemiologists require an accurate, reproducible method that estimates usual nutrient intakes of non-institutionalized persons, yields a high response rate, and minimizes professional cost and time. This goal has

presented a challenge to researchers to produce such a tool. The food frequency questionnaire exhibits several of these qualities, yet is limited in its ability to assess individual nutrient intake precisely (Chu et al., 1984; Mullen et al., 1984; Russell-Briefel et al., 1985).

For example, Engle et al. (1990) evaluated the reproducibility and comparability of a computerized food frequency questionnaire with a 7-day food record. They found no significant differences in mean intakes between two administrations of the food frequency questionnaire, but differences in means between the record and food frequency questionnaire were significant. Bergman and colleagues (1990) compared a food frequency questionnaire with a 3-day diet record. They found the food frequency questionnaire to yield consistently higher estimates than the record, however, mean percentages of total energy from fat, protein and carbohydrate were not significantly different between the two methods. In 1985, Willett et al. evaluated the reproducibility and validity of a food frequency questionnaire compared with four 1-week diet records. All correlations were positive between the two methods, and the researchers determined it was an appropriate tool for assessing individual nutrient intakes.

As a contribution to investigations of dietary assessment instruments that assess intake with more accuracy than those already suggested, this thesis has the following objectives:

1. to assess whether a 3-day food frequency recall (FFR) can produce similar individual and group results as a 3-day food record with respect to energy, macronutrient and calcium intake
2. where estimations between the methods differ, to identify and classify the sources of these differences.

Chapter II

LITERATURE REVIEW

2.1 DIETARY ASSESSMENT METHODS

Since the 1930s, researchers have attempted to estimate individual diets. It was at this time that additional data were becoming available on the amounts of specific vitamins and minerals in food. Subsequently, interest in analyzing the diets of the public grew. Since then, a variety of dietary intake assessment methods have been developed, both prospective and retrospective.

It is virtually impossible to assess a free-living individual's exact food and/or nutrient intake. This would involve unobtrusive observation that could at very least be accomplished only in institutional settings. Duplicate meals are one other possibility yet the cost of such a study would severely limit their use to very small samples. Consequently, in free-living populations, researchers are restricted to the use of the following methods. Each has its advantages and limitations.

The diet history attempts to capture the long-term pattern of usual intake. A trained nutritionist interviews the respondent, a time-consuming and expensive procedure generally not suitable for large-scale studies. Subjects may have problems remembering their diet. Research suggests that attempts to remember diet in the distant past are influenced by present diet (Jensen et al., 1984).

The 24-hour recall is also interviewer-administered, but may be performed by persons without a nutrition background. Subjects are asked to recall their exact food intake during the previous twenty four hours, or the preceding day. While this method is appropriate for assessing intakes of large groups, it is not suitable for assessing usual diet of individuals due to the limited amount of time investigated (one day) (Beaton et al., 1979; Block, 1982). As individual dietary intake from day to day is highly variable, data provided may not be representative of usual diet for an individual.

Food records can be weighed or estimated. Respondents are asked to record their intake at time of consumption, and include recipes for mixed dishes. Portion sizes are estimated using household measures, or weighed with scales provided by the investigator. The number of days of intake recorded may vary, usually from three to seven. This method produces valid and accurate results for individual intake, but has a high degree of respondent burden and processing time.

Other methods have been proposed and used, including telephone interviews, duplicate meals, photographs and self-administered computer programs. To date, a widely used method for assessing group intake has been the food frequency questionnaire.

2.2 GROUP VS. INDIVIDUAL DATA

When designing a dietary assessment study, researchers must decide what type of information is needed; there are four types.

1. mean intake of a group
2. mean intake and distribution of consumption in a group
3. relative magnitude of the food consumption of an individual as belonging to a certain percentile of the distribution of intakes
4) absolute magnitude of the average consumption of an individual.

(adapted from Cameron and Van Staveren, 1988)

While there is no ideal method for assessing dietary intake, and each has systematic errors, four points must be considered before making a choice. First is the objective of the study, then accuracy of the methods, followed by the target group, and finally availability of resources (Cameron and Van Staveren, 1988).

2.3 FOOD FREQUENCY QUESTIONNAIRES

Food frequency questionnaires have traditionally been used to obtain qualitative, descriptive information about usual, long-term food consumption patterns, at a much lower cost than a diet history (Gibson, 1990a). A nutritionist is not necessary to interview the subject, and a food frequency questionnaire can be self-administered. The underlying principle is that average long-term consumption over weeks, months or years is the conceptually important exposure rather than intake over the short-term (Willett, 1990).

A food frequency questionnaire typically consists of a list of foods thought to be commonly eaten in the population being surveyed. Respondents are asked to indicate how frequently each of the foods are eaten, i.e., how many times per day, week, month, usually up to one year. Food frequency questionnaires are usually self-administered, but can also be interviewer-administered. They tend to pose less burden on respondents than other methods, as they can usually be completed within fifteen to thirty minutes. A detailed diet history interview is much more time consuming and can include a 24-hour recall, a 3-day record and a checklist of foods consumed over the preceding month (Willett, 1990). Food frequency questionnaires are restricted to a list of foods, but may have a section of open-ended questions where subjects can put additional information. This allows for inclusion of important nutrient sources that may be missed, but also increases processing cost and time.

Foods to be included in the list are usually determined by the nutrient(s) of interest to the investigator. If only a few nutrients are to be investigated, the food frequency questionnaire may be focused, including only those foods containing significant amounts of the target nutrients (Gibson, 1990a). If estimates of total nutrient intake are desired, a more extensive food list may be required. According to Willett (1990), for a food item to be informative it must have three characteristics: 1. food must be used often by the population in question; 2. food must contain a substantial amount of the target nutrients; and 3. in order to be discriminating, use of the food must vary from person to person.

To compile the food frequency questionnaire food list for describing dietary intake, several approaches can be taken. Food composition tables can be examined for foods contributing the largest amounts of the target nutrients. The only advantages this approach offers are it is rapid and simple. It can, however, lead to inclusion of nutrient-dense foods that are not commonly eaten in the population being investigated. Another option would be to start with a long list of potentially nutrient-dense foods derived from composition tables, other food frequency questionnaires, and nutritionists who have worked with the population to be surveyed. The list, in either case, is then systematically reduced by pilot testing the questionnaire. Some authors have

attempted to use prediction equations to determine the most nutrient dense food items for a given population, in an effort to refine the food list. This approach, however, had only limited success (Hankin et al., 1970).

A true food frequency questionnaire does not require information on portion sizes; it only estimates frequency of consumption. Such qualitative data are useful for hypothesis-generating in the investigation of possible associations between diet and disease. It also allows classification of the usual intake of individuals into categories (Block, 1982).

The semi-quantitative food frequency questionnaire specifies a portion size on the food list and requires the respondent to estimate their usual consumption by indicating how often the specified portion size is consumed. For example, asking how often one bowl of cereal is consumed rather than only how often cereal is consumed.

A quantitative approach asks respondents to describe their usual portion size in addition to frequency, rather than indicating frequency of a pre-specified portion size. This allows the estimation of absolute levels of nutrient intake for public health and clinical purposes, as well as for the refinement of etiologic hypotheses (Block et al., 1986). Subjects could be asked to indicate if their portion is a small, medium or large serving. Another option would be to provide a typical serving size and have subjects indicate their size as a multiple of this. Food models or pictures may

be used as a reference, and respondents choose the one that corresponds to them.

In order to provide useful information, however, respondents must be able to indicate their portion sizes with reasonable accuracy. Unfortunately, it has been determined that most people are unable to do this (Guthrie, 1984). Some guidance or training is effective in improving their estimations (Bolland et al., 1988).

2.4 FOOD AND NUTRIENT COMPOSITION TABLES

Whatever method is used to collect food consumption data, this information must be transposed into nutrients. Next to accurate estimation of what is actually consumed, knowledge of the nutrient composition of the foods is the most important component of any dietary assessment study (Cameron and Van Staveren, 1988). Ideally, investigators would perform chemical analyses of aliquots of the foods consumed by study participants. This process is, however, exceedingly costly and time-consuming, and few researchers have access to the facilities required to achieve this type of evaluation.

The majority of studies rely on food composition tables to transpose consumption data into energy and nutrients. Tables are available for most major areas of the world, and variability does exist between these tables. This is due to differences in varieties of produce, differences in manufacturing and production methods, geographical

differences, differences in fortification procedures and differences in analyses methods. It therefore is logical to use a composition table or tables that have been developed in the country or geographical region where the study is to take place. In Canada, the Canadian Nutrient File (Health and Welfare Canada, 1988) is updated every few years. This composition table combines information from several sources: Department of Agriculture (USDA) Nutrient Data Base for Standard Reference, Release 6, 1987; USDA Handbook No. 456, 1982; and the Nutrition Canada Survey data base, 1972.

2.5 SOURCES OF ERROR IN DIETARY ASSESSMENT METHODOLOGIES

As mentioned, it is practically impossible to assess an individual's "true" dietary intake. Consequently, investigators must rely on the methods previously mentioned, every one with its advantages and limitations. Because participation by respondents is an integral part of each of these, as well as input by interviewers and/or researchers, all the methods have some degree of error.

There are two basic types of error that can arise in dietary assessment: systematic and random. Systematic error occurs when a measurement produces on average, an over- or under-estimation of what the method is intended to measure, resulting in a bias in the estimation (Cameron and Van Staveren, 1988). It can be minimized by properly training or

excluding the use of interviewers and coders, standardizing and pre-testing questionnaires, and running a pilot study to ensure useability of questionnaires (Gibson, 1990a). Random error occurs whether there is systematic error or not. Here, assessment of intake on any given day may differ from actual intake for various reasons, such as errors in estimation of amount consumed, foods omitted, or coding errors (Cameron and Van Staveren, 1988). These types of error may affect the precision of the estimated mean intake, but can be minimized by increasing the number of observations (Gibson, 1990b).

Both random and systematic errors can occur within a person or between persons. Within-person variation occurs due to day-to-day fluctuations in dietary intake. This is inevitable, and the more varied a person's usual diet, the greater will be his/her within-person variability. Between-person variation is the result of people eating differently from one another.

No attempts should be made to eliminate within- and between-person variability because they characterize true usual intake. The dietary assessment method should instead, be designed such that these two sources of variability can be separated and estimated systematically (Gibson, 1987).

One day of intake is insufficient for estimating individual intakes (Beaton et al., 1979; Gibson, 1990b). Within-person variability is high, especially in North America where an extremely varied diet is consumed. Consequently,

intake for any one subject will vary considerably from day to day. This period of time is also not acceptable to most epidemiologic studies that require an assessment of long-term food consumption (Willett, 1990), for the same reasons. As indicated, dietary intake is extremely variable from day to day, resulting in high within-person variation. The number of measurement days depends on the day-to-day variation of the nutrients of interest (Gibson, 1990a). It is generally agreed that a minimum of three days is required to achieve a representative estimate for macronutrients and energy (Marr and Heady, 1986; Basiotis et al., 1987). If all days cannot be assessed consecutively, repeated administrations of the questionnaire are an alternative. This would capture day-of-week variation as well as seasonal effects.

Systematic errors can introduce significant bias into nutrient intake results, which cannot be removed by subsequent statistical analysis. Consequently, efforts should be made to eliminate this type of error. There will always be error arising from incorrect or incomplete composition tables, coding errors and subjective code selection; consequently, random error can never be completely eliminated, but should be reduced as much as possible.

2.5.1 MEMORY BIAS

Retrospective assessment of dietary intake requires subjects to recall past diet, usually as part of a diet

history, recall or food frequency questionnaire. This may be the previous twenty four hours, the previous twelve months or even years in the past.

One advantage to recall types of assessment is that they tend to place minimal burden on respondents. Whether interviewer- or self-administered, they are not excessively time-consuming; they can be completed in up to one hour, or as little as ten minutes. Subjects do not have to use weighing equipment or record foods immediately after they are eaten.

One potential problem associated with this method is that subjects must rely on their memories to estimate their intakes. This may not be suitable to all types of respondents. Cavanaugh et al. (1983) demonstrated that memory capacity decreases with age, and that younger adults experience fewer memory failures. Consequently this approach may have limited effectiveness when applied to elderly subjects.

Another problem, especially with food frequency questionnaires, is the level of abstract thought required by respondents. Traditional, semi-quantitative food frequency questionnaires that ask respondents to estimate portions eaten over a time span of up to one year require mental integration of frequencies of consumption with the specified portion size. This is a complex task, even if the portion specified is close to their personal norm (Hunter et al., 1988).

A variety of other factors affect individuals' abilities to recall diet. Individual food consumption patterns are one important determinant. Foods consumed as the main portion of a meal are better remembered than foods added as condiments (Guthrie, 1984). Foods eaten at least once a week or habitually are recalled with better accuracy than those consumed less often or without a pattern (Hankin et al., 1975; Jain et al., 1980). This can be partially explained by the fact that repetition strengthens memory (Wickelgren, 1981). External cues also prompt memories such as where and when foods were eaten. Associative clustering has also been demonstrated to enhance memory (Jenkins and Russell, 1952; Jenkins et al., 1958). Increasing the associative strength is an important factor in word clustering during recall. Having respondents recall from a list of foods clustered according to a particular meal pattern would facilitate better remembering of what was actually consumed, for example, recalling what was eaten at breakfast from a list of breakfast-type foods.

Mood at both time of learning and time of recall influences accuracy of recall. Elevated mood is associated with increased recall of positive events and decreased recall of negative events. The opposite was observed for depressed mood (Natale and Hantas, 1982). Consequently, if consumption of food was considered a positive or negative experience, or if the respondent is in a depressed mood at time of recall, memory may be affected.

Salience of the information to be retrieved will affect the likelihood of it being retained over time. For most disease-free individuals, diet is insignificant material that is likely to be forgotten as time goes by. This has been demonstrated with recalls of past diet, which tend to be influenced by current diet (Jensen et al., 1984).

2.5.2 RESPONDENT BIAS

Any scientific research is subject to volunteer bias which asserts that those who selectively participate in a study are different somehow from those who refuse to participate (Kramer, 1988).

More specific to dietary assessment studies, respondents may be inclined to over-report "socially-desirable" foods and under-report foods perceived as "bad" or "snack" or "fast" foods, including alcohol (Gibson, 1990a). This may be exaggerated by interviewer-administration of questionnaires, where interviewers may give non-verbal cues as to the correct answer, or respondents simply perceive that a particular answer is expected of them.

2.5.3 CODING

When transcribing food consumed according to a dietary assessment form, a researcher is trying to reflect nutrient composition listed on that form with the nutrient composition of foods listed in a code book, and the subsequent composition

table. Coding errors can arise in several areas. Reading or transcription errors can occur during food code selection, transcription of code or amount eaten; improper conversion of weight and/or volume; foods or parts of meals forgotten by coder; or data entered twice can all occur (Cameron and Van Staveren, 1988). In addition to this, subjective choice of codes by coders may cause problems e.g. ground beef coded as lean instead of regular. Intra-coder variation is another potential problem. Two different coders may select different food codes for the same food listed on a form. This can be eliminated by having one person do all coding. There may also be errors in the nutrient database, which are usually beyond the control of the researcher.

By using a food frequency questionnaire with a pre-set list of foods, to which no others can be added, most of these errors can be avoided. Data processing will require less time, and will also be less costly, as no coders need hiring.

2.5.4 PORTION SIZE ESTIMATION

Errors occur when respondents are unable to accurately quantify portion sizes. Several studies indicate that this occurs very frequently. Guthrie (1984) indicated that few young adults were able to describe portions within 25% of actual amount, without the aid of measuring devices. Bolland et al. (1988) demonstrated that even brief training significantly improved the ability to estimate portions

accurately. With a sample of 61 college students, Wein and Sabry (1990) found that 30 of 39 foods were observed within 20% of actual portion size using a 24-hour recall. Over-estimation was more frequent than under-estimation and amorphous foods were most difficult to describe.

In an effort to maximize the ability of a food frequency questionnaire to estimate quantitative data, it has been suggested that information be obtained on individuals' typical serving sizes (Hunter et al., 1988; Clapp et al., 1991). Systematic bias can occur when a standard portion size is provided, and this would be less likely were participants able to provide their own portion sizes.

Samet et al. (1984) attempted to assess preformed vitamin A and beta-carotene intake using a frequency questionnaire with and without portions. They discovered frequency alone was sufficient for large-scale studies where the purpose is to establish subjects' relative intake of specific nutrients, however, combination with amounts markedly improved the accuracy of intake estimates.

Clapp et al. (1991) found significant differences in mean intakes calculated from reported portion size data and those calculated from standard portion sizes already listed on the questionnaire, for all nutrients. Nutrient values obtained using standard sizes were consistently lower. If researchers were comparing nutrient intake data from one population using standard portions with another using reported portions, they

may erroneously conclude the second population has a higher intake. This can have serious implications when attempting to establish a dose-response relationship between a disease and intake of a specific nutrient. Another source of error may arise when respondents are asked to indicate their portion as small, medium or large. Their perception may differ greatly from each other and the investigators, i.e. a 30-year old male may view one cup of potatoes as a small portion, while a 60-year old female views the same amount as a large portion.

Some researchers have suggested that the concept of "usual" portion size is difficult for some people. Hunter et al. (1988) analyzed variability of portion sizes for 68 foods. For each food, between-person and within-person variance was determined for the population. For the vast majority of the items, the within-person variance exceeded the between-person variance. This suggests respondents may experience substantial difficulty in specifying their "usual" portion size. This is likely due to portion sizes of the same food differing at different meals.

Researchers may be able to further divide within-person variation if respondents were able to indicate different portions at different meals. It would also be easier for respondents to conceptualize their usual serving sizes at each meal rather than overall.

2.5.5 FLAT SLOPE SYNDROME

Several dietary assessment methods have been observed to produce a "flat slope." This is where respondents exhibit the tendency to under-estimate high intakes and over-estimate low intakes. This leads to a "flat slope" (see Figure 2.5.1) and occurs when dietary information collected by a simplified instrument, such as a food frequency questionnaire, is compared with information collected by more detailed methods, such as a weighed food record (Bingham, 1983 in Boeing et al., 1989). This phenomenon is sometimes referred to as "talking a good diet," and results in a downward bias in the number of subjects with extremely low and extremely high intakes (Gibson, 1990a). Both food frequency instruments and 24-hour recalls exhibit this phenomenon (Boeing et al., 1989).

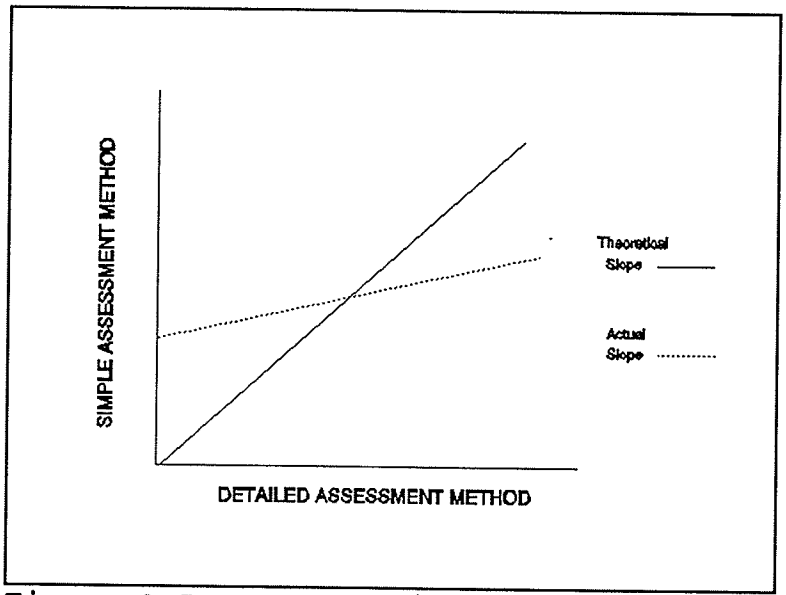


Figure 2.5.1. Comparison of intake estimated by a detailed method vs. simple intake method.

2.6 WEIGHED VS. UNWEIGHED INTAKE ESTIMATES

Where precision requires that portion size be estimated, another decision researchers using prospective dietary assessment must make is whether to have subjects weigh food or not. While weighed records are more accurate, they place considerably more burden on subjects who must weigh food before eating, and any leftovers after the meal. Use of this method is restricted to highly literate and motivated participants. There exists the possibility that subjects may alter usual eating habits to either impress the investigator or simplify the weighing or measuring process (Gibson, 1990a). Finally, subjects may use the weighing equipment incorrectly, resulting in recording errors.

Estimated records require respondents to describe foods eaten as accurately as possible, in household measures or inches, immediately after they are eaten. While this method is less accurate than weighing, it allows rapid and low-cost assessments for large numbers of subjects, because weighing equipment is not required (Cameron and Van Staveren, 1988). Co-operation will likely be higher with this method because the recording technique is less cumbersome.

2.7 DEVELOPMENT OF DIETARY ASSESSMENT INSTRUMENTS

Whether opting for a particular dietary assessment method for use in research, developing a new method, or altering an existing one, the performance of that method must at some

point be evaluated. This is becoming even more important as the use of traditional dietary assessment methods make way for those more economical and less time-consuming, such as food frequency instruments. Based on the objectives of a study, a method's performance is evaluated by measuring its validity and reliability.

2.7.1 VALIDITY

Validity is defined as the ability of an instrument to measure what it is intended to measure. It is also referred to as accuracy. Most dietary assessment tools are intended to measure usual intake over a specified period of time (Block and Hartman, 1989). Assessment of the validity of a new dietary intake instrument is achieved by comparing it to the performance of another method. In dietary assessment there is no 'gold standard' to compare with a new method; that is, there is no tool that is 100% accurate for measuring what a person eats. Such a method would require twenty-four hour surveillance of subjects for the entire length of the assessment period, an impossible feat with free-living populations. Consequently, only the relative validity of a new method can be assessed (Block, 1982; Cameron and Van Staveren, 1988). The reference method is generally an accepted measure of intake that is judged to be superior, or has a greater degree of demonstrated validity. This lack of a perfect standard is not restricted to dietary assessment.

All measures have error, though they may differ in magnitude (Kramer, 1988; Willett, 1990).

When designing a validation study, there are several points to consider. First, it is essential to administer both the reference method and the test method to the same group of subjects (Cameron and Van Staveren, 1988). This allows for assessment of within-person variability that could not be achieved with different samples. Both methods should measure the same time period and their errors should be independent. For example, using a retrospective measure for both the reference and test methods (e.g. a diet history and a food frequency questionnaire) will result in the same major sources of error: memory, interpretation of questions and estimation of portions (Willett, 1990). This approach is not entirely without problems. If comparing a standard prospective method (diet record) with a test retrospective method (food frequency questionnaire), assessment of the same time period may result in bias. Correlations may be spuriously high because at the time subjects are asked to recall their diet, they will have just completed recording all intake for the specified time. Such action would facilitate better remembering of what was eaten, giving the tool a heightened level of validity.

This problem can be avoided by having respondents complete the questionnaires for the same day(s) of the week, in successive weeks. This ensures the same season is covered. Also, as it is commonly assumed that group results are similar

on the same days of the week, any individual differences (within-person variability) will cancel out, resulting in a fair comparison between the two methods (Cameron and Van Staveren, 1988). To realize this effect, however, a rather large sample is required. Comparing a retrospective method with a prospective method will result in the least correlated errors (Suitor et al., 1989). The diet record contains errors associated primarily with the interpretation of foods by a coder, and some with interpretation of portion size if the record is estimated. Food frequency questionnaires possess errors related to memory, restrictions imposed by a fixed food list, perception of portion size, and interpretation of questions (Willett, 1990). Errors arising from composition tables, however, will remain for both methods. Administration of the retrospective questionnaire first eliminates any memory effect that may be observed if the record were completed first.

One other procedure that can be used to validate a dietary intake method is comparison of results to biochemical parameters. This is realistic only for small samples in controlled settings. Serum levels may be affected by homeostatic mechanisms, health status, or other factors such as smoking (Block and Hartman, 1989).

Validation studies are abundant in the literature. Attempts to improve the accuracy of food frequency questionnaires have been undertaken by several researchers.

Early validity studies were designed to determine the ability of food frequency questionnaires to assess group intakes and distinguish between groups (Trulson and McCann, 1959). However, sample sizes were usually small, limiting representativeness of results.

2.7.2 RELIABILITY

Reliability is also known as precision or reproducibility. It refers to the variability of a measurement on the same subject when used repeatedly under similar conditions (Gibson, 1990a). One important note is that a reliability study is not the same as a validity study; it tells nothing about whether the instrument is producing the correct answer, only whether it produces the same estimate on two separate occasions (Block and Hartman, 1989). A test of reliability can provide a useful first approximation of questionnaire performance (Willett, 1990). It can flag problems in instrument design, respondent instructions or quality control. These indicators will help the investigator in improving the functionality of the questionnaire (Block and Hartman, 1989). Inadequate instructions, resulting in incorrect answers or misplaced answers, can produce incorrect nutrient estimates, resulting in poor reproducibility. Coding and keying errors are also potential problems.

As with validation studies, it is impossible to have identical situations in which questionnaires are administered.

This would require asking a subject to recall and record his/her intake on the same day (Cameron and Van Staveren, 1988). Making the situations as close as possible is sufficient, e.g. having subjects complete the questionnaire on or for the same weekday(s), with a suitable time lapse between. In this test/retest situation, care must be taken in order that the second measurement is not influenced by the first one, as a result of recollection of the first recall. Using this design, the method is considered reliable if the nutrient intakes on both administrations of the method are similar (Gibson, 1990a). Some error will always remain, and part of the difficulty with reliability studies is defining this error. It is impossible to distinguish unequivocally whether what is being measured remains unchanged (i.e., there will always be within-person variability because people eat differently, even on the same day of the week). Consequently, it is impossible to know whether dissimilar results on two different occasions reflect an unreliable measure, or a reliable measure which is measuring a truly changed condition (Block, 1982). The more time that has elapsed between the two tests, the more dietary change has likely occurred. In order to minimize this effect, the second questionnaire should be administered within a fairly short time, but long enough so there will not be a training effect, whereby the subject is simply remembering what he/she ate (Block and Hartman, 1989).

It has been observed that lack of standard portion sizes can result in less systematic bias (Clapp, 1991). A questionnaire that does not include variable portion sizes is less variable, and will likely be more reliable than a questionnaire which permits flexible portions. While this high level of reliability may seem desirable, it is not sufficient. A high validity score is also required (Block and Hartman, 1989).

2.8 VALIDATION AND RELIABILITY STUDIES

In more recent years, attempts have been made to improve the accuracy of food frequency questionnaires. Several researchers have performed validation studies on qualitative food frequency questionnaires, having respondents indicate only frequencies with which foods were consumed.

In an attempt to find a brief method for estimating vitamin A and C intakes, Gray et al. (1984) used a self-administered food frequency questionnaire containing 56 foods and compared it to a modified diet history that included a 24-hour recall and a food frequency questionnaire. Spearman correlations between the two methods were 0.03 for vitamin A (not significant) and 0.29 for vitamin C ($p<0.05$). For vitamin A and C respectively, 24% and 40% were in the same tertile while 22% and 14% were grossly misclassified. The authors concluded that the food frequency questionnaire was suitable for estimating group intakes, but less so for individual intakes, especially for vitamin A.

Mullen et al. (1984) attempted to validate a food frequency questionnaire for assessing individual food intake. Thirty-one college students living in a dormitory completed check lists of foods chosen at every meal for 28 consecutive days. These data were compared to a food frequency questionnaire containing 278 foods administered prior to the 28-day validation period. Individual regression equations based on foods chosen yielded Pearson correlation coefficients ranged from 0.23 to 0.91, with 85% of values greater than 0.50 and 55% greater than 0.71. Results indicated that while some individuals were successful at estimating their intake, others were not. Also, while these were all highly significant, the tool did not produce the same level of accuracy for all food categories. No data were presented on correlation coefficients for nutrients.

Russell-Briefel et al. (1985) compared three methods of assessing vitamin A intake: 24-hour recall, 3-day record and one-year food frequency questionnaire containing 40 foods which were major sources of carotenoid and vitamin A in the American diet. Results indicated the food frequency questionnaire provided the highest mean intake and the 3-day record the lowest. Mean estimates of vitamin A from the record were significantly lower than both the food frequency questionnaire and the recall. Correlation coefficients were significant between the 3-day record and the 24-hour recall ($r=0.28$). Tests for agreement of classification into

quartiles indicated the food frequency questionnaire and record resulted in 38% of subjects being categorized into the same quartile, and only 7% grossly misclassified. For the food frequency questionnaire and recall, results were 66% and 13%, respectively. It was concluded that although these methods may estimate adequate group intakes of vitamin A, the individual results were less than desirable. As well, the authors concluded that the considerable within-person variability between methods suggested the intake of vitamin A estimated by one method does not predict intake estimated by another.

Pietinen et al. (1988) performed a reliability and validity study on a food frequency questionnaire designed to measure select nutrients. The food frequency questionnaire contained 44 food items and was compared to food records kept for 12 two-day periods, distributed over six months. Correlations ranged from 0.33 to 0.68. On average, 72% of subjects fell in the same or within-one quintile category when classified by the two methods. Correlations for reproducibility between pairwise measurements of the nutrients ranged from 0.48 to 0.86. These results indicate that the food frequency questionnaire was acceptable for assessing most nutrients, however some were more accurate and precise than others.

In a study designed to compare a food frequency questionnaire and a diet recall method, Suitor et al. (1989)

administered three 24-hour recalls and a food frequency questionnaire to 95 low-income pregnant women. Correlation coefficients for the recalls and the food frequency questionnaire were low, ranging from 0.00 to 0.46 for absolute nutrient value. These improved when respondents with more than 4500 kilocalories per day were excluded from the sample, and when calorie-adjusted values were used. Reliability measures were high, with correlations ranging from 0.59 to 0.94. The fact that some subjects had unrealistically high caloric intakes suggests problems with the questionnaire format, and the authors concluded that further testing is required.

Bergman et al. (1990) compared a food frequency questionnaire with a diet record. 47 women completed the 141 item questionnaire and a 3-day diet record. The food frequency questionnaire resulted in consistently higher estimates than the record. Of the 17 nutritional variables compared between the two methods, only 7 did not differ significantly. No categorization or correlation analyses were provided.

Other researchers have concentrated on validating semi-quantitative and quantitative food frequency questionnaires. Musgrave et al. (1989) assessed the validity of a food frequency questionnaire for assessing dietary calcium intake. These results were compared to 4-day diet records. As calcium was the only nutrient of interest, this focused food frequency

questionnaire contained only 53 items. Correlations for the two methods were observed in two seasons. Results were r=0.73 in winter and r=0.82 in summer indicating a high level of accuracy. Correlation for reproducibility of the two administrations of the food frequency questionnaire was 0.86, demonstrating no seasonal difference. Angus et al. (1989) achieved similar results with another food frequency questionnaire designed to measure calcium intake.

In 1975, Hankin et al. conducted a validity study comparing a 7-day diet record of the frequencies and amounts of 33 food items with a subsequent recall of the same items. Correlations between the two methods ranged from 0.44 to 0.88, with higher correlations (>0.70) being observed for foods eaten habitually. No data were presented for nutrient correlations. However, these results suggest that for studies involving the role of particular food items with respect to subsequent disease, this type of method is worth considering.

Another group examining variation in food consumption compared a self-administered, 55-item food frequency questionnaire with four 7-day food records collected over one year (Salvini et al., 1989). Correlations for food choices ranged from 0.09 to 0.83, with 73% of foods having a coefficient greater than or equal to 0.50.

Jain et al. (1982) evaluated a self-administered questionnaire for use in a cohort study, which asked respondents about both frequency and amount consumed for 69

food items. This was validated against a detailed diet history. Correlation coefficients were all positive and statistically significant ($p<0.05$), ranging from 0.47 to 0.72. Computed means of 3 of the 12 measured variables were significantly different. These results support the use of self-administered questionnaires for studies involving large samples.

In one of the most frequently cited studies of validity, Willett et al. (1985) assessed the performance of a semi-quantitative food frequency questionnaire. It was compared to four 1-week diet records collected over one year. After adjusting for total caloric intake, correlation coefficients ranged from 0.36 to 0.75. When classified into quintiles, 48% and 49% of subjects were in the lowest and highest categories respectively. Only 3% were grossly misclassified. The authors concluded that this tool can measure individual intakes for a variety of nutrients.

Larkin et al. (1989) compared 16 days of recalls and records collected over 1 year with a 116-item food frequency questionnaire. The food frequency questionnaire showed consistently higher mean nutrient intakes. Correlations ranged from 0.09 to 0.62; not all were significantly different from zero. This study was unique in that it subdivided subjects into sex and race groups, enabling them to delineate which subgroup had the greatest tendency to over- or under-report. This indicates that not all assessments will rank participants similarly.

A few researchers have attempted to use modified food frequency questionnaires for assessment of individual diets in short-term recall situations. Krall and Dwyer (1987) compared a 3-day record with a semi-quantitative 1-week food frequency questionnaire, two weeks in a row. Both food frequency and record data were compared to actual intake. Subjects were enroled in a controlled nutrition study, where all meals were consumed at a common facility. Nutrient intakes estimated by the food frequency questionnaire were underestimated 9% to 24% as compared to actual intake, primarily due to foods omitted. The correct frequency of consumption was reported on only 51% of the questionnaires. Foods eaten at least once a day were recalled with greatest accuracy, while foods eaten less frequently were recalled least. No correlation coefficients were provided for the two methods, and individuals may have experienced difficulty remembering foods consumed, as they were not their own freely chosen diet. Sample size was also quite small (n=19).

Eck et al. (1991) modified Willett's (1985) semi-quantitative food frequency questionnaire to assess nutrient intake for a 7-day period as opposed to one year. This was compared to three 24-hour recalls collected throughout one week. Pearson correlation coefficients for the mean of the 3 recalls and the food frequency questionnaire ranged from 0.42 to 0.88 with a mean of 0.74. For nutrients analyzed, percentage of subjects who remained in the same quartile for

mean of recalls and food frequency questionnaire ranged from 32% to 54%. Those moving to the extreme quartile ranged from 0% to 7%. In order to assess reliability, the food frequency questionnaire was administered to one group one week apart and to a second group three hours apart. Correlations for the one week group ranged from 0.25 to 0.75; for the three-hour group the interval was 0.81 to 0.96. This improvement is not surprising, given the brief time period and the fact that the questionnaire was administered in the same place for the three-hour group. The authors concluded that their data do, however, support use of this tool for assessing short-term dietary change or intake.

This review of literature points to some notable trends in validity and reliability research. Higher values are observed when food choices are correlated between methods, rather than nutrients (Hankin et al., 1970; Mullen et al., 1984; Salvini et al., 1989). This is seen partly because similar foods, which could correlate with each other, may have widely differing nutrient contents, e.g. certain fruits and vegetables, particular cuts of meat. Work by Byers et al. (1985) supports this assertion, as they found that a large portion of the variability in nutrient intake in a population could be explained by a small number of foods.

Validation studies examining only short-term recall situations (Eck et al., 1991) experienced higher overall correlations than those assessing over longer periods.

Due to the wide variations seen in correlations, it is evident that not all nutrients or nutrition variables being measured can be estimated with the same degree of accuracy. Distinct trends in the literature can be seen. Vitamin A experienced the lowest correlations (0.0 to 0.38) in all but one study. Minerals also had low values (iron and zinc, r=0.22; selenium, r=0.33) or mean intakes were significantly different between the two methods (phosphorus, iron, potassium, and magnesium) as found by Bergman (1990). Vitamin C was correlated intermediately, ranging from 0.29 to 0.64. Energy ranged from 0.23 to 0.43, while macronutrients were generally found to have intermediate to high coefficients (fat, 0.27 to 0.58; carbohydrate, 0.46 to 0.57; protein, 0.36 to 0.60). Adjusting for total caloric intake tended to improve these values somewhat. The nutrient that appeared to have the highest correlations was calcium, with r values ranging from 0.46 to 0.88. This is possibly due to calcium being found in relatively few foods (i.e., dairy products) which are consumed with high frequency in several segments of the population. Work by Salvini et al. (1989) supports this, suggesting that higher correlations are observed for foods consumed frequently by a substantial portion of the population.

2.9 SUMMARY

The objective of much of the recent research in dietary assessment has focused on the development of a tool that provides an accurate and precise estimate of individual diet, minimizes respondent burden, and decreases professional cost and time. Attempts to develop a new, or modify an existing assessment tool, involve validation and reliability studies. Validity is the extent to which a tool measures what it is intended to measure, while reliability indicates whether a tool will provide the same results on repeated occasions.

Food frequency questionnaires possess several of the features desired by nutrition epidemiologists. Unfortunately, their level of accuracy and precision leave much to be desired and in the past their usefulness has been limited to qualitative group data.

There are two classes of error associated with intake methodologies: systematic and random. Systematic errors can introduce significant bias into results, which cannot be minimized by increasing sample size. Random error affects reliability and can be decreased by increasing the number of observations (Gibson, 1990a). The most common types of error include those associated with respondent, interviewer, memory, ability to judge portion sizes, coding errors, and over- and under-estimation of low and high intakes. By identifying sources of error in validity and reliability studies, one can target these areas to improve the ability of these tools to

provide quantitative data on individual diets. As well, it has been noted that food frequency instruments which require subjects to estimate intakes for the past year result in 'outliers', i.e. subjects whose intakes exceed 4500 kilocalories per day. This is partly due to respondents having difficulty conceptualizing both frequency of consumption and portion size over such a long period of time. A shorter time period with a food frequency format allowing flexible portion sizes would require less abstract thought, and presumably lead to more accurate and precise results.

Chapter III

RESEARCH OBJECTIVES AND HYPOTHESES

The purpose of this research was two-fold. The first objective was to assess whether a self-administered 3-day food frequency recall, which incorporates three unique features in its design, can produce similar group and individual results as a 3-day food record with respect to energy, macronutrient and calcium intake. The three unique features are 1. the short time period covered - 3 days as opposed to 1 year, as with most food frequency instruments; 2. the prompts for meal patterns i.e. recall format is split into 4 commonly understood meals: breakfast, lunch, supper, snacks; and 3. variable portion sizes i.e. subjects are allowed to express their usual portion size for each meal as a multiple of a given reference portion. The second objective involved identifying and classifying the sources of difference between the two methods, where estimations differed.

The study hypotheses were as follows:

The estimation of calcium, macronutrients and energy from a 3-day food frequency questionnaire, with respondent guidance will show:

1. Similar group means for nutrient intakes as the 3-day record.
2. Similar variability of nutrient intake estimates as those from the 3-day record.
3. Respondents categorised in high and low nutrient intake groups the same way as estimates from the 3-day record.
4. No bias at high or low intakes compared to the estimates from the 3-day record.
5. Greater involvement in meal preparation increases ability to recall foods eaten and estimate portion sizes with greater accuracy.
6. Where estimates from the two methods differ, these errors can be attributed to:
    i. Respondents being unable to judge portion sizes adequately.
    ii. Respondents being unable to estimate the correct number of times a food was eaten.
    iii. Respondents forgetting foods eaten, or adding foods not eaten, during the three day assessment period.
    iv. Discrepancies between data processing by the food frequency recall program and the food record program.
    v. Foods eaten that do not appear on the food frequency recall food list.

7. Repeated administration of the FFR will show similar variability between sets of results.

Appropriate analyses to estimate the relative importance of these sources of error will be carried out.

To test these hypotheses, the following variables will be used:

Hypothesis 1: a) mean differences in intake estimates between the 3-day record and FFR1 and the 3-day record and FFR2, for energy, macronutrients, and calcium

b) mean intake estimates of energy, macronutrients and calcium assessed by the 3-day record, FFR1 and FFR2.

Hypothesis 2: a) mean intake estimates and standard deviations of energy, macronutrients and calcium

b) individual intake estimates of energy, macronutrients and calcium.

Hypothesis 3: a) individual intake estimates of energy, macronutrients and calcium ranked from lowest to highest value.

Hypothesis 4: a) individual intake estimates for kilocalories as estimated by the 3-day record, FFR1 and FFR2

b) residual plots for the 3-day record vs. FFR1 and the 3-day record vs. FFR2, with

kilocalories (3-day record) as the dependent variable, and kilocalories (FFR1 and FFR2) as the independent variables.

Hypothesis 5: a) dependent variable is the individual differences between the 3-day record and FFR2 for kilocalories while independent variable is the individual number of meals prepared in a month as reported by the subjects.

Hypothesis 6: a) dependent variables are: the individual differences between the 3-day record and FFR2 for kilocalories, macronutrients and calcium; independent variables are: the individual differences between the 3-day record and FFR2 for energy, the individual differences between FFR2 and FFR2 adjusted for a) portion sizes b) frequency c) foods added/forgotten, for energy, macronutrients and calcium.

Hypothesis 7: a) individual intake estimates of energy, macronutrients and calcium.

Hypotheses and indicators are summarized in Table 3.1.

Table 3.1

Hypothesis Number	Statement of Hypothesis	Variables Measured	Statistical Tests
	3-day FFR compared to 3-day record will:		
One	lead to similar group means for nutrient intakes	a) mean difference in intake estimates between record and FFR1/FFR2 b) mean intake estimates from record, FFR1, FFR2	a) paired t-test b) percent differences between group mean intake estimates
Two	show similar variability of nutrient intakes	a) mean intake estimates and standard deviations from record, FFR1, FFR2 b) individual intake estimates from record, FFR1, FFR2	a) Pearson correlation coefficients b) standard deviations from mean intake estimates
Three	categorise respondents similarly in high and low nutrient intake groups	individual intake estimates ranked lowest to highest by record, FFR1, FFR2	ranked individual intakes divided into quartiles
Four	show no bias at high or low intakes	a) individual energy estimates from record, FFR1, FFR2	a) residual plots b) sensitivity/specificity
Five	show that involvement in meal preparation increases ability to recall diet	dependent variable = record-FFR2 kilocalories independent variable = number of meals prepared per month	regression
Six	Where estimates differ, errors are due to respondents: a) being unable to judge portion sizes b) being unable to estimate frequency c) forgetting/adding foods	dependent variable = record-FFR2 intake estimates independent variables = FFR2-FFR2 (adjusted for portions/frequency/foods)	multiple regression
Seven	FFR repeated twice will show similar	individual intake estimates	Pearson correlation coefficients

Chapter IV

METHODOLOGY

4.1 EXPLANATION OF 3-DAY FOOD FREQUENCY RECALL

The 3-day food frequency recall (FFR) incorporates the principles of two existing dietary assessment methodologies: the diet recall and the food frequency questionnaire. It acts as a recall in that it asks subjects to remember everything eaten and drunk for a specified period of time in the immediate past - three days. It differs from a recall because it is not open-ended; subjects must respond to a pre-set list of foods. It is this predefined food list that makes this tool similar to a food frequency questionnaire. In addition, subjects must indicate their frequency of consumption of the foods, over the past three days. Where the tool differs from a traditional food frequency questionnaire is first, the length of time covered is much shorter (three days as opposed to one year), and second, subjects are asked to indicate their usual portion size for each food, at each meal eaten.

The FFR incorporates two features that differ from both these methods. Respondents are asked to recall foods eaten

for each of four different meals - breakfast, lunch, supper and snack. As well, they must indicate how much was consumed at each meal by expressing their serving size as a multiple or fraction of a given reference portion.

4.2 DEVELOPMENT OF 3-DAY FOOD FREQUENCY RECALL

4.2.1 VARIABLES

The FFR was designed to reflect total food intake, plus one mineral. Hence, the variables selected for measurement in this research were total energy, fat, carbohydrate, protein, alcohol and calcium. As well, macronutrients expressed as proportion of total energy were examined. Several authors conclude that kilocalories and macronutrients require the least amount of time (minimum of three days) to achieve a representative estimate of nutrient intake (Marr and Heady, 1986; Basiotis et al., 1987). Other nutrients require considerably longer periods for estimation (Basiotis et al., 1987). In attempts to validate for an array of vitamins and minerals, a very long food list would be necessary, because nutrients vary considerably between foods and within foods. In addition, processing methods can affect the vitamin content of fruits and vegetables. These could be reflected in seasonal variations as well, as fresh produce is generally eaten less in winter while canned and frozen products are consumed more frequently. This can be seen in past attempts

to validate for all or many nutrients where vitamins and minerals consistently show lower correlations than macronutrients (Pietinen et al., 1988; Suitor et al., 1989; Bergman et al., 1990). All of the variability requires more food choices on the food list to reflect the diet eaten.

The exception to this was calcium. Calcium has exhibited high correlations in validation studies (Musgrave et al., 1989; Angus et al., 1989). This mineral is not affected by cooking or processing methods, and is found in relatively few foods consumed by a large portion of the population. Calcium is a nutrient of great interest to many researchers attempting to define the link between dietary calcium intake and osteoporosis. It is an important nutrient, especially for women, some of whom appear to have difficulty meeting their daily recommended intakes (Delvin et al., 1988). For these reasons, calcium was included in this analysis.

It is also possible to construct other food lists based on the one presented here, using different target nutrients such as iron or vitamin A. The food list would have to be adapted to include foods high in the target nutrients, but the conceptual theory and FFR format would remain the same.

4.2.2 DEVELOPMENT OF FOOD LIST

The approach outlined by Willett (1990) was used to establish the list of foods for the instrument. Two hundred and twenty-eight foods most commonly eaten by the study

population were identified. This was achieved by referring to food frequency questionnaires previously used in this geographical region (Manitoba Heart Health Project, 1990) and personal communication from a dietitian who had worked with clients living in the same geographical area as the study population (Bouchard, 1991). The 228 foods were then grouped according to five food groups: milk and dairy products; breads and cereals; fruits and vegetables; meats, alternates and mixed dishes and extras including fats and condiments. Amounts of protein, carbohydrate, fat, calories, alcohol and calcium were determined for each food. Next, the number of foods within each group was reduced by eliminating those that did not contribute significant amounts of the target nutrients. Of the remainder, those with similar energy, macronutrient and calcium contents were combined under the name of the most commonly eaten one, for example, taco listed under "cheeseburger". The nutrient values from the Canadian Nutrient File (CNF) (Health and Welfare Canada, 1988) of the key food choice were used in the FFR list. The initial format of the recall contained 102 foods.

It is important to mention that not all the foods on the FFR list contribute significant amounts of the target nutrients. Coffee and tea were included because they act as prompts for respondents to record the amounts of sugar and milk or cream used with these beverages, which contribute significantly to both fat and carbohydrate levels. Diet soft

drinks were placed in a category by themselves. Had they been left under the regular "soft drinks" category, it was felt respondents would not differentiate between aspartame and sugar sweetened beverages, and recording of diet drinks here would result in an over-estimation of carbohydrate intake. This is especially important if several diet beverages are consumed daily. Salad dressings were divided into diet and regular because of the difference in fat levels. Consumers are extremely conscious of fat content in foods, and at nine kilocalories per gram, even a small amount of fat omitted or included will contribute significantly to estimates of energy intakes.

4.2.3 LENGTH AND FORMAT OF FOOD FREQUENCY RECALL

The FFR was designed so respondents are asked to recall food items eaten in the past three days only. With the FFR, the food list acts as a prompt and there is no allowance for additional information, while traditional recall and food frequency questionnaire prompts to aid the respondent's memory are minimal. With longer recalls, such as a 7-day recall, memory may quickly fade beyond the most recent couple of days. The question researchers must ask is: Will loss in accuracy exceed gain in representativeness? (Block, 1982). It was felt that three days were a short enough time for subjects to remember what they had eaten; the list of foods acted as a prompt to further increase accuracy. Because the FFR only

takes approximately ten to fifteen minutes to complete, and five to ten minutes to process, it can be distributed at intervals throughout a research project to capture greater representativeness of usual diet, including weekends and seasonality.

Instead of merely asking how many times a food was eaten during the past three days, the FFR was designed to include meal patterns, i.e., breakfast, lunch, supper and snacks. Consequently, respondents are asked, for each meal, how many times they have eaten the food in the last three days. When confronted with a food, respondents only have to remember one meal at a time during which the food may have been eaten, rather than abstractly having to recall an impression of average consumption. This makes use of associative clustering researched by Jenkins et al. (1952 and 1958).

4.2.4 MEASUREMENT OF PORTION SIZES

As one of the objectives of this research is to determine whether the FFR can estimate individual nutrient intakes with high precision, it was decided to obtain information on portion size for each food consumed. This has been suggested by other researchers, in an attempt to collect quantitative data on individual consumption (Hunter et al., 1988; Clapp et al., 1991). Obtaining information on the serving size eaten by each respondent, rather than providing a standard serving on the questionnaire, reduces the chance of systematic bias.

It has been suggested that the concept of "usual" portion size may be difficult for some people. Researchers have found that the same person varies in portion size from meal to meal and day to day, resulting in within-person variation exceeding between-person variation for many food items (Hunter et al., 1988). For example, a subject may have consumed 1/2 cup of milk with cereal at breakfast, but two cups were drunk at lunch and one at supper. To total this and arrive at an average over one day is conceptually difficult. Having respondents indicate usual serving size at each meal will facilitate more precise quantification of intakes, as well as allow respondents to more easily conceptualize their usual serving sizes. For this FFR, a reference portion was listed for each food item. This was determined based on the following criteria: 1) at which meal the food was usually consumed; 2) most common serving form for that food, for example, cooked, diced, mashed; 3) portion size recorded for that use from the literature citing similar sex-age groups (Krebs-Smith and Smiciklas-Wright, 1985), and other food frequency questionnaires (Manitoba Heart Health Project, 1990). Portions were relatively small because respondents were asked to indicate their usual portion size in reference to the listed portion size i.e., a multiple or fraction of the listed portion, and it is conceptually easier to describe multiples of smaller units.

4.2.5 PRE-TESTING OF FOOD FREQUENCY RECALL

A pilot study was performed to evaluate useability and readability of the FFR. Twenty-eight female subjects completed the FFR. The list of foods was originally in a format following the four major food groups with an 'extra' category at the end. This was similar to what was observed in other food frequency questionnaire food lists. Results from the pilot sample suggested the order of foods be reorganised. Foods were rearranged into an order following typical meal patterns, i.e. breakfast foods, lunch foods, supper foods followed by snacks and extras. Discussion with respondents revealed some frustration in completing the FFR because they had to constantly be looking for foods that generally clustered during a particular meal. This entailed much page-turning, which increased confusion and decreased precision. By redistributing the foods to follow somewhat of a pattern as encountered chronologically throughout a day, respondents could deal with one meal at a time, as instructed by the FFR, without a great deal of searching for the foods generally associated with that meal. Clustering foods in such a way will facilitate better recall of foods eaten over the past three days (Jenkins and Russell, 1952; Jenkins et al., 1958).

Three foods that had not been included in the original food list were added: perogies to the existing category "mashed potatoes", and tofu to the "cottage cheese" category, and pretzels to "crackers". These existing food categories had the closest nutritional values to the newly added foods.

A generic "sandwich" category was added, because it was observed that respondents were having a great deal of trouble breaking down a sandwich into food components on the FFR list. Instructions were also added to the "bread" category to not include sandwiches here, but to indicate them only in the "sandwich" category.

"Butter" and "margarine", originally two separate categories, were both placed into one, as only total fat was being examined, not saturated and unsaturated. The final food list contained 101 foods (see Appendix A).

4.2.6 FIRST VALIDATION STUDY

A 3-day estimated record (see Appendix B) was also administered to a group of five nutrition-trained professionals, followed immediately by the 3-day FFR. The same days were covered by both methods, and respondents could refer to the record for information while completing the 3-day FFR. The purpose of this was to establish validity, defined as the ability to reflect the 3-day record on the 3-day FFR; i.e. could the information contained in a 3-day record be transcribed onto the 3-day FFR with reasonable accuracy.

4.3 EFFECT OF MEAL PREPARATION ON RECALL ABILITY

Work by Campbell et al. (1967) showed that recall of diet was best performed by women. This is possibly due to, particularly at the time the study was conducted (i.e. 1967),

women being responsible for the majority of food preparation for families and food service facilities. Roles have since shifted, with women often doing less preparation and men assuming greater responsibility for meal planning in the home. However one could still hypothesize that greater involvement in meal preparation could have an impact on the ability to both recall both foods eaten, and estimate portion sizes. Presumably skills involving measurement are required in meal preparation. As well there is simply more contact with the food (as opposed to just eating it), further facilitating remembering what was eaten.

In an attempt to determine if involvement in meal preparation affected this study population's ability to record portion sizes and recall foods eaten, subjects in the main validation study were asked to indicate how many meals they prepare in a month, on average. Specifically they were asked "how many cooked meals do you prepare by yourself in a month?"

4.4 SAMPLING PROCEDURE

In accordance with research guidelines, approval for this research was granted by the Human Ecology Ethics Committee, at the University of Manitoba.

For the pilot sample, a group of 28 women already participating in a study investigating associations between a walking exercise program and serum cholesterol levels was asked to complete the FFR. The purpose of this was to

determine useability and readability of the FFR. They were also asked to complete a second FFR to determine reliability of the FFR.

For the validation component of this study, two procedures were used. The first involved a sample of nutrition-trained professionals, all graduates the Human Ecology faculty, University of Manitoba, and the type of validity tested was that which determined whether the information on the 3-day record could be represented by the food list and format of the FFR. The second and main component determined whether the FFR could assess the diets of a large sample of subjects, both individually and as a group, using results estimated by the 3-day record as a comparative standard.

Two hundred university students from a first year Human Ecology class were invited to take part in the main validation study. The students were informed of the purpose of the study, and it was stressed that any decision to participate or not participate would not affect any academic work or evaluation regarding the class. All volunteers signed a consent form which guaranteed confidentiality of all information they provided. They were also told they could withdraw from the study at any time without notice or explanation. No monetary compensation was provided for participation, however volunteers were provided with a copy of their own nutrient intake at the end of the study.

Confidentiality was ensured by having respondents identify their questionnaires with their student number rather than their name. Each student's questionnaire was assigned a code number that was used for data entry.

No random sample was used for this study. As this is a validation study, and not an attempt to describe usual diet in a population, a random sample was not necessary. The study concluded on the performance of methods, not the adequacy of nutrient intake of respondents. Conclusions regarding the performance of either tool will be in the context of the characteristics and skills of the self-selected group of respondents. Since all participants lived in the same geographical area, and responded at the same time, there would be no between-person error due to different geographical locations or seasonality.

4.5 MAIN VALIDATION STUDY DESIGN

The research questions require that two methods of recording food consumption be used by the same respondents, namely the 3-day FFR and the 3-day estimated record. The 3-day record was chosen as a standard against which the FFR would be validated for several reasons. It places minimal burden on subjects, as they do not have to weigh their food. While a weighed record is a more precise method for measuring usual individual food and/or nutrient intakes, respondents may change their usual eating patterns to simplify the measuring

and recording process, or to hide eating habits they may perceive as unacceptable (Gibson, 1990a). Cost is lower using estimated records, as weighing equipment is not required. Co-operation from respondents is likely to be higher, as they must simply record portion sizes using common household measures, or with weights derived from packaging. Sample size will be higher as well, as more respondents will be willing to volunteer in a study that minimizes their participation. It is also desirable to validate a retrospective method against a prospective method, rather than another retrospective one. Comparing the same type of methods can result in the same type of error occurring in both sets of results. For example, all recall methods involve some memory component. If subjects have difficulty remembering their diet, comparison with another method that requires memory will mask this outcome, resulting in spuriously high estimates. For the above reasons, researchers in both nutrition and other health-related fields often choose a 3-day estimated record as the optimum means of assessing individual food and/or nutrient intakes.

Subjects were required to complete two 3-day FFRs and one 3-day estimated record. Data collection started with subjects completing the first FFR on Friday, November 1, 1991 for the previous three days (Tuesday, Wednesday, Thursday). The FFRs were given to the researcher immediately after completion. Three days later, Monday, November 4, subjects were given a 3-

day record to complete for Tuesday, Wednesday and Thursday, November 5, 6 and 7. Subjects returned the completed 3-day record seven days after the start of data collection, at the beginning of class on Friday, November 8. At the same time they were given a second 3-day FFR to complete, which was also collected immediately after completion. This figure is illustrated in Figure 4.5.1.

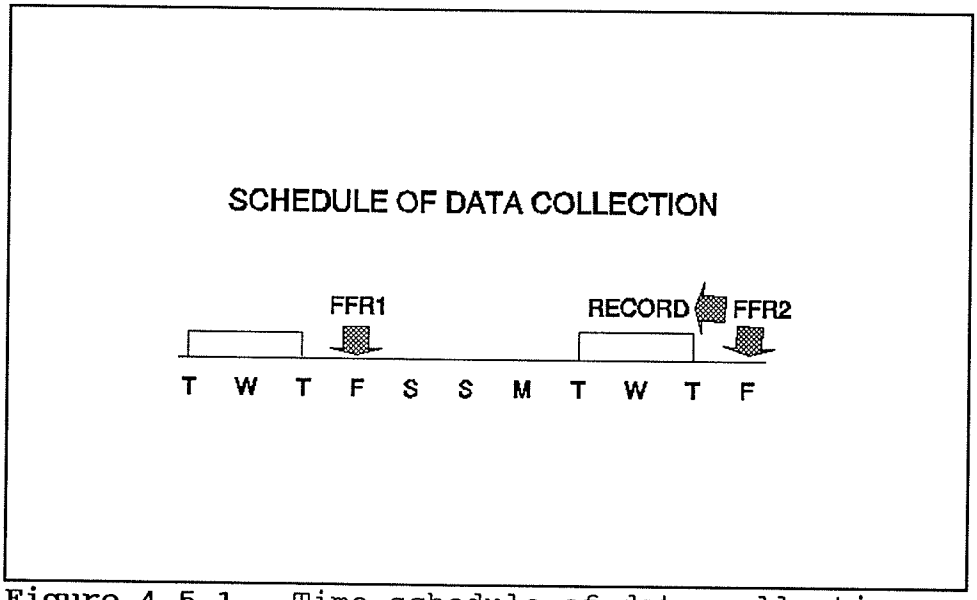


Figure 4.5.1. Time schedule of data collection.

During the class when the first 3-day FFR was completed, subjects were instructed as to what constituted household measures and how to use them. An overhead slide was used to emphasize differences between four ounce, six ounce and eight ounce glasses, as well the difference between a teaspoon and a tablespoon (Appendix C). For the 3-day record, subjects

were instructed to use household measuring devices for the first time a food was consumed, then estimate their portions in reference to this measure for any consecutive occasions when the food was eaten. Any packaging which provided a gram weight, or volume in millilitres or ounces, was encouraged to be recorded as well.

Two FFRs were collected in order to identify within-person and between-person variation. The second FFR, which referred to the same days as the record, was administered in order for the calculated nutrient intakes to refer to the same days' food consumption. This would eliminate any within-person variability for the entire three day period, because the same food intake is being monitored by the two methods. Subjects would however, likely be influenced by the fact they just completed recording everything they ate for the last three days, and correlations between this FFR and the record would be spuriously high.

The first FFR was collected one week earlier to avoid this problem in interpretation. Having the same weekdays represented will minimize within-person variability, but not eliminate it as people eat differently from day to day, even the same weekday. However, respondents will not experience any training bias, as they will not have completed the 3-day record at the time FFR1 is completed.

4.6 DATA PROCESSING

The investigator examined each completed FFR and record separately for discrepancies or incomplete answers. Respondents whose forms were questionable were contacted to remedy any concerns. Two problems appeared on the completed FFRs. Six subjects multiplied the "number of meals" column by the "portion size" column, instead of answering each independently. This resulted in a very large portion size, which appeared to be physiologically impossible. These subjects were asked if these portion sizes were in fact correct, and if they had multiplied them. In all but one case, the students replied that the large portions did not apply to them, and that they had multiplied the two columns. The second problem arose from simply too little information on the FFRs. This was indicated by very little or no foods selected throughout an entire meal, e.g. lunch or supper. Subjects were contacted and asked to confirm their responses. All respondents explained they had made up their day's intake from other meals, or had been ill and not eaten as per usual throughout the study period.

The FFR was pre-coded using the Canadian Nutrient File (CNF) database (Health and Welfare Canada, 1988). For every food or food group on the FFR list, the researcher had selected the one food from the group that most closely represented the nutrient composition of each the foods in the group, and matched it with a food code from the CNF

composition table. This eliminates any subjective coding errors that could occur because of coder discretion, or errors due to mistakenly transcribed codes, both of which arise when using diet record, history or traditional recall methods. It is this feature that makes the FFR resemble a food frequency questionnaire.

A computer program was developed to analyze the FFRs. This was derived from the existing Nutrient Analysis Program (University of Manitoba) used to analyze diet records using the CNF database. The number of times a food was eaten in the last three days and how much of the reference portion respondents typically ate at each meal are entered into computer storage using the computer program. For each subject, the researcher entered the foods indicated on the FFR via each meal. For each meal, the researcher would scroll down the food list until arriving at the appropriate food that matched the one designated on the FFR. At this point, the number of meals and the portion size listed on the FFR were entered. The program multiplies them to provide the appropriate gram weight. This procedure was repeated for all four meals (breakfast, lunch, supper, snack). Once all the data are entered, and the appropriate command executed, the program calculates the nutritional content of the specified recall and divides it by three to give a daily estimate for each of the nutrient variables indicated, i.e. energy, fat, protein, carbohydrate, alcohol and calcium. This procedure takes between five and ten minutes to complete per FFR.

The records were coded for food choice and food amounts by an independent nutritionist. Using one coder minimized intra-coder variability which could arise from having more than one coder. All coding was checked and corrected where necessary by the researcher. The work of the nutritionist minimized bias in coding judgements, while the work of the researcher minimized error, thus providing consistent data quality.

Food names listed by the CNF were used for coding the records. Volumes of foods were converted into gram weights where possible, or imperial weights were converted to grams. Standard codes were chosen where discrepancies might arise, for example, where there are several codes for "chicken breast" in the CNF, one code was chosen initially. This code was used whenever unspecified "chicken breast" was found on a food record. This same procedure was used for other foods with multiple codes. This process minimized error due to different nutrient composition for slightly different food codes.

Data from the records were analyzed by the Nutrient Analysis Program (University of Manitoba). All food codes for each subject are manually entered into computer storage, along with a gram weight for each food. A "check" program lists out the entered codes and the corresponding foods, as well as any wrong codes. This allows the researcher to find any problems before analysis is done.

Again, once the data were all entered and the specific command executed, the program calculates the nutritional content of the specified record and divides it by three to give a daily estimate for each of the nutrient variables indicated. This procedure, from the coding stage through to analysis, takes approximately one hour to complete for each 3-day food record.

4.7 SOURCES OF ERROR IN FOOD FREQUENCY RECALL

Both record and FFR2 assessed the same days for each subject. Consequently there is no within-person variability between the two questionnaires. Since the record is considered the "true" intake, errors arise when the FFR2 is completed. In an attempt to classify this remaining error, several potential sources were identified:

1. incorrect estimation of portion sizes
2. incorrect frequency of consumption
3. not indicating foods on FFR2 which were eaten according to the record (i.e. foods forgotten) or foods added to FFR2 that were not eaten according to the record
4. differences in precision of portion sizes, i.e. the computer program for the record can accept more than one decimal place, while the program for the FFR can accept only one decimal place

5. some foods eaten according to the record may not have been comparable to the foods on the FFR food list, and consequently would not have been indicated on the FFR.
6. food codes chosen from the CNF to analyze the record may have differed slightly from codes pre-set on the FFR food list e.g. there is only one sandwich category on the FFR, but many types of sandwiches may have been indicated on the record.

It was felt that the first three sources of error - portion size, frequency and foods - would be the sources that contributed most to the total error. Also, these sources were under the subject's control.

An effort was made to determine which one of these factors, if any, contributed the most to the observed differences between the record and the FFR. This type of examination was possible because one of the FFRs (FFR2) contained data about the same 3 day period as the record.

FFR2 was completed an additional 3 times by the investigator, for each subject. Using the record as the "true" reference, the FFR was completed once with corrected portion sizes (according to the record data), once with corrected frequency of foods eaten, and finally with corrected foods, i.e. including those forgotten, and excluding those added, according to the record.

4.8 REPRODUCIBILITY

Twenty eight subjects who participated in the pilot study were each administered two FFRs. Time between the two FFRs ranged, for each subject, from two weeks to two months. As well, no attempt was made to have the same days of the week represented by both FFRs. Consequently, they were not administered under the same conditions, i.e. same time length between the two administrations, and same days of the week represented. It can thus be assumed that reproducibility results will be conservative.

4.9 HYPOTHESIS TESTING AND ANALYSIS

All three estimates of food intake, the initial FFR, the 3-day record and the last FFR, were used to describe usual food intakes. Each research question was therefore answered by two separate analyses; once using the record and the second FFR, and another time using the record and the first FFR results. Interpretation of the findings used the fact that the comparison between the record and FFR2 excluded within-person variability due to changes in daily food choice and allowed calculation of the extent to which incomplete recording influences nutrient intake estimates.

Research questions regarding sources of error in data generated by the FFR were answered by completing each subject's FFR2 an additional 3 times, correcting for one of each of three identified sources of error every time. This is

again possible because FFR2 excluded within-person variability; consequently none of the errors could be attributed to different food choices due to different days as both the record and the FFR reflect intake on the same three days.

The SAS Statistical Analysis System (1982) was used to analyze the data generated by this research. Statistical tests used to accept or reject the hypotheses were as follows:

Hypothesis 1: a) paired t-test compared the differences between means of intakes estimated by the 3-day record vs. FFR1 and the 3-day record vs. FFR2

b) measure of percent differences between group mean intakes estimated by the 3-day record, FFR1 and FFR2.

Hypothesis 2: a) Pearson correlation coefficients determined the similarity of intake estimates from the 3-day record and FFR1, FFR2

b) standard deviations from mean estimates of intake from the 3-day record, FFR1 and FFR2 as an indication of variability.

Hypothesis 3: a) individual estimates of intakes estimated from lowest to highest for the 3-day record, FFR1 and FFR2; ranked variables were divided into quartiles for each method.

Hypothesis 4: a) residual plots and sensitivity/specificity analyses determined bias at low and high estimates of intake.

Hypothesis 5: a) regression analysis determined if greater involvement in meal preparation increases ability to recall and estimate portions

Hypothesis 6: a) multiple regression analysis determined significance of sources of error between intake estimated from the 3-day record and FFR2.

Hypothesis 7: a) Pearson correlation coefficients determined similarity of intake estimates from both FFRs.

All results are presented as both absolute values (kilocalories; grams of fat, protein, carbohydrate and fat; milligrams of calcium) and as proportions of total energy (% fat, % protein, % carbohydrate, and % alcohol where warranted). These were determined by dividing the caloric value of each macronutrient by total energy.

When diet-disease relationships are examined, nutritional variables may be evaluated in terms of absolute amount or in relation to total energy intake. Absolute values are included because many outcome variables are associated with individual differences in energy intake. According to Willett and Stampfer (1986), these variables can be attributed to body size, physical activity, metabolic efficiency, and net energy balance. The meaning of total energy intake is often

overlooked in epidemiological studies. In some cases, total caloric intake is associated with disease outcome. In studies of diet and coronary heart disease, subjects who eventually developed disease tended to have lower total caloric intakes than those who did not develop disease (Garcia-Palmieri et al, 1980; Gordon et al, 1981; Thompson and Billewicz, 1961). There are many interpretations and implications of this, including the fact that intake of most nutrients tends to correlate with caloric intake; however it demonstrates a need for absolute values of nutritional variables.

Absolute intake of a nutrient that selectively affects an organ system not correlated with body size (e.g. central nervous system) will be of greater importance to an investigator (Willett and Stampfer, 1986). However, some vitamins and the macronutrients are metabolized in close proportion to total caloric intake. In this case, it will be more biologically relevant to examine them in relation to energy intake. Proportions of macronutrients can be evaluated in relation to diet and health recommendations, such as the Nutrition Recommendations for Canadians (Health and Welfare Canada, 1990). These state that Canadians over the age of two should not consume more than 30% of total energy as fat, and between 55 and 60% of total energy as carbohydrate.

Chapter V

RESULTS

5.1 CHARACTERISTICS OF STUDY SAMPLE

For the pilot study, twenty-eight women aged 55-70 years completed two food frequency recalls each for the pilot study. Five nutrition-trained professionals, aged 25-45 years, each completed one 3-day record and one FFR for the first validation study. All were graduates of the faculty of Human Ecology, University of Manitoba.

For the main validation study 131 students completed FFR1; only 88 went on to do the 3-day record and the final sample who completed all three questionnaires (FFR1, 3-day record, FFR2) consisted of 82 subjects. Of the final sample, 5 were male and 77 were female. Ages ranged from 17 to 38 years, with a mean of 20.06, a median of 21.0 and a mode of 18.0.

5.2 FIRST VALIDATION TEST - HYPOTHESES ONE AND TWO

A validation test was performed with a sample of five nutrition-trained professionals. They completed both the FFR and the 3-day record in an attempt to determine whether the dietary information contained in a 3-day record could be transcribed on to the 3-day FFR. The results are listed in Tables 5.2.1 and 5.2.2.

The lowest observed correlation coefficient was 0.88 for alcohol while the highest was 0.99 for kilocalories. Results are shown in Tables 5.2.3 and 5.2.4. When converted to proportion of total energy, the lowest value was 0.86 for % fat and the highest was 0.95 for % alcohol. All values were significant at $p < 0.05$ or better, except for % fat where $p = 0.06$.

Group means were compared using a paired t-test. Results are listed in Table 5.2.5. None of the mean differences between variables was significantly different from zero at $p < 0.05$.

Table 5.2.1. Mean absolute daily energy and nutrient intakes estimated by 3-day record and FFR.

	RECORD		FFR	
VARIABLE	MEAN	SD	MEAN	SD
kilocalories	1747.046	700.558	1717.046	645.251
fat (g)	68.330	27.613	70.333	31.538
protein (g)	66.083	19.444	60.125	16.744
carbohydrate (g)	213.335	111.581	207.040	96.522
alcohol (g)	6.906	6.872	6.080	8.351
calcium (mg)	787.676	333.804	695.994	280.564

Table 5.2.2. Mean calorie-adjusted nutrient intakes estimated by 3-day record and FFR.

	RECORD		FFR	
VARIABLE	MEAN	SD	MEAN	SD
% fat	35.58	7.21	35.58	7.75
% protein	15.86	2.59	14.73	2.54
% carbohydrate	47.81	9.25	47.92	8.74
% alcohol	2.74	3.01	2.45	3.42

Table 5.2.3. Pearson correlation coefficients for comparison of FFR intake estimates with those from 3-day record.

VARIABLE	FFR VS. RECORD
kilocalories	0.99**
fat (g)	0.98**
protein (g)	0.97**
carbohydrate (g)	0.97**
alcohol (g)	0.88*
calcium (mg)	0.90*

* $p < 0.05$
** $p < 0.01$

Table 5.2.4. Pearson correlation coefficients for comparison of calorie-adjusted FFR intake estimates with those from 3-day record.

VARIABLE	FFR VS. RECORD
% fat	0.86[a]
% protein	0.93*
% carbohydrate	0.92*
% alcohol	0.95*

[a] $p = 0.06$
* $p < 0.05$

Table 5.2.5. Comparison of individual mean nutrient estimates from 3-day record and FFR2 with paired t-test.

VARIABLE	MEAN DIFFERENCE	SD	SE	t-STAT
kilocalories	30.45	126.99	56.79	0.54[a]
fat (g)	-2.0	6.95	3.11	0.64[a]
protein (g)	5.96	5.20	2.33	0.49[a]
carbohydrate (g)	5.53	28.0	12.52	0.44[a]
calcium (mg)	91.68	146.63	65.57	1.40[a]

[a] not significant at $p < 0.05$

5.3 MAIN VALIDATION STUDY

5.3.1 DATA QUALITY

Univariate plots were determined for all variables. Most exhibited apparently normal distribution, while some had a small number of statistical 'outliers'. Data were, however, interpreted in their original form without being transformed to their respective logarithms. The sample size was large enough for standard tests of normality (w-statistic) to indicate significant deviation, however visual assessment indicated the slope of the distribution conformed to the expected normal.

The only variable that was definitely non-normal was alcohol. This macronutrient was not consumed by everyone in the sample, as were the other nutrients. For FFR1, only 20 subjects indicated alcohol consumption. For FFR2, consumption was reported by only 11 subjects, and for the record, the total was also eleven.

As well, subjects who consumed alcohol on FFR1 did not necessarily consume it on FFR2, as can be seen by the decrease in total number of subjects consuming alcohol from FFR1 to the record. It is for these reasons that values for alcohol are excluded from some of the data analyses.

5.3.2 MEAN INTAKES OF VARIABLES - HYPOTHESES ONE AND TWO

All variables were measured as either absolute values (kilocalories, grams or milligrams), or as proportions of total energy intake (% fat, % protein, % carbohydrate). Group mean intakes are shown in Tables 5.3.1 and 5.3.2. For FFR1, total energy intake ranged from 446.24 kilocalories to 5311.89 kilocalories. The range was 565.29 to 3206.98 kilocalories for FFR2 and 552.98 to 2755.13 kilocalories for the record.

Comparing standard deviations of the means of FFR1 and the record variables, one can see the FFR1 variables are much more widely distributed about the means. The standard deviations of FFR1 variables are, on average, 66.8% greater than the standard deviations of the record variables.

The standard deviations of the FFR2 variables are much more closely patterned to those of the record variables. On average, they differ only by 6.1%

Table 5.3.1. Mean absolute daily energy and nutrient intakes estimated by 3-day record, FFR1 and FFR2.

	RECORD		FFR1		FFR2	
VARIABLE	MEAN	SD	MEAN	SD	MEAN	SD
kilocalories	1703.47	474.83	1836.74	839.74	1514.45	467.69
fat (g)	59.47	21.92	64.29	33.04	54.12	18.46
protein (g)	66.13	22.75	76.0	41.81	64.90	24.92
carbohydrate (g)	231.41	74.25	240.15	113.33	194.60	68.69
alcohol (g)	1.15	4.04	3.11	7.35	1.30	4.07
calcium (mg)	809.95	399.78	1008.98	618.10	805.91	389.88

Table 5.3.2 Mean daily calorie-adjusted nutrient intakes estimated by 3-day record, FFR1 and FFR2.

	RECORD		FFR1		FFR2	
VARIABLE	MEAN	SD	MEAN	SD	MEAN	SD
% fat	31.22	6.62	31.43	6.58	32.29	5.57
% protein	15.71	3.62	16.43	4.07	17.32	4.30
% carbohydrate	54.20	8.22	52.58	8.22	51.10	8.19
% alcohol	0.50	1.77	1.22	3.16	0.63	2.09

5.3.3 COMPARISONS OF GROUP MEANS - HYPOTHESIS ONE AND TWO

In order to test hypothesis one, group means were compared using a paired t-test. Because tests of significance give no indication of variability, 95% confidence intervals were also calculated for the testing of hypothesis two. Results are given in Tables 5.3.3. to 5.3.6. When the record is compared with FFR1, mean differences for energy, fat, and carbohydrate are not significantly different from zero, while for protein and calcium they are significantly different.

Comparison of the record with FFR2 indicates no significant difference from zero for protein and calcium, while energy, fat and carbohydrate are significantly different from zero.

Mean differences are not significantly different from zero for FFR1 % fat, % protein, or % carbohydrate, but are significantly different from zero for FFR2 % fat, % protein and % carbohydrate.

The differences between the means of the record variables and the means of the FFR1 and FFR2 variables can be expressed as percentages; they are shown in Table 5.3.7 and 5.3.8.

Table 5.3.3. Comparison of individual mean nutrient estimates from 3-day record and FFR1 with paired t-test, and 95% confidence intervals for mean differences between 3-day record and FFR1.

RECORD - FFR1

VARIABLE	MEAN DIFFERENCE	SE	P	95% CONFIDENCE INTERVAL
kilocalories	-132.81	83.27	0.1146	(-269.02,30.39)[a]
fat (g)	-5.02	3.72	0.1813	(-12.32,2.28)[a]
protein (g)	-9.87	3.67	0.0087	(-17.07,-2.67)[b]
carbohydrate (g)	-8.74	11.10	0.4333	(-30.49,13.01)[a]
calcium (mg)	-199.03	56.57	0.0007	(-309.90,-88.16)[b]

[a] not significantly different from zero
[b] significantly different from zero

Table 5.3.4. Comparison of individual mean nutrient estimates from 3-day record and FFR2 with paired t-test, and 95% confidence intervals for mean differences between 3-day record and FFR2.

RECORD - FFR2

VARIABLE	MEAN DIFFERENCE	SE	P	95% CONFIDENCE INTERVAL
kilocalories	189.02	33.63	0.0001	(123.08,254.94)[b]
fat (g)	5.15	1.69	0.0032	(1.83,8.46)[b]
protein (g)	1.23	1.85	0.5073	(-2.39,4.85)[a]
carbohydrate (g)	36.82	5.21	0.0001	(26.60,47.03)[b]
calcium (mg)	4.02	29.65	0.8919	(-54.07,62.16)[a]

[a] not significantly different from zero
[b] significantly different from zero

Table 5.3.5. Comparison of individual mean estimates of calorie-adjusted macronutrients from 3-day record and FFR1, and 95% confidence intervals for mean differences between record and FFR1.

RECORD VS. FFR1

VARIABLE	MEAN DIFFERENCE	SE	P	95% CONFIDENCE INTERVAL
% fat	-0.21	0.78	0.7856	(-1.74,0.57)[a]
% protein	-0.72	0.46	0.1188	(-1.61,0.17)[a]
% carbohydrate	1.63	0.93	0.0848	(-0.20,3.45)[a]

[a] not significantly different from zero
[b] significantly different from zero

Table 5.3.6. Comparison of individual mean estimates of calorie-adjusted macronutrients from 3-day record and FFR2 and 95% confidence intervals for mean differences between record and FFR2.

RECORD VS. FFR2

VARIABLE	MEAN DIFFERENCE	SE	P	95% CONFIDENCE INTERVAL
% fat	-1.07	0.54	0.0513	(-2.13,-0.001)[b]
% protein	1.61	0.37	0.0001	(-2.33,0.89)[b]
% carbohydrate	3.10	0.67	0.0001	(1.79,4.41)[b]

[a] not significantly different from zero
[b] significantly different from zero

Table 5.3.7 Percent difference between absolute means estimated by 3-day record and means estimated by FFR1 and FFR2.

VARIABLE	FFR1 % DIFFERENCE	FFR2 % DIFFERENCE
kilocalories	7.8	11.1
fat (g)	8.1	8.9
protein (g)	14.9	1.9
carbohydrate (g)	3.8	15.9
calcium (g)	24.6	0.5

Table 5.3.8 Percent difference between means of calorie-adjusted macronutrients estimated by 3-day record, FFR1 and FFR2.

VARIABLE	FFR1 % DIFFERENCE	FFR2 % DIFFERENCE
% fat	0.7	3.4
% protein	4.5	10.2
% carbohydrate	3.0	5.7

For FFR1 absolute means, kilocalories, fat and carbohydrate were all within 10% of the corresponding record means. When adjusted for calories, fat, protein and carbohydrate were all within 10% of the record means.

For FFR2 absolute means, fat, protein and calcium were all within 10% of the corresponding record means. When adjusted for calories, fat, protein and carbohydrate were all within 10% of the record means.

The differences between the means of calorie-adjusted macronutrients estimated by both FFR1 and FFR2 and the record are less than 10%, with the exception of FFR2 % protein, which differed from record-estimated % protein by 10.2%.

The size of the confidence intervals for the record vs. FFR1 variables are consistently larger by approximately 100%. Difference observations are much more tightly distributed about the mean for the record vs. FFR2.

5.3.4 VARIABILITY OF INTAKE - HYPOTHESIS TWO

In order to evaluate the extent of the relationship between the 3-day record and both FFR1 and FFR2, Pearson correlation coefficients were determined for all variables. Results are listed in Tables 5.3.9 and 5.3.10 for both absolute and calorie-adjusted values.

Correlation coefficients between the results of the record and FFR1 were as low as 0.16 for alcohol, and as high as 0.61 for protein. All values were significant at $p < 0.01$ or better, except for alcohol. The mean value for these correlations, excluding alcohol, was 0.48.

Table 5.3.9 Pearson correlation coefficients for comparison of absolute FFR scores with those from 3-day record.

VARIABLE	RECORD VS. FFR1	RECORD VS. FFR2
kilocalories	0.45****	0.79****
fat (g)	0.30**	0.72****
protein (g)	0.61****	0.76****
carbohydrate (g)	0.49****	0.78****
alcohol (g)	0.16 NS	0.87****
calcium (mg)	0.57****	0.77****

** $p < 0.01$
**** $p < 0.0001$
NS not significant

Table 5.3.10 Pearson correlation coefficients for comparison of calorie-adjusted record and FFR scores for macronutrients.

VARIABLE	RECORD VS. FFR1	RECORD VS. FFR2
% fat	0.43****	0.69****
% protein	0.43****	0.66****
% carbohydrate	0.47****	0.73****
% alcohol	0.46****	0.91****

**** $p < 0.0001$

No significant changes in correlations were observed when the macronutrient values were adjusted for energy intake, except for fat (increased from 0.30 to 0.43) and protein (decreased from 0.61 to 0.43). The lowest correlation coefficient was 0.43 for both % fat and % protein while the highest was 0.47 for % carbohydrate. Excluding alcohol, the mean correlation value was 0.44. All values were significant at $p < 0.0001$.

When absolute results from the record and FFR2 were compared, the lowest correlation coefficient was 0.72 for fat while the highest was 0.87 for alcohol. Mean correlation value, without alcohol, was 0.76.

After adjusting for energy, the correlation coefficient for % protein decreased to 0.66 while alcohol increased slightly to 0.91. Excluding alcohol, mean correlation value was 0.69. All correlations for the record vs. FFR2, both absolute and adjusted for energy intake, were significant at $p < 0.0001$.

Correlations improved noticeably for comparison between the record and FFR2 results over comparison between the record and FFR1 results.

5.3.5 COMPARISON OF CATEGORIES OF RESPONDENTS - HYPOTHESIS THREE

Data for all variables were divided into quartiles to determine if the FFR could classify them in the same manner as the record. Results are shown in Tables 5.3.11 and 5.3.12.

For FFR1, respondents remaining in the same quartile ranged from 30% for carbohydrate to 46% for protein. Moving one quartile they ranged from 29% for % protein to 44% for fat. Respondents moving two quartiles ranged from 12% for protein to 27% for % protein. One percent of respondents moved 3 quartiles for calcium up to 7% for fat. Remaining in the same or next quartile they ranged from 68% for % protein to 85% for protein.

When classified according to FFR2 estimates, 48% of respondents remained in the same quartile for protein, while 62% remained in the same quartile for % protein. Moving one quartile, respondents ranged from 28% for calcium to 40% for protein. Moving two quartiles they ranged from 6% for kilocalories to 14% for % fat. No respondents were grossly misclassified into extreme quartiles for kilocalories, fat and % carbohydrate; 1% moved three quartiles for protein, carbohydrate and % protein and 2% moved into extremes for calcium and % fat.

Respondents remaining in the same or next quartile ranged from 83% for % fat to 94% for kilocalories.

Table 5.3.11. Percentage of subjects (n=82) changing quartile between means of 3-day record and FFR1.

	FFR1 %				
VARIABLE	SAME QUARTILE	MOVE 1 QUARTILE	MOVE 2 QUARTILES	MOVE 3 QUARTILES	SAME OR NEXT QUARTILE
kilocalories	38	35	23	4	73
calcium	44	40	15	1	84
fat	32	44	17	7	76
protein	46	39	12	2	85
carbohydrate	37	40	20	4	77
% fat	34	37	22	6	71
% protein	39	29	27	5	68
% carbohydrate	30	44	23	2	74
average	38	39	20	4	77

Table 5.3.12 Percentage of subjects (n=82) changing quartile between means of 3-day record and FFR2.

	FFR2 %				
VARIABLE	SAME QUARTILE	MOVE 1 QUARTILE	MOVE 2 QUARTILES	MOVE 3 QUARTILES	SAME OR NEXT QUARTILE
kilocalories	57	37	6	0	94
calcium	60	28	9	2	88
fat	56	37	7	0	93
protein	48	40	11	1	88
carbohydrate	52	38	9	1	90
% fat	49	34	14	2	83
% protein	62	28	9	1	90
% carbohydrate	50	37	13	0	87
average	54	35	10	1	89

5.3.6 MEASURE OF BIAS AT HIGH AND LOW INTAKE ESTIMATES - HYPOTHESIS FOUR

The FFR has potential to be used as a screening tool, classifying subjects into high or low categories of intake. The mean energy intake of the record (1703 kilocalories) was defined as the mid-point where subjects were classified into "high" or "low" intake. Using the formulae for sensitivity (proportion of correctly identified "high intake" persons) and specificity (proportion of correctly identified "low intake" persons) (Kramer, 1988), the results are shown in Figures 5.3.1 and 5.3.2.

A test for which sensitivity and specificity sum to 1 contributes no more information than pure chance. Both FFR1 and FFR2 show that values for sensitivity and specificity total more than one, resulting in allocation to high or low groups by more than pure chance. Measuring the same days improved the ability of the FFR to identify low intake people.

Residual plots were calculated for record kilocalories vs. FFR1 and FFR2 residuals to determine if bias was present at high or low energy intakes. In the model, residuals estimated by FFR1 or FFR2 were the dependent variable with kilocalories estimated from the record as the independent variable. The residual plots are shown in Figures 5.3.3 and 5.3.4. There is no consistent pattern at high or low intakes, above or below zero.

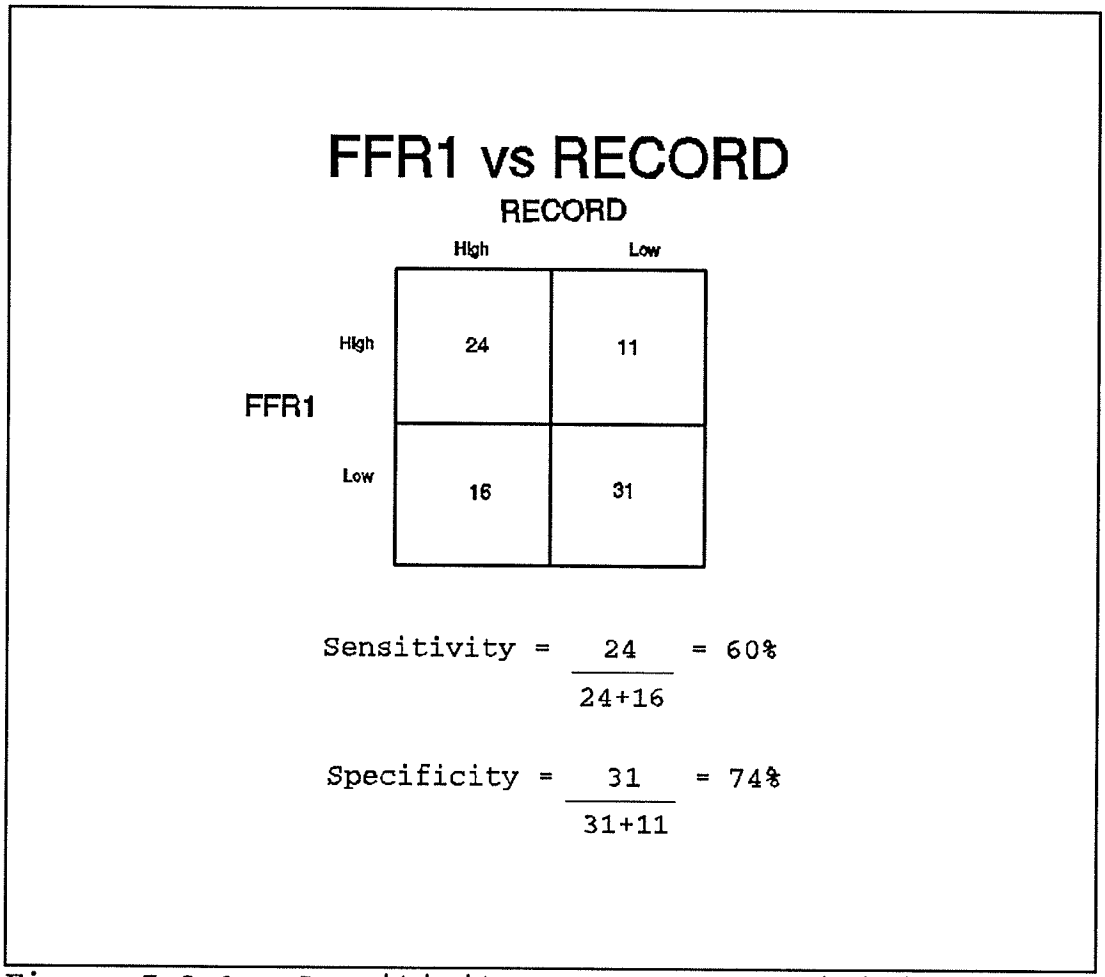


Figure 5.3.1. Sensitivity and specificity for kilocalories estimated by 3-day record vs. FFR1.

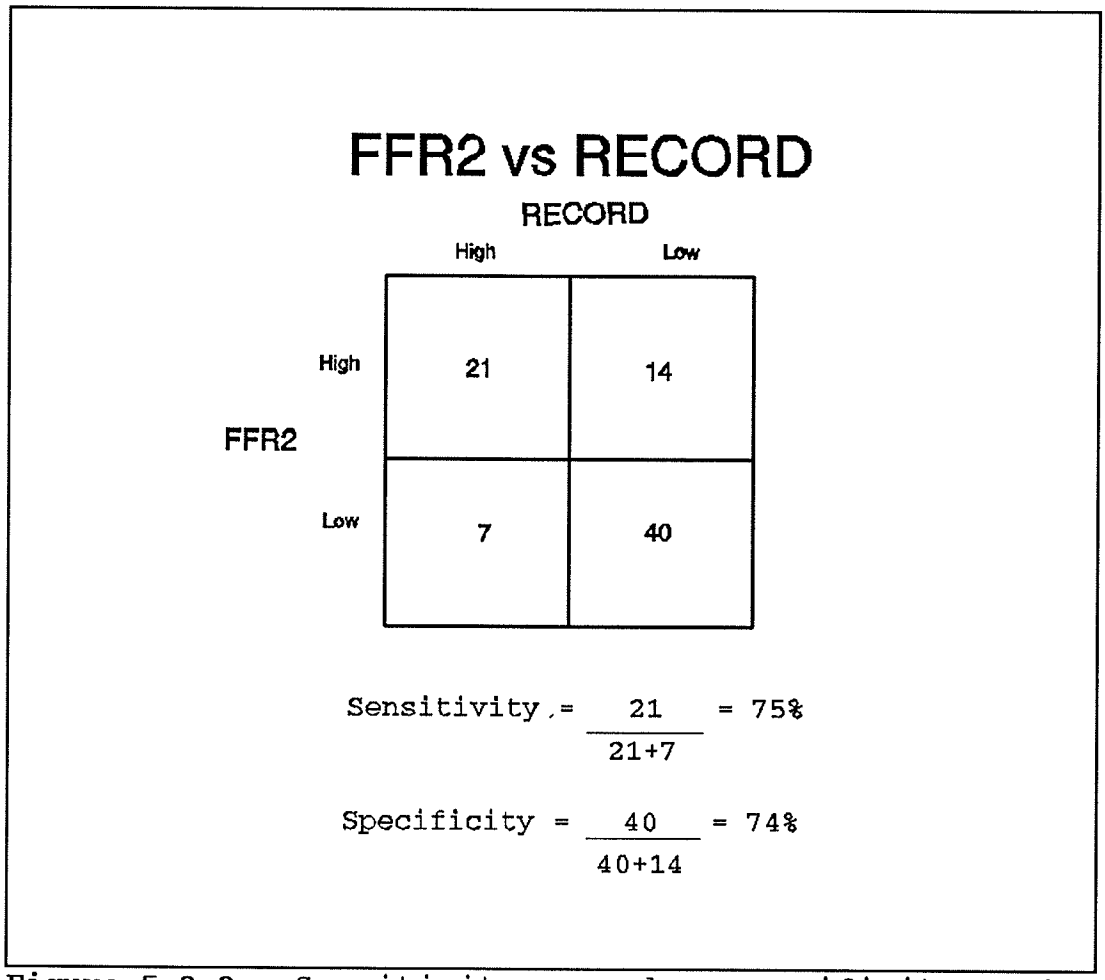


Figure 5.3.2. Sensitivity and specificity for kilocalories estimated by 3-day record vs. FFR2.

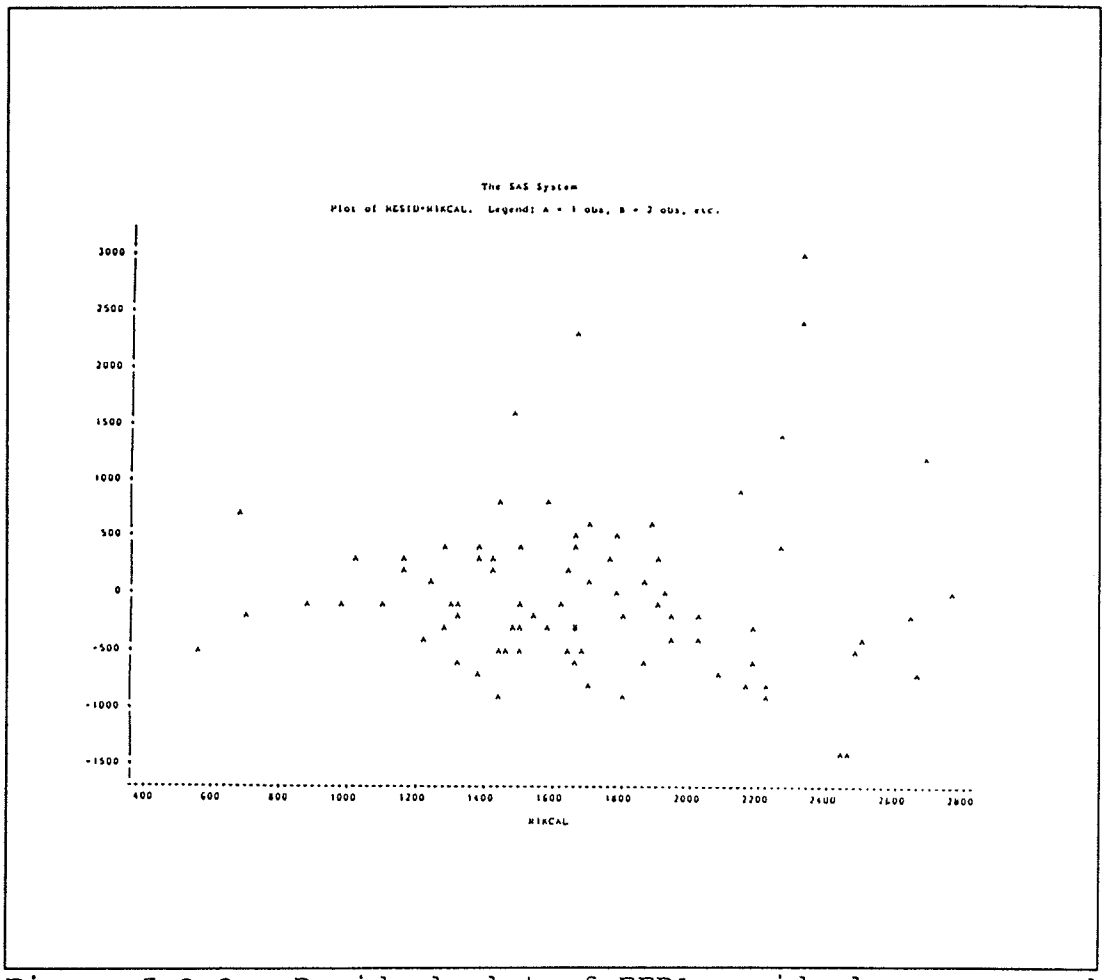


Figure 5.3.3. Residual plot of FFR1 residuals vs. record kilocalories

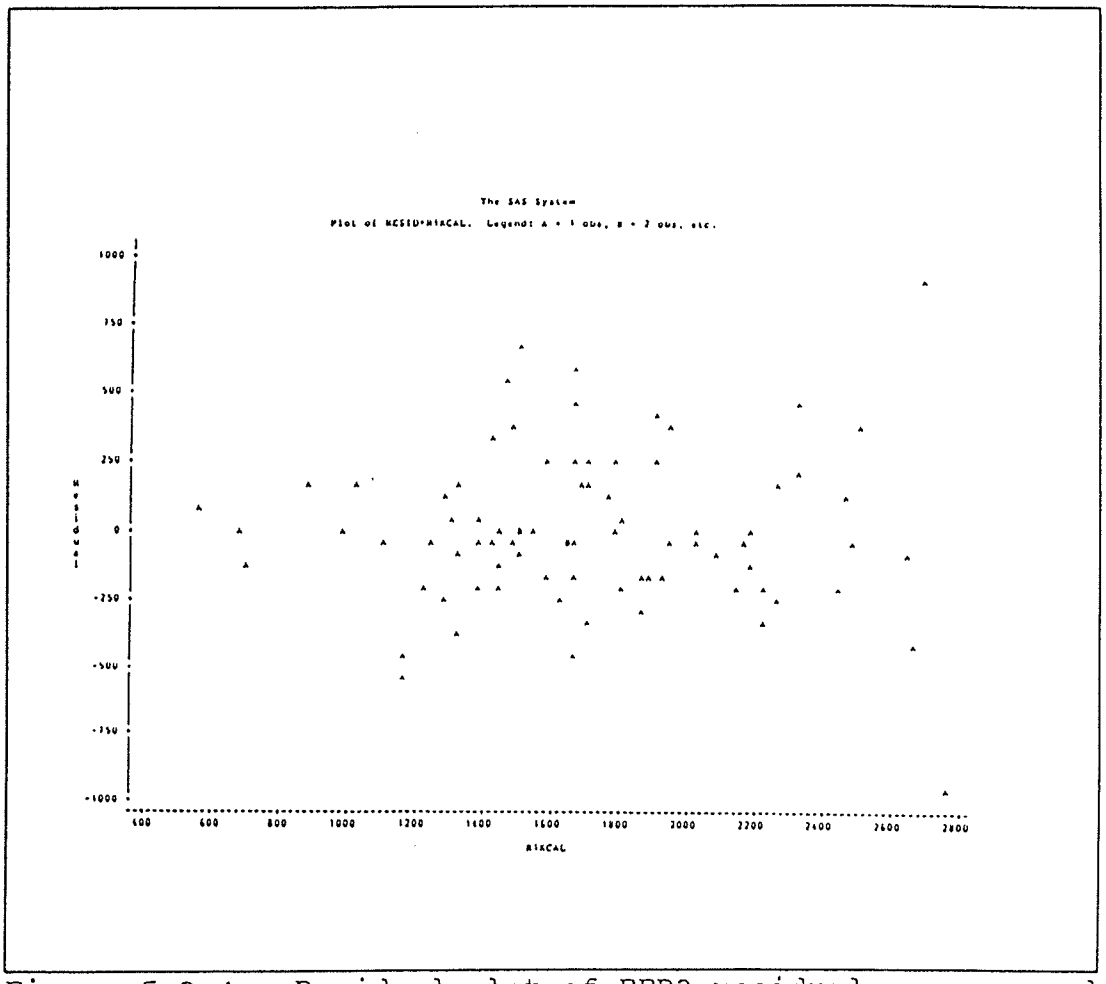


Figure 5.3.4. Residual plot of FFR2 residuals vs. record kilocalories.

5.3.7 EFFECT OF MEAL PREPARATION ON RECALL ABILITY - HYPOTHESIS FIVE

In order to determine if greater involvement in meal preparation affected ability to recall and estimate portion sizes, analysis of variance was performed. The difference between kilocalories estimated by the 3-day record and the FFR2 was used as the dependent variable, and number of meals as the independent variable.

The association between the total amount of error (record kilocalories - FFR2 kilocalories) and the number of meals was not significant (p=0.0547); however 4.54% of the total variance explained by increasing number of meals. Results are shown in Table 5.3.13.

Table 5.3.13 Regression analysis of effect of number of meals cooked per month vs. difference between 3-day record estimates of energy intake and FFR2 estimates of energy intake.

SOURCE	DF	F-VALUE	Pr<F
meals	1	3.803	0.055
error	80		

r-squared = 0.0454

5.4 SOURCES OF ERROR IN FOOD FREQUENCY RECALL - HYPOTHESIS SIX

The correlation coefficients between the record and FFR2 do not equal one. The amount of "error" remaining ranges from 0.13 for alcohol to 0.28 for fat. Since the record is considered the subjects' actual intakes, errors arise when the FFR2 is completed. These sources of error were identified in the methods section. The three sources of error thought to contribute most to total error were: incorrectly estimated portion sizes; incorrectly estimated frequency of consumption; foods forgotten from the record or added to the FFR2. These are random errors. The data were reanalysed, and mean group results are listed in Table 5.4.1 and 5.4.2.

Multiple regression was performed on the adjusted data. In the model statement, the dependent variable was defined as the difference between the record values ("true" values) and the FFR2 values, or the total amount of error. The independent variables were defined as the difference between FFR2 and each of a) the portion size-adjusted FFR2 b) the frequency-adjusted FFR2 and c) the foods forgotten/added-adjusted FFR2.

Total energy, as indicated by the record, was also included as an independent variable. The premise here was, the greater an individual's total energy intake, the greater will likely be his/her total error, and this must accounted for in the regression. Results for both absolute and calorie-adjusted values are listed in Tables 5.4.3. and 5.4.4.

Table 5.4.1. Mean absolute intakes estimated by FFR adjusted for incorrect portion size estimates, incorrect frequency estimates, and foods forgotten from/added to FFR2.

	PORTIONS[a]		FREQUENCY[b]		FOODS[c]	
VARIABLE	MEAN	SD	MEAN	SD	MEAN	SD
kilocalories	1498.77	486.48	1470.84	460.30	1697.96	512.99
fat (g)	54.47	20.18	52.83	19.02	59.29	20.22
protein (g)	62.63	23.28	62.07	24.30	71.28	28.64
carbohydrate (g)	192.51	70.22	189.42	65.42	223.36	74.55
alcohol (g)	1.39	4.27	1.38	4.20	1.13	3.81
calcium (mg)	781.80	418.26	779.67	385.16	900.38	409.56

a FFR2-FFR(adjusted for portion sizes)
b FFR2-FFR(adjusted for frequency)
c FFR2-FFR(adjusted for foods forgotten/added)

Table 5.4.2. Mean calorie-adjusted macronutrient intakes estimated by FFR adjusted for incorrect portion size estimates, incorrect frequency estimates, and foods added to/forgotten from FFR2.

	PORTIONS[a]		FREQUENCY[b]		FOODS[c]	
VARIABLE	MEAN	SD	MEAN	SD	MEAN	SD
% fat	32.89	6.18	32.45	5.94	31.53	5.54
% protein	16.98	3.77	16.98	4.04	16.83	4.05
% carbohydrate	50.90	7.94	51.31	8.13	52.47	7.87

a FFR2-FFR2 (adjusted for portion sizes)
b FFR2-FFR2 (adjusted for frequency)
c FFR2-FFR2 (adjusted for foods forgotten/added)

Table 5.4.3. Multiple regression analyses of intakes estimated by FFR2 minus FFR2 (adjusted) scores vs. 3-day record minus FFR2 absolute scores.

KILOCALORIES:

SOURCE	DF	F-VALUE	Pr<F
kilocalories (record)[a]	1	10.98	0.0014
portions[b]	1	2.17	0.1453
frequency[c]	1	0.69	0.4085
foods[d]	1	14.51	0.0003
error	73		

FAT:

SOURCE	DF	F-VALUE	Pr<F
kilocalories (record)[a]	1	6.97	0.0101
portions[b]	1	0.34	0.5601
frequency[c]	1	1.56	0.2162
foods[d]	1	4.64	0.0346
error	73		

PROTEIN:

SOURCE	DF	F-VALUE	Pr<F
kilocalories (record)[a]	1	0.61	0.4380
portions[b]	1	2.87	0.0943
frequency[c]	1	0.00	0.9876
foods[d]	1	42.21	0.0001
error	73		

CARBOHYDRATE:

SOURCE	DF	F-VALUE	Pr<F
kilocalories (record)[a]	1	6.90	0.0105
portions[b]	1	2.56	0.1140
frequency[c]	1	4.49	0.0374
foods[d]	1	25.72	0.0001
error	73		

CALCIUM:

SOURCE	DF	F-VALUE	Pr<F
kilocalories (record)[a]	1	0.00	0.9872
portions[b]	1	6.65	0.0119
frequency[c]	1	1.08	0.3022
foods[d]	1	20.75	0.0001
error	73		

[a] total kilocalories as indicated on record
[b] FFR2-FFR(adjusted for portion sizes)
[c] FFR2-FFR(adjusted for frequency)
[d] FFR2-FFR(adjusted for foods forgotten/added)

Table 5.4.4. Multiple regression analyses of calorie-adjusted macronutrients estimated by FFR2 minus FFR2 (adjusted) scores vs. 3-day record minus FFR2 absolute scores.

% FAT:

SOURCE	DF	F-VALUE	Pr<F
portions[b]	1	2.74	0.1021
frequency[c]	1	0.20	0.6554
foods[d]	1	7.18	0.0091
error	73		

% PROTEIN:

SOURCE	DF	F-VALUE	Pr<F
portions[b]	1	4.30	0.0415
frequency[c]	1	4.89	0.0301
foods[d]	1	49.82	0.0001
error	73		

% CARBOHYDRATE:

SOURCE	DF	F-VALUE	Pr<F
portions[b]	1	3.12	0.0816
frequency[c]	1	0.04	0.8449
foods[d]	1	27.62	0.0001
error	73		

[b] FFR2-FFR(adjusted for portion sizes)
[c] FFR2-FFR(adjusted for frequency)
[d] FFR2-FFR(adjusted for foods forgotten/added)

For kilocalories, fat and carbohydrate, total record kilocalories contributed significantly to the variation seen in the dependent variable.

For every variable it was error due to foods forgotten from the record or added to the FFR2 that contributed most to the variation in the dependent variable, record-FFR2. Error due to incorrect frequency was significant only for carbohydrate, while calcium was the only variable where incorrect portion sizes made a difference.

Results for percentages of macronutrients exhibited the same pattern. Foods forgotten/added contributed the most to the variation seen in record - FFR2. Both portion size and frequency were also significant contributors for % protein, but to a lesser extent.

Neither the correction for portion size nor the correction for frequency moves the means very far from the original FFR2 mean. Correcting for foods added or forgotten, however, moved the means very close to those observed for the record. This trend can be seen diagramatically, as shown in Figures 5.4.1 to 5.4.7. It is correction for foods added/forgotten that brings the mean FFR2 intake estimates closest to the mean record intake estimates for all variables except protein and calcium. Movement of these two variables is overshadowed by an interaction effect of frequency and portion. This is not seen in the multiple regression analyses because the effect exerted by each type of error (foods, frequency, portion) is independent.

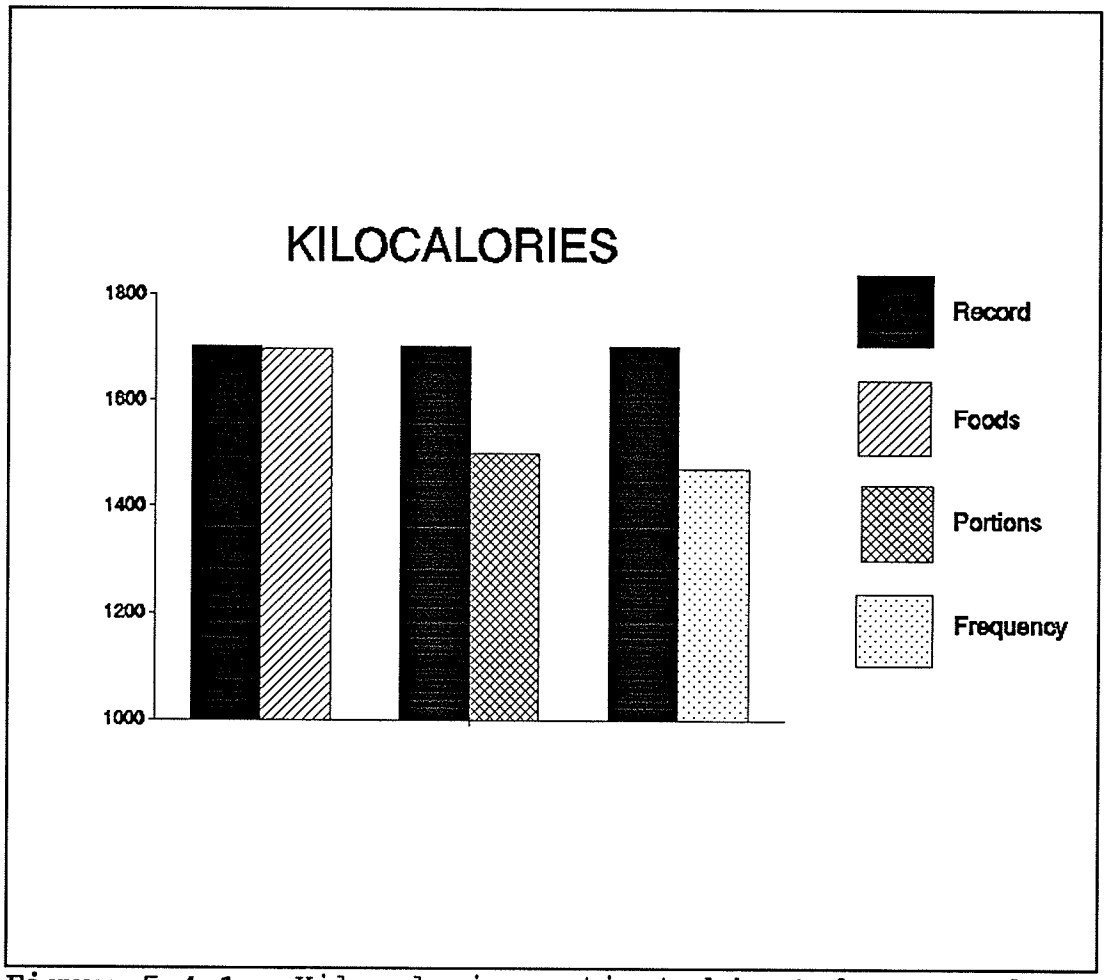


Figure 5.4.1. Kilocalories estimated by 3-day record vs. FFR2 adjusted for foods, portions and frequency.

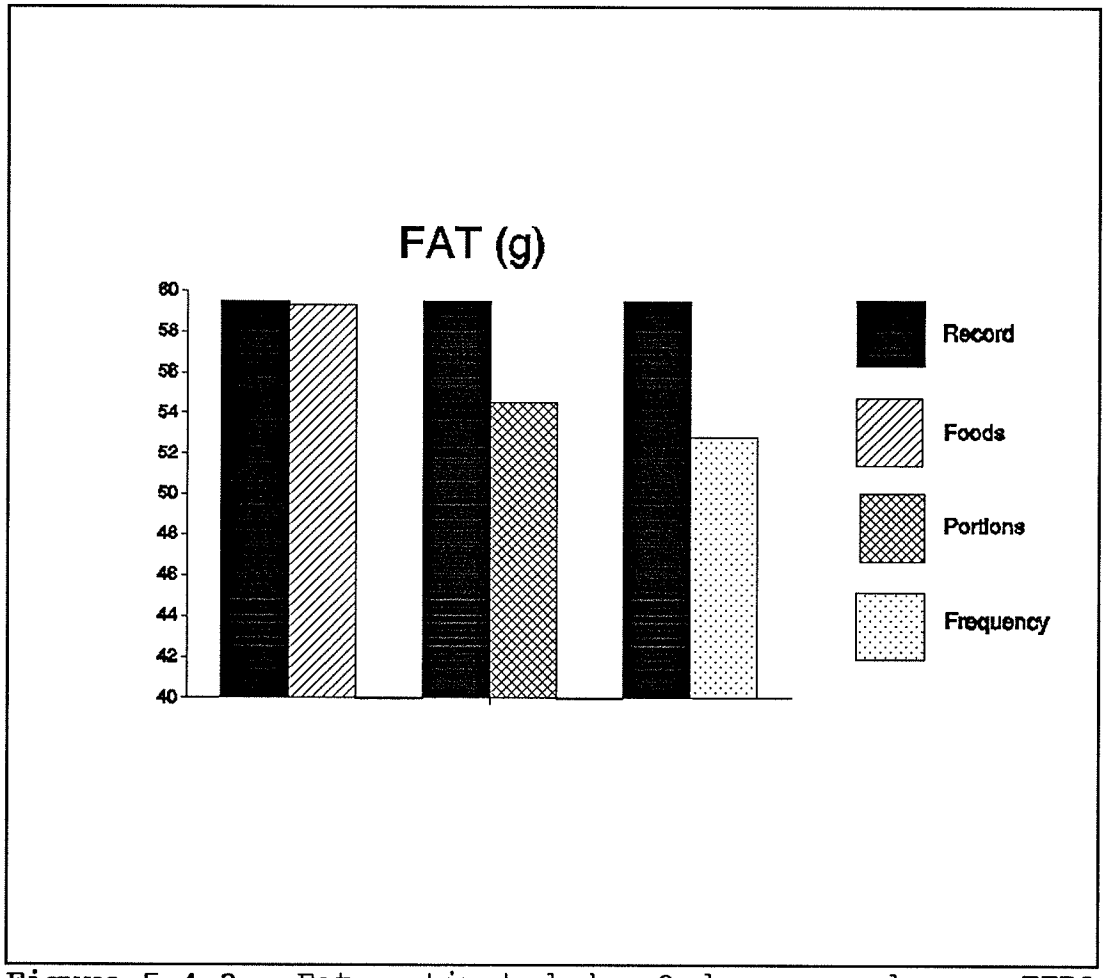


Figure 5.4.2. Fat estimated by 3-day record vs. FFR2 adjusted for foods, portions and frequency.

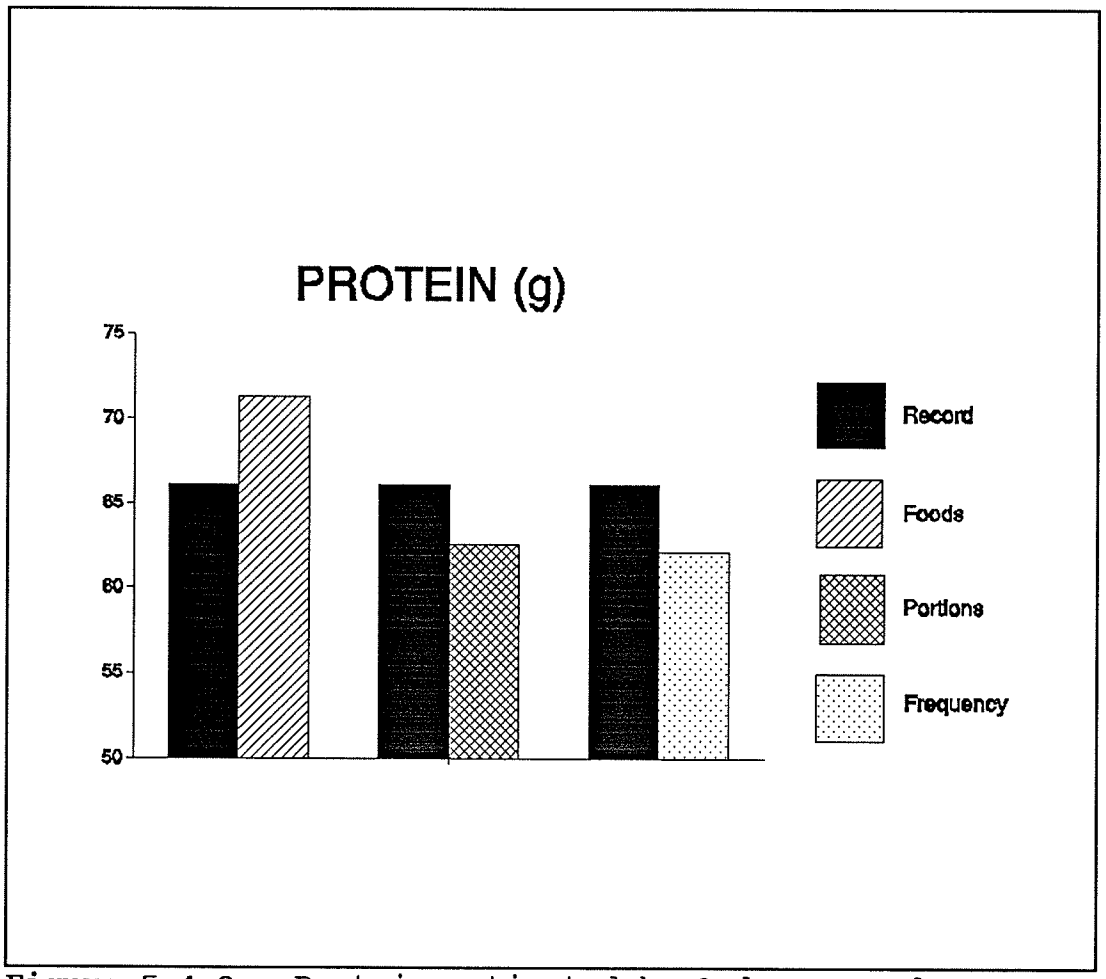


Figure 5.4.3. Protein estimated by 3-day record vs. FFR2 adjusted for foods, portions and frequency.

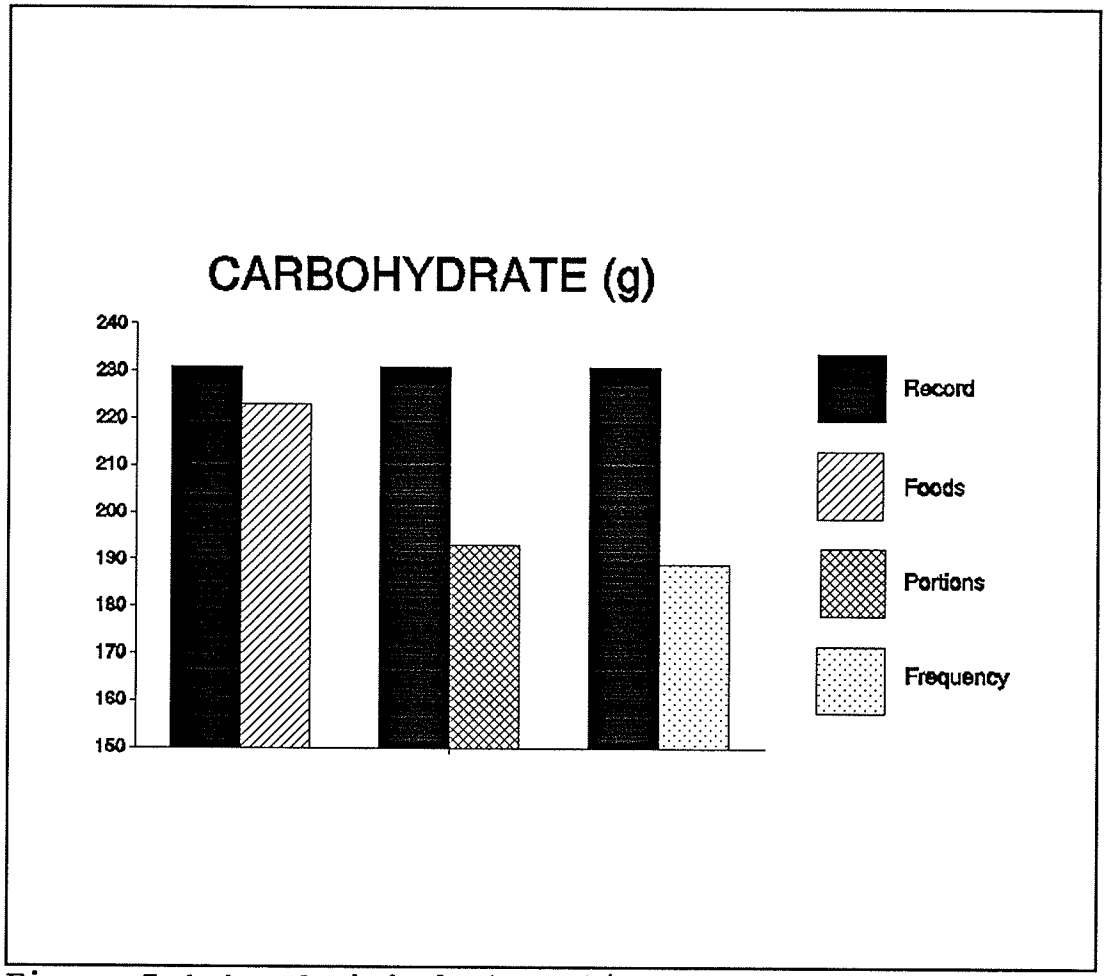


Figure 5.4.4. Carbohydrate estimated by 3-day record vs. FFR2 adjusted for foods, portions and frequency.

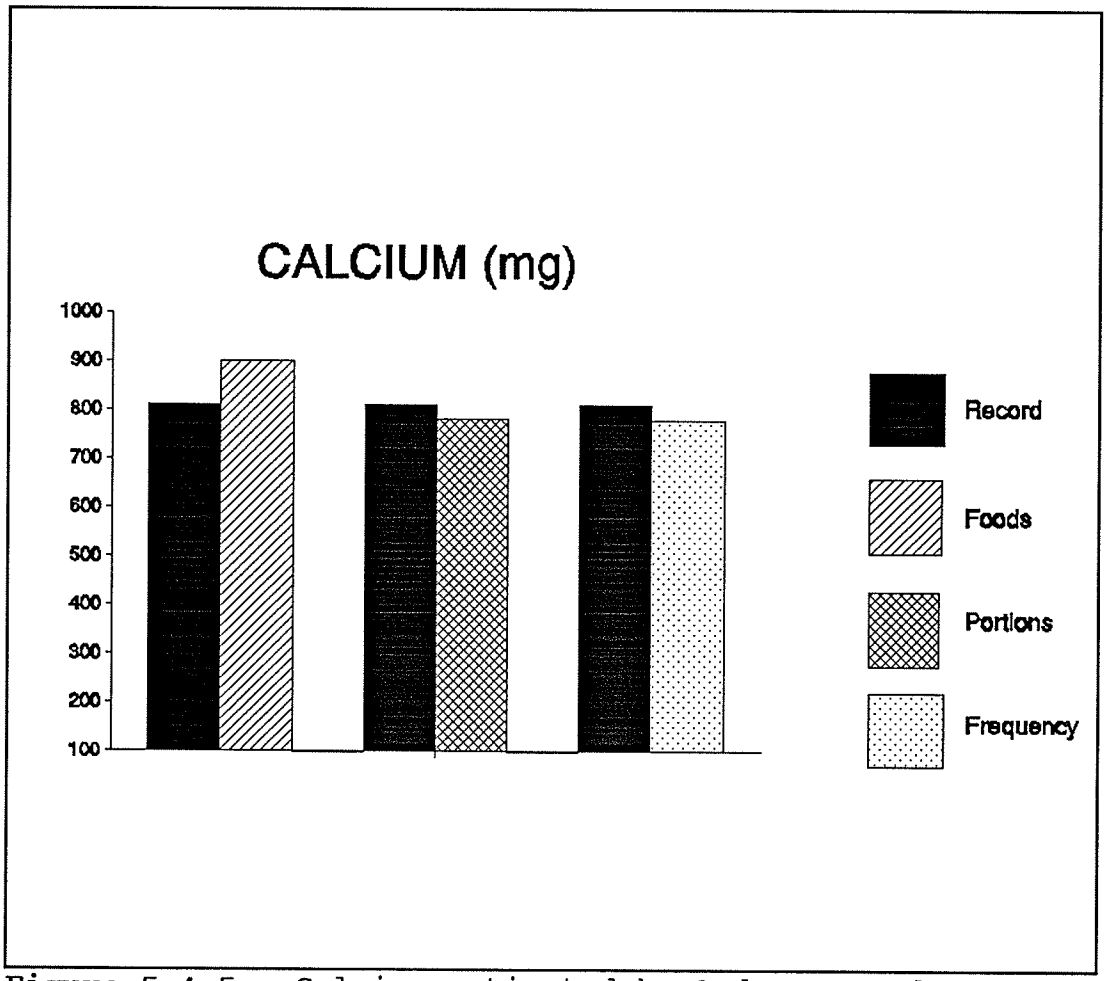


Figure 5.4.5. Calcium estimated by 3-day record vs. FFR2 adjusted for foods, portions and frequency.

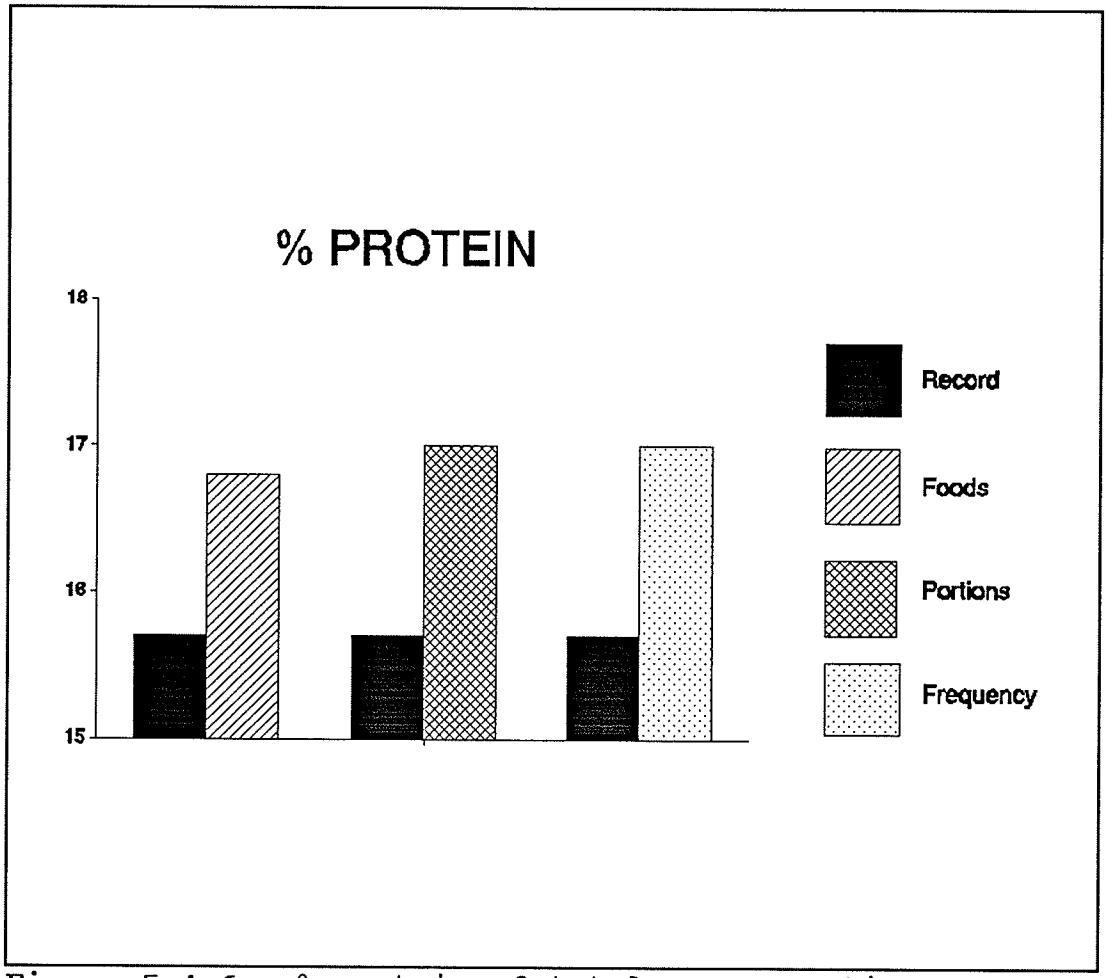


Figure 5.4.6. % protein of total energy estimated by 3-day record vs. FFR2 adjusted for foods, portions and frequency.

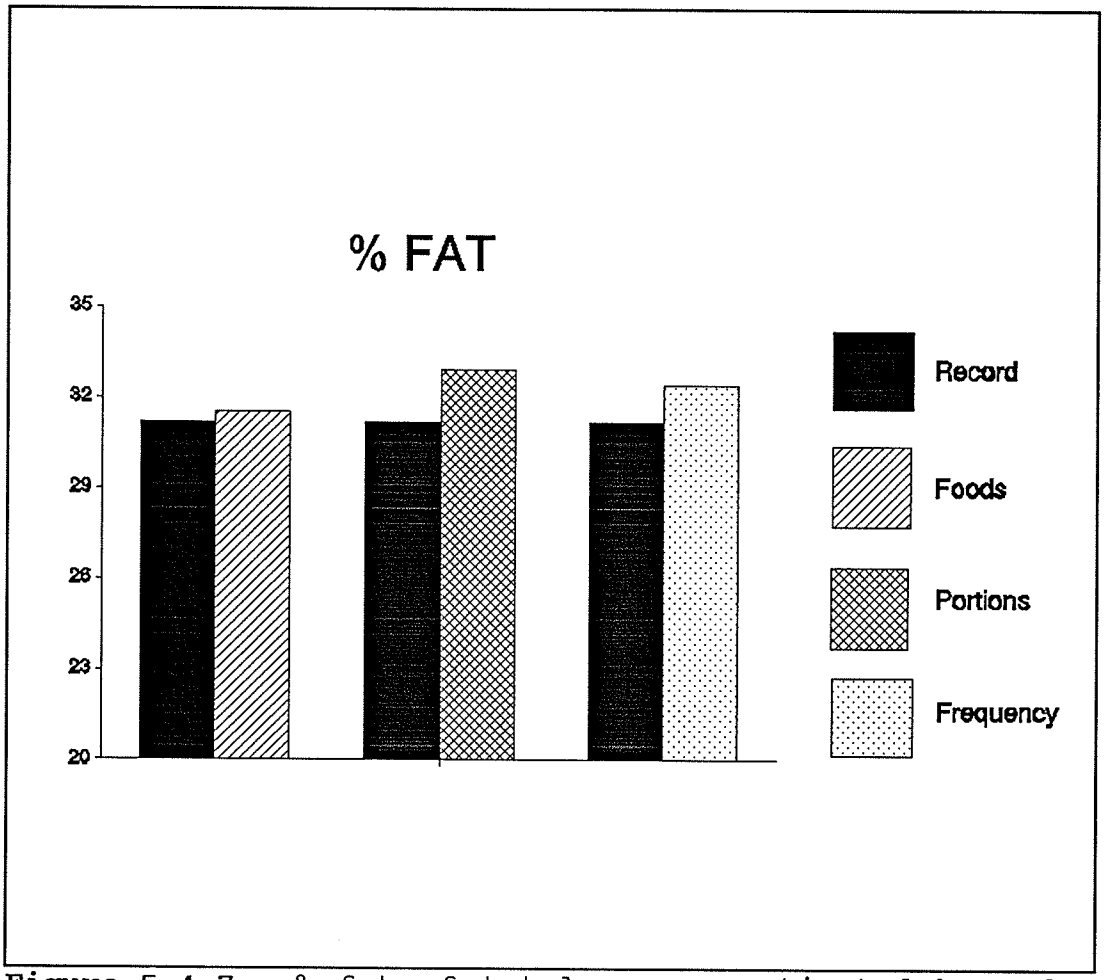


Figure 5.4.7. % fat of total energy estimated by 3-day record vs. FFR2 adjusted for foods, portions and frequency.

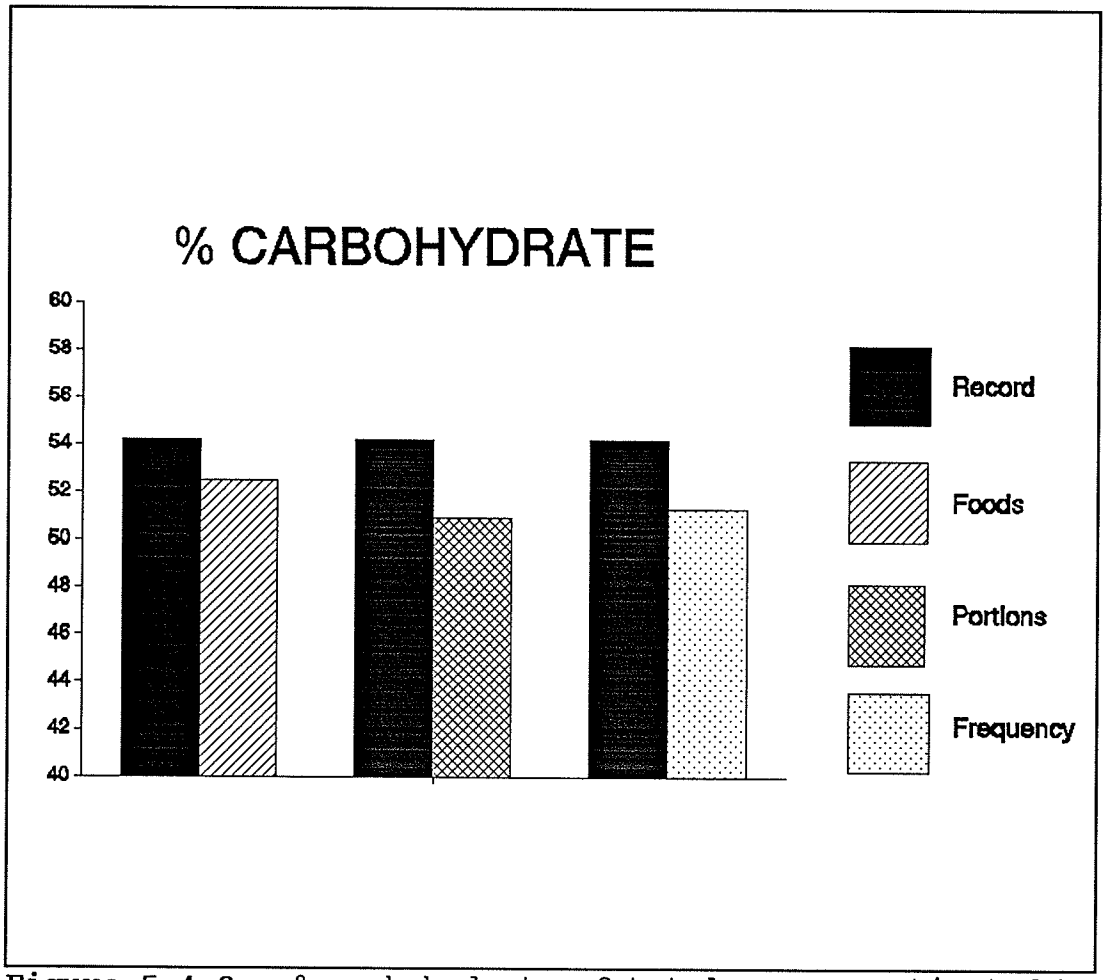


Figure 5.4.8. % carbohydrate of total energy estimated by 3-day record vs. FFR2 adjusted for foods, portions and frequency.

5.5 RELIABILITY TEST - HYPOTHESIS SEVEN

The pilot sample of 28 women completed two FFRs each. Time between the two administrations of the FFR varied for each participant, from 2 weeks to 2 months. No attempts were made to have the same days of the week represented by each administration. Results from the repeated administration of the 3-day FFR were compared using correlation coefficients (see Tables 5.4.1 and 5.4.2).

Correlation coefficients between the results of the two methods were as high as 0.64 for fat and as low as 0.44 for protein. All correlations were very significant, except for % protein. With greater experimental control one could presume these values would improve, i.e. be both higher and less variable.

Table 5.5.1 Pearson correlation coefficients for FFRs administered twice.

VARIABLE	FFR1 VS FFR2
kilocalories	0.62***
fat (g)	0.64***
protein (g)	0.44*
carbohydrate (g)	0.57**
alcohol (g)	0.59***
calcium	0.49**

* $p < 0.05$
** $p < 0.01$
*** $p < 0.001$

Table 5.5.2 Pearson correlation coefficients for FFRs administered twice.

VARIABLE	RECORD VS. FFR
% fat	0.41*
% protein	0.32 NS
% carbohydrate	0.39*
% alcohol	0.52**

* $p < 0.05$
** $p < 0.01$

Chapter VI

DISCUSSION

6.1 FIRST VALIDATION TEST

Correlation coefficients for the intakes of the 3-day records and the FFRs completed by the 5 nutrition-trained professionals, and results from the paired t-test show the FFR is a valid tool. The 3-day FFR has the ability to reflect 3 days of intake as recorded on a 3-day record with respect to the variables being examined. These results lead to acceptance of hypotheses one and two.

The correlations were not equal to 1.0, indicating a very small amount of error still present. This can be attributed to slight differences in portion sizes (the FFR program can only compute total numbers to one decimal place, while the record program can compute to more than one) and slight variability in nutrient composition of food codes chosen for foods listed on the record. These codes may have been different than the ones pre-selected for the 3-day FFR food list, even though the same generic food is indicated on both instruments.

Results from the paired t-test indicate that group mean differences for the two methods (record and FFR) were not significantly different from zero. This suggests the FFR is appropriate for estimating group intakes. Though the sample was small and the conditions under which the FFR was administered were optimal (completed by nutrition-trained professionals), these results demonstrate that the FFR can estimate similar group means for nutrient intakes as indicated on the 3-day record.

Both the correlation coefficients and the results of the t-test show the difference between intakes estimated by the FFR and the 3-day record is negligible. This indicates that the FFR has the potential to be used for individual dietary assessment, even for clinical purposes. The FFR was, however, administered under "ideal" circumstances - respondents had previous nutrition knowledge and could refer to their 3-day records. It is unlikely this level of accuracy could be achieved in a larger, more diverse population, yet it is important that this validity be established.

6.2 MAIN VALIDATION STUDY

6.2.1 COMPARISON OF GROUP MEANS

Results of the 82 students showed similar group means for kilocalories, fat and carbohydrate, but not for protein and calcium when group means of the record and FFR1 variables were compared using a paired t-test. The opposite is seen when

comparing the record and FFR2; means for protein and calcium are similar while those for kilocalories, fat and carbohydrate are not. For estimates of calorie-adjusted means, all FFR1 variables are similar to the record, while none of the FFR2 variables are.

When looking at percentage differences between FFR group means and record means, a similar pattern is found. For FFR1, fat, kilocalorie and carbohydrate estimates are all within 10% of record estimates. For FFR2, fat, protein and calcium estimates are within 10% of record estimates. For the calorie-adjusted values, differences between FFR2 and the record were all greater than differences between FFR1 and the record.

These data lead to rejection of hypothesis one (the FFR will produce similar group means as the record) and suggest the FFR performs differently on different occasions. Because FFR1 measured intake on different days than the record, subjects' intakes on the FFR1 days may have truly been different than their intakes on the record/FFR2 days, i.e. greater within- and between-person variability. The fact that differences were still observed for FFR2 vs. record means, even though they covered the same time period, suggests subjects still had difficulty estimating their intakes using the FFR form.

6.2.2 MEAN INTAKE OF ENERGY AND NUTRIENTS

Intakes estimated by FFR1 are much more variable than those estimated by the record. Standard deviations of FFR1 variables are, on average, 66.8% greater than standard deviations of the record variables. In contrast, standard deviations for FFR2 variables are only 6.1% greater, on average, than standard deviations of the record variables. The 95% confidence intervals are also much more tightly distributed about the mean for FFR2 than FFR1. The FFR2 data lead to acceptance of hypothesis two which states the FFR will show a similar variability of nutrient intakes as the record. The more variable FFR1 data do not, however, support this hypothesis. This is possibly due to several reasons. First, because FFR1 measured intake on different days than the 3-day record, subjects' intakes on the FFR1 days may have truly been more variable, i.e. there was greater between- and within-person variability. Second, subjects may have had difficulty estimating intakes when they completed FFR1, resulting in highly variable data. However, when FFR2 was completed, subjects had just finished recording all intake for the same 3 days. A possible training effect may be present here, and subjects are presumed to be better able to recall all consumption for the past 3 days.

There were two subjects who had daily intakes greater than 4500 kilocalories. These values increased both the mean and standard deviation of all the FFR1 variables. These two

observations also did not correlate well with the record and FFR2 values, which were 2185.60 and 2455.70 kilocalories, respectively. These FFR1 estimates could potentially be considered 'outliers' or unrealistic values, given that it is rare for an individual to physiologically consume more than 4500 kilocalories daily, especially when the other methods (record and FFR2) indicate this is not the norm. However, when the FFR1 questionnaires were completed initially, a visual examination quickly pointed out those questionnaires with potential problems. Neither of these FFR1s demonstrated odd meal patterns or excessively large intakes of any one food item, giving no reason to exclude them from any analysis. The break-up of meal patterns and the limited number of days being recalled (three) with the 3-day FFR allows the researcher to quickly scan and detect inappropriate responses or odd patterns of intake before analysis of data. This is not possible with other food frequency formats.

Examples of inappropriate responses could be: more than 3 days indicated for any particular food item; exceptionally large portion sizes; instances where the subject has multiplied the portion size by the number of days; an exceptionally high number of food choices for any or all meals; a focus on only one meal i.e. all foods chosen at breakfast and no other meals.

With proper instruction emphasizing the information required in each column, and examples for demonstration, these

types of problems should be minimized. As well, the respondent can also visually make a judgement on the accuracy of his/her own response pattern. He/she is forced to think in terms of all meal patterns and for a limited period of time, rather than for all meals at once and for a time period of up to one year as with traditional food frequency questionnaires.

When administered to population groups, most traditional food frequency questionnaires over-estimate intake (Bergman et al, 1990; Eck et al, 1991; Russell-Briefel et al, 1987). They also lead to 'outliers' (respondents with excessively large energy intakes). Often these 'outliers' have daily caloric intakes exceeding 10,000 kilocalories and must be removed from statistical analyses. Because of the design of traditional food frequency questionnaires (simply a list of foods with a frequency category), 'outliers' are difficult to detect visually, and only after processing can be further assessed. The FFR allows the investigator to visually detect odd responses before data analysis rather than after. As well, using 4500 kilocalories as the cut-off for unacceptable estimates, there are only two for FFR1, which translates into 2.4% of the sample population. This amount is significantly less than is seen with other food frequency questionnaires, where up to 15% of the study sample must be discarded as 'outliers', which may be defined as high as responses of 6000 kilocalories and up. Suitor et al. (1989) attempted to validate a self-administered food frequency questionnaire

against 24-hour recalls. Eighteen percent of their respondents had caloric intakes in excess of 4500 kilocalories per day and were considered unusable. The Manitoba Heart Health Project Nutrition Survey used a food frequency questionnaire to assess diets. Using 6000 kilocalories per day as the cut-off point, 15% of subjects were removed from the final sample (Sevenhuysen, 1991).

For FFR2, the highest caloric value was 3206.98. For the record it was 2755.13. All mean values of FFR2 variables were lower than the mean record variables. It appears the FFR slightly underestimates intake compared to the record. This is the opposite of what is observed with other long-term food frequency questionnaires, but is consistent with observations from other short-term food frequency questionnaires (Krall et al, 1988).

6.2.3 VARIABILITY OF INTAKE ESTIMATES

Correlation coefficients were consistently lower between the record and FFR1 than between the record and FFR2. The larger amount of error for FFR1 can be partly attributed to differences in food choices for each subject observed from the FFR1 time period to the record period, i.e. within-person variability, even though the same days of the week were covered. This element was eliminated in the comparison of the record and FFR2, contributing to the higher correlations.

The FFR2 vs. record correlations show the performance of subjects who had completed the written record for the 3 days immediately preceding the FFR. It was important to have a set of data exclusive of any within-person variability. Any errors observed in the completed FFR2s would then be considered "true" errors, and be the result of other factors besides different food choices on different days. However the respondents may have had better recollection of food intake than others who did not also record food intake.

The correlation coefficients observed for FFR1 and FFR2 are higher than those observed elsewhere in the literature. Willett et al. (1985) compared a food frequency questionnaire both before and after a series of diet records. Correlations for the first food frequency questionnaire were 0.30, 0.33 and 0.39 for protein, fat and carbohydrate. For the second food frequency questionnaire they were 0.41, 0.35 and 0.37 respectively. It was concluded that their questionnaire could usefully measure individual intake for a variety of nutrients.

In a short-term study, Eck et al. (1991) modified Willett's (1985) food frequency questionnaire and attempted to validate it for a 7 day period. Using the 7-day food frequency questionnaire at the end of an assessment period including three 24-hour recalls, correlations were: energy 0.66; protein 0.43; carbohydrate 0.46; and calcium 0.88. Authors of this study concluded their tool was appropriate for assessing group data.

The confidence intervals for mean differences between record and FFR1 variables are approximately twice the size of the confidence intervals observed for mean differences between record and FFR2 variables. The differences between group means for FFR2 vs. record data are much tighter, indicating the two methods demonstrate similar variability.

The results indicate that the 3-day FFR has good ability to reflect intake as indicated on a 3-day record, compared to other self-administered frequency formats. These data lead to acceptance of hypothesis two which states that the FFR-estimated nutrients show similar variability to the record-estimated nutrients. This is true for both FFR1 and FFR2.

6.2.4 COMPARISON OF CATEGORIES OF RESPONDENTS

Results of comparing quartiles of individuals are comparable to, and even an improvement over those seen elsewhere in the literature. Eck et al. (1991) classified respondents into quartiles as well, based on energy intake, resulting in an average of 47% of respondents remaining in the same quartile; 40% moving one quartile; 11% moving two quartiles and 2% moving three quartiles for all nutrients. Willett et al. (1985) divided subjects into quintiles; for all nutrients, on average 73% were in the highest two quintiles; 77% were in the lowest two quintiles; 3% were grossly misclassified into opposite quintiles.

For FFR2, more subjects were ranked similarly to the record than for FFR1. This is due to the same days being represented by both methods, and may also be partly due to a training effect: subjects are more likely to recall what they have eaten after having recorded the same foods previously.

These results indicate that the FFR has the ability to classify subjects according to intake categories, particularly if the subjects are sensitized to their own food consumption. Hypothesis three is accepted, i.e. the FFR can categorize respondents in high and low nutrient intake groups in the same manner as estimates from the 3-day record.

6.2.5 BIAS AT HIGH AND LOW INTAKE

In an attempt to determine if bias was present at high or low intakes, residual plots were determined for record kilocalories vs. FFR1 and FFR2 residuals. The random scatter of the plots indicates there is no bias at low energy intakes. Some small eaters overestimate total intake while others underestimate intake; conversely, some large eaters overestimate intake while others underestimate caloric intake. There is no consistent pattern.

Bias at either high or low intakes will have an impact when a study based on actual intakes identifies a certain risk ratio between extreme actual categories. This risk ratio reflects a difference between estimated (FFR) categories which are much closer. Consequently, the estimated risk ratio per

frequency unit would be an underestimation of the actual risk ration per frequency unit, using the FFR scale (Boeing et al., 1989). For example, a subject may have a fat intake of 70 grams according to the FFR, but actually have an intake of 90 grams according to the record. If the cut-off point for high risk of developing disease "x" is 80 grams, this subject will be misclassified as a low fat consumer and be erroneously be placed at "low risk".

As these results do not demonstrate a consistent flat slope, and lead to acceptance of hypothesis four. No consistent bias is shown at high intakes or low estimates of energy intake.

Results from the sensitivity and specificity tests reveal more information than would have been realized purely by chance. For FFR1, sensitivity = 0.60, specificity = 0.74 and their sum = 1.34. For FFR2, sensitivity = 0.75 and specificity = 0.74; they sum to 1.49. This indicates an improvement over FFR1 in classifying truly high intake individuals. Measuring intake on the same days improved the ability of the FFR to identify subjects with high energy intakes; when different days are measured, sensitivity decreases. Hypothesis four is accepted; there is no bias at low or high energy intakes.

6.2.6 EFFECT OF MEAL PREPARATION ON RECALL ABILITY

Results from the analysis of variance indicate that increased number of meals prepared in a month had a slight impact on ability to recall foods and estimate portion sizes. However, the p-value was less than 0.05, and these results do not support the hypothesis that greater involvement in meal preparation increases recall and portion estimation ability. This hypothesis is subsequently rejected.

In this study, information on number of meals prepared was self-reported and interpretation of the question "how many cooked meals do you prepare by yourself in a month" may have varied between subjects. For instance, one subject may have included pouring milk on cereal as preparing a meal, where another may have only reported those meals requiring a stove or oven. Consequently, it is difficult to establish a causal relationship between number of meals cooked and recall ability, although these results suggest further investigation of this association is warranted.

6.3 MAIN SOURCES OF ERROR IN FOOD FREQUENCY RECALL

Results from the multiple regression indicate that for kilocalories, fat and carbohydrate, as a person's energy intake increases, so does their overall error (difference between record and FFR2). This can also be seen in the residual plots shown in Figures 5.3.3 and 5.3.4. This was not the case for protein or calcium, suggesting these variables

are less susceptible to fluctuations in total energy intake. Fat and carbohydrate are major contributors to total caloric intake. Fat contributes 9 kilocalories per gram, more than twice the energy provided by protein or carbohydrate by weight, while carbohydrate generally contributes 40% or more of total energy to the diet. Protein contributes only 4 kilocalories per gram and generally only comprises 15-20% of total energy. Calcium is not consistently found in high or low kilocalorie foods. Some cheeses may be high in both fat and calcium, while skim milk and skim milk products are high in calcium but low in fat and energy. Consequently, calcium cannot be predicted to increase consistently with energy.

For every variable, both absolute and calorie-adjusted values, variability due to foods forgotten from the record or added to the FFR contributed most to the variation in total error (the difference between the record and FFR2). This suggests that subjects have difficulty remembering specific foods consumed, or in some cases add foods that were not actually consumed. Forgetting foods was more common than adding. This has been observed in other studies (Jain et al, 1982; Krall and Dwyer, 1987).

Recalling frequency (number of times the food was eaten in the past 3 days) was achieved with better accuracy, and was only slightly associated with total carbohydrate and % protein variability.

Ability to estimate portion sizes also did not appear to exert much influence on the total number of errors, except with total calcium and protein. The small impact of incorrect portion sizes may be partly due to the fact that the record was estimated as well as the FFR. While subjects were asked to use household measures where possible for the record, it is not certain whether this instruction was always followed. Consequently, if both measures of portion size (record and FFR) were truly "guessed" measures, this will give a conservative result of the impact of estimating portions. The same error may be occurring in both measures, masking the true effect. Hence, using an estimated method to validate a new estimated method, the effect of portion size estimation on total error is likely to be underestimated.

It is also possible that the foods forgotten or added are associated with particularly large nutrient amounts; larger than with either frequency or portion errors.

These results indicate that improving people's ability to recall specific foods eaten will increase the accuracy of intake estimates. This could possibly be achieved by including pictures of all foods on the FFR food list. More feasible, perhaps, would be to administer the FFR in an interview setting, where the interviewer could prompt respondents for foods likely to be forgotten, such as rarely consumed foods or condiments (Boeing et al, 1989).

These results lead to acceptance of part iii. of hypothesis six which states that differences in estimates between the record and FFR can be attributed to respondents forgetting foods eaten, or adding foods not eaten, when completing the FFR. Parts i. and ii. are also accepted in that inaccurate estimation of both frequency and portion size also contribute to total error, yet to a lesser extent. Parts iv. and v. are not specifically supported by these results; however one can infer that these remaining sources of error are responsible for the remainder of the total error.

6.4 RELIABILITY

The two FFRs completed by the 28 subjects in the pilot study resulted in relatively low, variable intake estimates. This was due to several factors: no attempt was made to have the same days of the week represented; there was much discrepancy in time lapse between completion of the 3-day FFR and the 3-day record (varied from a few days to several weeks) for each individual. Consequently, both within- and between-subject variability would be high, contributing to the lower correlations observed. This is not indicative of the performance of the 3-day FFR, but rather the true variability of the subjects' daily food intake.

All correlations were very significant, however. With greater experimental control one could presume these values would improve, i.e. be both higher and less variable.

These results are comparable to those found by Eck and coworkers (1991), who re-administered their 7-day food frequency questionnaire one week after the first test. Test/re-test correlations were observed from a low of 0.25 for protein to a high of 0.72 for carbohydrate. These authors concluded their instrument produced moderately reliability when re-administered exactly one week later. Results from the repeated administration of the FFR could potentially be considered an improvement, because less stringent experimental control was exerted. Consequently, the correlations observed are probably conservative values. Hypothesis seven is accepted; the FFR can produce similar results when administered on separate occasions.

When these correlations were compared with those seen in the main validation study, these results were slightly higher than those observed for FFR1 vs. record and slightly lower than those observed for FFR2 vs. record. Since no effort was made to have the same days of the week represented, these results suggest that perhaps the subjects used in this reliability study have a greater ability to estimate intake. More work is warranted on being able to group people by skill level.

Chapter VII

SUMMARY AND CONCLUSIONS

7.1 SUMMARY

The FFR produced similar group means and demonstrated similar variability to the record when completed by nutrition-trained professionals.

For the main validation study, the FFR did not consistently provide group means similar to the record for all variables. The FFR did rank subjects from low to high intake for all variables similarly to the record. There was no bias present at high or low energy intakes.

Similar variability was demonstrated between the FFR and the record. The record and FFR2, which assessed intake for the same time period, has more similar variability than the record and FFR1, which was completed one week earlier. This is partly due to within-person variability which inevitably occurs from one week to the next.

The FFR produced no nutritional 'outliers', i.e. respondents with unreasonably large intakes. The two subjects who had estimates greater than 4500 kilocalories per day on

FFR1 did not have inappropriate responses on their FFR1 forms and were subsequently included in the analysis.

Experience in meal preparation appears to have some influence on ability to recall past diet and estimate portion sizes. This experience accounted for approximately 5% of the variability in caloric intake between the record and FFR2.

Intake estimates differed between the two methods (FFR and record), even when the same time period was assessed. For every nutrition variable, foods forgotten from or added to FFR2 contributed most to the variability in record vs. FFR2. Incorrect estimation of portion size and frequency of consumption also contributed to the total number of errors observed, but to a lesser degree. It was also observed that larger eaters exhibited greater variability between their record and FFR2 for fat and carbohydrate, indicating these nutritional variables are more susceptible to fluctuations in caloric intake.

Testing for reproducibility showed similar variability between the two administrations of the FFR. Correlation coefficients were similar to those found elsewhere in the literature.

7.2 CONCLUSIONS

The FFR is a valid dietary assessment tool. When administered under ideal conditions, the FFR has the potential to estimate dietary intake at an individual and even a

clinical level. However, it is unlikely that a study sample has nutrition training or a 3-day record for reference. When administered to a larger, more diverse group of subjects, the FFR cannot accurately estimate quantitative intakes and is valid only at the group level. It is appropriate for classifying or ranking subjects according to level of intake of the nutrition variable examined. This has important implications in epidemiological studies attempting to compare estimates to an established risk ratio. Categories of intake permit examination of nutritional hypotheses and assessment of dose-response relationships.

FFR1 produced only two estimates of caloric intake greater than 4500 kilocalories, while FFR2 produced none. This problem is encountered to a greater extent with other food frequency instruments. The small number of 'outliers' appears to be due to the format of the FFR, as well as the shorter assessment period. Subjects need only think about the past 3 days, and the guided meal patterns minimize the amount of abstract thinking required. Upon completion of the FFR, subjects can quickly examine their forms for any discrepancies which may not be readily observed on traditional food frequency instruments. As well, the investigator can spot problems with completed FFRs before data analysis. This has implications for nutrition epidemiological research, where up to 15% of the sample is often removed due to unrealistic intake estimates.

Correlation coefficients found in this validation study are similar to those found in other validation studies of food frequency instruments. They are also similar to those found for other biochemical assessments of dietary status (Block, 1982; Willett, 1990). This places the FFR on the same level as other measures of nutritional status in terms of acceptable measures of validity.

The FFR is useful for assessing short-term dietary intake or change. If information on intake is required over a longer period of time, the FFR is a simple and convenient enough method that it could be administered repeatedly throughout the length of the study. This would capture a broader picture of dietary intakes in populations with high within-person variability.

Forgetting actual foods eaten was the largest problem for subjects. By improving their memory ability even further, it is predicted that intakes estimated by the FFR would be closer still to intakes estimated by the record. Prompting subjects to recall specific foods could possibly be achieved by administering the FFR in an interview setting. While this would increase the cost and time required to collect intake information, the FFR is still less expensive than a multiple day food record. Further research is warranted to determine if interviewer-administering the FFR will improve its accuracy.

Further research is suggested in the area of assessing factors which affect subjects' ability to recall and estimate portion sizes. While this research attempted to find a relationship between involvement in meal preparation and recall ability, other factors may be salient and need to be identified in order to improve accuracy in dietary assessment methods.

The FFR has the potential to be used to assess the intake of other nutrients. The food list would, of course, have to be modified to reflect important target nutrient sources, and re-validated. However, the format of the FFR could remain the same.

Any attempt to quantify dietary intake in free-living populations is fraught with methodological problems. Characteristics of the population need to be identified and incorporated into the chosen assessment method. As well, sources of error must be identified when validating a new instrument. This provides an area on which to target improvement of the instrument for assessing intake.

The FFR is a valid dietary assessment instrument for classifying or ranking individuals according to nutrient intakes. Enabling subjects to remember specific foods will apparently increase accuracy. This could be achieved by administering the FFR in an interview setting. The unique format of the FFR, and its ability to minimize nutritional 'outliers', are a definite contribution to nutrition

epidemiologists' quest for a simple yet accurate assessment method. It is clear, however, there is still work to be done.

REFERENCES

Anderson, J.R. and Bower, G.H. 1974. A propositional theory of recognition memory. Mem and Cognition 2:406.

Angus, R.M., Sanbrook, P.N., Pocock, N.A. and Eisman, J.A. 1989. A simple method for assessing calcium intake in Caucasian women. J Am Dietet Assoc 89:209.

Barrett-Connor, E. 1991. Nutrition epidemiology: how do we know what they ate? Am J Clin Nutr 54:182S.

Basiotis, P.P., Welsh, S.O., Cronin, F.J., Kelsay, J.L. and Mertz, W. 1987. Number of days of food intake records required to estimate individual and group nutrient intakes with defined confidence. J Nutr 117:1638.

Beaton, G.H., Milner, J., Corey, P., McGuire, V., Cousins, M. Stewart, E., de Ramos, M., Hewitt, D., Grambsch, P.V., Kassim, N. and Little, J.A. 1979. Sources of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. Am J Clin Nutr 32:2456.

Bergman, E.A., Boyungs, J.C. and Erickson, M.L. 1990. Comparison of a food frequency questionnaire and a 3-day diet record. J Am Dietet Assoc 90:1431.

Block, G. 1982. A review of validations of dietary assessment methods. Am J Epidemiol 122:13.

Block, G. and Hartman, A.M. 1989. Issues in reproducibility and validation of dietary studies. Am J Clin Nutr 50:1133.

Block, G., Hartman, A., Dresser, C.M., Carrol, M.D., Gannon, J. and Gardner, L. 1986. A data-based approach to diet questionnaire design and testing. Am J Epidemiol 124:453.

Boeing, H., Wahrendor J., Heinemann, L., Kulesza, W., Rywik, S.L., Sznajd, J. and Thiel, C. 1989. Results from a comparative dietary assessment in Europe: I. Comparison of dietary information derived from concurrently applied frequency questionnaires and quantitative measurement instruments. Eur J Clin Nutr 43:367.

Bolland, J.E., Yuhas, J.A. and Bolland, T.W. 1988. Estimation of food portion sizes: effectiveness of training. J Am Dietet Assoc 88:817.

Bouchard, P., Registered Dietitian. 1991. Personal Communication.

Byers, T., Marshall, J., Fielder, R., Zielezny, M. and Saxon, G. 1985. Assessing nutrient intake with an abbreviated dietary interview. Am J Epidemiol 122:41.

Cameron, M.E. and Van Staveren, W.A. 1988. Manual on methodology for food consumption studies. Oxford University Press, Oxford.

Campbell, V.A. and Dodds, M.L. 1967. Collecting dietary information from groups of older people. J Am Dietet Assoc 51:29.

Cavanaugh, J.C., Grady, J.G. and Perlmutter, M. 1983. Forgetting and use of memory aids in 20 to 70 year olds everyday life. Int J Aging Hum Devel 17:113.

Chu, S.Y., Kolonel, L.N., Hankin, J.H. and Lee, J. 1984. A comparison of frequency and quantitative dietary methods for epidemiologic studies of diet and disease. Am J Epidemiol 119:323.

Clapp, J.A., McPherson, R.S., Reed, D.B. and Hsi, B.P. 1991. Comparison of a food frequency questionnaire using reported vs. standard portion sizes for classifying individuals according to nutrient intake. J Am Dietet Assoc 91:316.

Delvin, E.E., Imbach, A. and Copti, M. 1988. Vitamin D nutritional status and related biochemical indices in an autonomous elderly population. Am J Clin Nutr 48:373.

Eck, L.H., Klesges, R.C., Hanson, C.L., Slawson, D., Portis, L. and Lavasque, M.E. 1991. Measuring short-term dietary intake: development and testing of a 1-week food frequency questionnaire. J Am Dietet Assoc 88:602.

Engle, A., Lynn, L.L., Koury, K. and Boyar, A.P. 1990. Reproducibility and comparability of a computerized, self-administered food frequency questionnaire. Nutr Cancer 13:281.

Garcia-Palmieri, M.R., Sorlie, P., Tillotson, J., Costas, R., Cordero, E. and Rodrigue, M. 1980. Relationship of dietary intake to subsequent coronary heart disease incidence: The Puerto Rico Heart Health Program. Am J Clin Nutr 33:1818.

Gibson, R.S. 1987. Sources of error and variability in dietary assessment methods: a review. J Can Dietet Assoc 48:150.

Gibson, R.S. 1990a. Principles of nutritional assessment. Oxford University Press, New York.

Gibson, R.S. 1990b. Validity in dietary assessment: a review. J Can Dietet Assoc 51:275.

Gordon, T., Kagan, A., Garcia-Palmieri, M., Kannel, W.B., Zukel, W.J., Tillotson, J., Sorlie, P., and Hjortland, M. 1981. Diet and its relation to coronary heart disease and death in three populations. Circulation 63:500.

Gray, G.E., Paganini-Hill, A., Ross, R.K. and Henderson, B.E. 1984. Assessment of three brief methods of estimation of vitamin A and C intakes for a prospective study of cancer: comparison with dietary history. Am J Epidemiol 119:581.

Guthrie, H.A. 1984. Selection and quantification of typical food portions by young adults. J Am Dietet Assoc 84:1440.

Guthrie, H.A. and Crocetti, A.F. 1985. Variability of nutrient intake over a 3-day period. J Am Dietet Assoc 85:325.

Hankin, J.H., Messinger, H.B. and Stallones, R.A. 1970. A short dietary method for epidemiologic studies. IV. Evaluation of questionnaire. Am J Epidemiol 91:562.

Hankin, J.H., Rhoads, G.G. and Glober, G.A. 1975. A dietary method for an epidemiologic study of gastrointestinal cancer. Am J Clin Nutr 28:1055.

Health and Welfare Canada. 1972. Nutrition Canada survey data base.

Health and Welfare Canada. 1988. Canadian nutrient file.

Health and Welfare Canada. Nutrition recommendations for Canadians.

Hislop, T.G., Lamb, C.W. and Ng, V.T. 1990. Differential misclassification bias and dietary recall for the distant past using a food frequency questionnaire. Nutr Cancer 13:223.

Hunter, D.J., Sampson, L., Stampfer, M.J., Colditz, G.A., Rosner, B. and Willett, W.C. 1988. Variability in portion sizes of commonly consumed foods among a population of women in the United States. Am J Epidemiol 127:1240.

Jain, M.G., Harrison, L., Howe, G.R. and Miller, A.B. 1982. Evaluation of a self-administered dietary questionnaire for use in a cohort study. Am J Clin Nutr 36:931.

Jain, M.G., Howe, G.R., Johnson, K.C. and Miller, A.B. 1980. Evaluation of a diet history questionnaire for epidemiologic studies. Am J Epidemiol 111:212.

Jenkins, J.J., Mink, W.D. and Russell, W.A. 1958. Associative clustering as a function of verbal association strength. Psychol Rep 4:127.

Jenkins, J.J., Russell, W.A. 1952. Associative clustering during recall. J Abnorm Soc Psychol 47:818.

Jensen, O.M., Wahrendorf, J., Rosenqvist, A. and Geser, A. 1984. The reliability of questionnaire-derived historical dietary information and temporal stability of food habits in individuals. Am J Epidemiol 120:281.

Krall, E.A. and Dwyer, J.T. 1987. Validity of a food frequency questionnaire and a food diary in a short-term recall situation. J Am Dietet Assoc 87:1374.

Krall, E.A., Dwyer, J.T. and Coleman, K.A. 1988. Factors influencing accuracy of dietary recall. Nutr Res 8:829.

Kramer, M.S. 1988. Clinical epidemiology and biostatistics. Springer-Verlag, New York.

Krebs-Smith, S.M., Smiciklas-Wright, H. 1985. Typical serving sizes: implications for food guidance. J Am Dietet ASsoc 85:1139.

Larkin, F.A., Metzner, H.L., Thompson, F.E., Flegal, K.M. and Guire, K.E. 1989. Comparison of estimated nutrient intakes by food frequency and dietary records in adults. J Am Dietet Assoc 89:215.

Manitoba Heart Health Project (MHHP) Nutrition Survey. 1990.

Marr, J.W. and Heady, J.A. 1986. Within- and between-person variation in dietary surveys: number of days needed to classify individuals. Hum Nutr Appl Nutr 40:347.

Mullen, B.J., Krantzler, N.J., Grivetti, L.E., Schultz, H.G. and Meiselman, H.L. 1984. Validity of a food frequency questionnaire. Am J Clin Nutr 39:136.

Musgrave, K.O., Giambalvo, L., Leclerc, H.L., Cook, R.A. and Rosen, C.J. 1989. Validation of a quantitative food frequency questionnaire for rapid assessment of dietary calcium intake. J Am Dietet Assoc 89:1484.

Natale, M. and Hantas, M. 1982. Effect of temporary mood states on selective memory about the self. J Pers Soc Psychol 42:927.

Nutrient Analysis Program. University of Manitoba, Department of Foods and Nutrition.

Pietinen, P., Hartman, A.M., Haapa, E., Rasanon, L., Haapakoski, J., et al. 1988. Reproducibility and validity of dietary assessment instruments. II. A qualitative food frequency questionnaire. Am J Epidemiol 128:667.

Russell-Briefel, R., Caggiula, A.W. and Kuller, L.H. 1985. A comparison of three dietary methods for estimating vitamin A intake. Am J Epidemiol 122:628.

Salvini, S., Hunter, D.J., Sampson, L., Stampfer, M.J., Colditz, G.A., Rosner, B. and Willett, W.C. 1989. Food-based validation of a dietary questionnaire: the effects of week-to-week variation in food consumption. Int J Epidemiol 18:858.

Samet, J.M., Humble, C.G. and Skipper, B.E. 1984. Alternatives in the collection and analysis of food frequency interview data. Am J Epidemiol 120:572.

SAS Statistical Analysis System. 1982. SAS Institute Inc., Cary, NC.

Sevenhuysen, G.P. 1991. Report on food patterns recorded by respondents of the MHHP nutrition survey. Manitoba Heart Health Project.

Suitor, C.J., Gardner, J. and Willett, W.C. 1989. A comparison of food frequency and diet recall methods in studies of nutrient intake of low-income pregnant women. J Am Dietet Assoc 89:1786.

Trulson, M.F. and McCann, M.B. 1959. Comparison of dietary survey methods. J Am Dietet Assoc 35:672.

United States Department of Agriculture. 1987. Nutrient data base for standard reference, release 6.

United States Department of Agriculture. 1982. Handbook No. 456.

Thompson, A.M. and Billewicz, W.Z. 1960. Height, weight and food intake in man. Brit J Nutr 15:241.

Wein, E.E., Sabry, J.H. and Evers, F.T. 1990. Recalled estimates of food portion size. J Can Dietet Assoc 51:400.

Wickelgren, W.A. 1981. Human learning and memory. Ann Rev Psychol 32:21.

Willett, W.C., Sampson, L., Stampfer, M.J., Rosner, B., Bain, C., Witschi, J., Hennekens, C.H. and Speizer, F.E. 1985. Reproducibility and validity of a semiquantitative food frequency questionnaire. Am J Epidemiol 122:51.

Willett, W.C. and Stampfer, M.J. 1986. Total energy intake: implications for epidemiologic analysis. Am J Epidemiol 124:17.

Willett, W.C. 1990. Nutritional epidemiology. Oxford University Press, New York.

Appendix A

FOOD FREQUENCY RECALL

FOOD FREQUENCY RECORD FOR THREE DAYS ONLY

This record will give you an estimate of your energy, protein, fat, carbohydrate, calcium and alcohol intake.

PLEASE TAKE YOUR TIME FILLING IN THE DETAILS, SO THE RESULTS CAN BE AS ACCURATE AS POSSIBLE.

Student #: _____ Age: _____ Sex: _____

To decide your frame size, place your fingers of one hand around the wrist of your other hand. If thumb and middle finger meet, fill in "medium frame", if they overlap, write "small frame" and if they do not meet, write "large frame".

Height:cm _____ or ft.in _____

Weight:kg _____ or lbs_____

Frame size: _____

Dates Recorded: _____ _____ _____

How many cooked meals do you prepare by yourself in a month? _____

INSTRUCTIONS:

1. Starting with breakfast, go down the list of foods on the following pages and for each item decide how many times you have eaten it **IN THE LAST THREE DAYS.**

2. At each meal, on average, did you eat more or less than the portion size given in the list? If you ate less, write for example 1/2 or 1/3 of the portion size. If more, write for example 2 or 3 portions.

3. Repeat for other meals and snacks.

Example: 2 slices of toast eaten at 2 out of 3 breakfasts, and
1 slice of bread at supper every night, and
1/2 cup of macaroni and cheese for lunch one day,
is written as:

FOOD	EXAMPLE OF PORTION SIZE	BREAKFAST		LUNCH		SUPPER		SNACKS	
		Number of breakfasts with this food in the last three days	How many example portions per breakfast	Number of lunches with this food in the last three days	How many example portions per lunch	Number of suppers with this food in the last three days	How many example portions per supper	Number of snacks with this food in the last three days	How many example portions per snack
BREAD(all types)	1 slice	2	2			3	1		
Macaroni+Cheese	1 cup			1	.5				

UPON COMPLETION OF THIS FORM, PLEASE ANSWER THE FOLLOWING QUESTION:
Did you find any part of this questionnaire difficult to fill in? If so, please explain.

FOOD	EXAMPLE OF PORTION SIZE	BREAKFAST		LUNCH		SUPPER		SNACKS		
		Number of breakfasts with this food in the last three days	How many example portions per breakfast	Number of lunches with this food in the last three days	How many example portions per lunch	Number of suppers with this food in the last three days	How many example portions per supper	Number of snacks with this food in the last three days	How many example portions per snack	
DAIRY AND EGGS FOR ITEMS 1, 2, AND 3 - INCLUDE MILK USED IN TEA AND/OR COFFEE.										
1 Milk (Skim or 1%)	1 cup									1
2 Milk (2%)	1 cup									2
3 Milk (whole, homo)	1 cup									3
4 Chocolate Milk	1 cup									4
5 Milkshake	1 cup									5
6 Cottage Cheese/Tofu	1/2 cup									6
7 Hard Cheese	1" cube/1/2 oz.									7
8 Processed Cheese Slice/Spread	1 slice/1 Tbsp.									8
9 Low Fat Cheese (eg. low fat mozzarella)	1" cube/1/2 oz.									9
10 Cream Cheese	1 Tbsp.									10
11 Yoghurt	1 small tub									11
12 Cream in tea/coffee	1 Tbsp.									12
13 Eggs (boiled, poached)	1 egg									13
14 Eggs (fried, scrambled)	1 egg									14
BREADS AND CEREALS 15 Breads (all types) DO NOT INCLUDE SANDWICHES	1 slice									15
16 English Muffin/Bagel	1 medium									16
17 Croissant/Donut/Danish	1 medium									17
18 Pancakes/Waffles	3 medium									18
19 Muffin	1 medium									19
20 Cooked Cereal (eg. oatmeal/cream of wheat)	3/4 cup									20
21 Granola-type Cereal (eg. Harvest Crunch)	1/2 cup									21
22 Sweetened Cereal (eg. Honeycomb/Frosted Flakes/Froot Loops)	3/4 cup									22
23 Ready-to-Eat Cereal (Group A) (eg. Shreddies/ Raisin Bran/Life/Bran Flakes/Fruit 'n Fibre)	3/4 cup									23
24 Ready-to-Eat Cereal (Group B) (eg. Special K/ Corn Flakes/Rice Krispies/ Puffed Wheat/Cheerios)	3/4 cup									24
25 Crackers/Pretzels	4 crackers/ 25 sticks									25

FOOD	EXAMPLE OF PORTION SIZE	BREAKFAST		LUNCH		SUPPER		SNACKS	
		Number of breakfasts with this food in the last three days	How many example portions per breakfast	Number of lunches with this food in the last three days	How many example portions per lunch	Number of suppers with this food in the last three days	How many example portions per supper	Number of snacks with this food in the last three days	How many example portions per snack
OTHER DISHES									
26 Sandwich (all types)	1 sandwich								26
27 Hamburger (with bun)	1 burger								27
28 Cheeseburger (with bun)/Taco	1 burger/2 Tacos								28
29 Hotdog (with bun)	1 dog								29
30 Pizza	1 - 5" section								30
31 Lasagna/Spaghetti/Other Pasta with Meat Sauce/Cabbage Rolls	1 cup/ 2 cabbage rolls								31
32 Macaroni and Cheese	1 cup								32
33 Soup made with Water (eg. chicken noodle, beef vegetable)	1 cup								33
34 Cream Soup made with Milk (eg. cream of chicken, mushroom)	1 cup								34
35 Chicken Pot Pie	1/6 pie								35
36 Beef Stew	1 cup								36
37 Chop Suey	1 cup								37
38 Pork and Beans/Bean burrito	1/2 cup/1 burrito								38
39 Rice/Noodles	3/4 cup								39
MEAT, FISH, POULTRY AND ALTERNATES									
40 Roast Meat, Steak (beef, pork or lamb, fat removed)	3 oz/3 thin slices								40
41 Roast Meat, Steak (beef, pork or lamb, fat left on)	3 oz/3 thin slices								41
42 Ground Beef/Meatloaf/Chili	3 oz. cooked								42
43 Bacon	3 slices								43
44 Sausage	3 small links								44
45 Organ Meats (eg. liver/kidney/heart)	3 oz. cooked								45
46 Chicken/Turkey (skin removed)	3 oz/3 slices								46
47 Chicken/Turkey (skin left on)	3 oz/3 slices								47
48 Fried Chicken	1 piece								48
49 Fish (baked/canned/ poached/broiled)	1 fillet								49
50 Fish (fried, fish sticks)	3 oz/2-3 pieces								50
51 Shellfish (eg. shrimp, lobster, scallops, oysters)	3 oz.								51
52 Lentils, Dried Peas & Beans	1/2 cup								52

FOOD	EXAMPLE OF PORTION SIZE	BREAKFAST		LUNCH		SUPPER		SNACKS	
		Number of breakfasts with this food in the last three days	How many example portions per breakfast	Number of lunches with this food in the last three days	How many example portions per lunch	Number of suppers with this food in the last three days	How many example portions per supper	Number of snacks with this food in the last three days	How many example portions per snack
FRUITS AND JUICES									
53 Apples/Pears	1 medium								53
54 Apricots/Plums	3 small								54
55 Banana	1 medium								55
56 Nectarine/Peaches	1 medium								56
57 Melon/Pineapple	1/2 cup								57
58 Strawberries/Raspberries/ Blueberries	1/2 cup								58
59 Cherries/Grapes	15 medium								59
60 Orange	1 medium								60
61 Grapefruit	1/2 medium								61
62 Canned Fruit (water pack)	1/2 cup								62
63 Canned Fruit (juice pack or light syrup)	1/2 cup								63
64 Canned Fruit (heavy syrup)	1/2 cup								64
65 Dried Fruit (eg. raisins/dates)	1/4 cup								65
66 Fruit Juice (Type 1) (eg. grape/cranberry/pineapple)	1/2 cup								66
67 Fruit Juice (Type 2) (eg. grapefruit/apple/orange)	1/2 cup								67
68 Vegetable Juice (eg. tomato, V-8)	1/2 cup								68
VEGETABLES									
69 Broccoli/Spinach	1/2 cup								69
70 Squash/Turnip	1/2 cup								70
71 Brussel Sprouts/Cabbage/ Cauliflower/Peppers	1/2 cup								71
72 Peas	1/2 cup								72
73 Corn	1/2 cup								73
74 Asparagus/ Wax or String Beans	1/2 cup								74
75 Carrots	1/2 cup								75
76 Cole Slaw	1/2 cup								76
77 Mixed Green Salad	1 cup								77
78 French Fries	15 pieces								78
79 Potatoes (mashed/baked/ /boiled) or perogies	1/2 cup 2 perogies								79

FOOD	EXAMPLE OF PORTION SIZE	BREAKFAST		LUNCH		SUPPER		SNACKS	
		Number of breakfasts with this food in the last three days	How many example portions per breakfast	Number of lunches with this food in the last three days	How many example portions per lunch	Number of suppers with this food in the last three days	How many example portions per supper	Number of snacks with this food in the last three days	How many example portions per snack
DESSERTS									
80 Pie	1/6 pie								80
81 Cake with Icing	2 1/2" square								81
82 Cookie	2 cookies								82
83 Pudding	1/2 cup								83
84 Ice Cream/Ice Milk	1/2 cup								84
85 Sherbet/Jello	1/2 cup								85
BEVERAGES									
86 Soft Drink (eg. cola, non-carbonated flavored beverages sweetened with sugar)	355 ml can								86
87 Diet Soft Drink	355 ml can								87
88 Tea/Coffee	1 cup								88
89 Beer	355 ml can								89
90 Wine	3 1/2 oz.								90
91 Hard Liquor (eg. rye, gin, vodka)	1 oz.								91
SNACK FOODS									
92 Potato Chips/Tortilla Chips	1 small bag								92
93 Popcorn	2 cups								93
94 Peanuts/Nuts	1/4 cup								94
95 Chocolate Bar	1 bar								95
EXTRAS									
96 Jam/Jelly/Honey/Sugar/ Brown Sugar	1 teaspoon								96
97 Peanut Butter	1 Tablespoon								97
98 Butter, margarine (on bread, muffins, vegetables, pancakes)	1 teaspoon								98
99 Salad Dressing/Mayonnaise (regular)	1 Tablespoon								99
100 Salad Dressing/Mayonnaise (light or calorie-reduced) Regular Sour Cream	1 Tablespoon								100
101 Gravy	2 Tablespoons								101

Appendix B

3-DAY RECORD

3-DAY FOOD INTAKE RECORD

This record will give you an analysis and assessment of your energy, protein, fat, carbohydrate, calcium and alcohol intake.

PLEASE TAKE YOUR TIME FILLING IN THE DETAILS, SO THE RESULTS CAN BE AS ACCURATE AS POSSIBLE.

Student #: _____ Age: _____ Sex: _____

Height:cm _____ or ft.in _____

Weight:kg _____ or lbs _____

Dates recorded: _____ Frame size: _____

To decide your frame size, place your fingers of one hand around the wrist of your other hand. If thumb and middle finger meet, fill in "medium frame", if they overlap, write "small frame" and if they do not meet, write "large frame".

INSTRUCTIONS:

1. Using the attached pages, record everything you eat and drink at home and away from home for three consecutive days. If possible, one of these days should fall on a weekend.
2. Describe each food item in as much detail as possible - include information such as brand name; fresh, frozen or canned; cut of meat; diet or regular; fat content of milk; etc. State cooking method (eg. baked, fried, broiled, microwaved, etc.), if applicable. Include description of any toppings that may have been served with the food (eg. sauces, gravy, salad dressing, sour cream, whipping cream, etc.).
3. Indicate the amount eaten for each food item. Some suggested ways of measuring foods are: grams, ounces, milliliters, cups, teaspoons, tablespoons, centimeters or inches.
4. Be sure to include all snacks, alcoholic beverages, soft drinks, candy, cream and sugar in coffee, tea, etc.
5. **REMEMBER THE MORE DETAILED YOUR FOOD RECORD, THE MORE ACCURATE YOUR NUTRIENT ANALYSIS.**

An example for one day is shown on the next page.

DATE: November 1, 1991 Student #: EXAMPLE

Food Item	Description (brand name; fresh/ frozen/canned; cut cut of meat; fat intake of milk, etc.)	Method of Cooking	Amount Eaten	OFFICE USE ONLY CNF CODE
Breakfast: grapefruit	pink, fresh		½ medium	
granola	Harvest Crunch with raisins		½ cup	
milk	2%		¼ cup	
coffee	brewed		1 cup	
cream	half + half		1 Tbsp.	
Lunch: tomato soup	canned, made with water	microwave	1 cup	
ham sandwich:				
bread	60% whole wheat		2 slices	
ham	Schneider's, extra lean		2 slices	
margarine	Becel		2 tsp.	
lettuce	Iceberg		1 leaf	
mayonnaise	Hellman's, light		1 Tbsp.	
milk	2%		8 oz.	
apple	McIntosh, peeled		1 medium	
Snack: chocolate bar	Coffee Crisp		57g	
Dinner: lasagna	homemade	baked	4" square	
parmesan cheese			2 Tbsp.	
garlic toast			2 slices, 1" thick	
with butter			2 Tbsp.	

DATE: November 1, 1991 Student #: EXAMPLE

Food Item	Description (brand name; fresh/ frozen/canned; cut cut of meat; fat intake of milk, etc.)	Method of Cooking	Amount Eaten	OFFICE USE ONLY CNF CODE
tossed salad :				
lettuce	Iceberg, shredded		1/2 cup	
tomato			1/3 medium	
green pepper	diced		1/4 small	
celery	chopped		1 stalk	
salad dressing	Kraft, Italian		1 Tbsp.	
pie	pecan		1/6 pie	
with whipped cream			2 Tbsp.	
wine	red, dry		1 4oz. glass	
Snack: tea	Earl Grey		1 cup.	
cookies	chocolate chip	homemade	2	

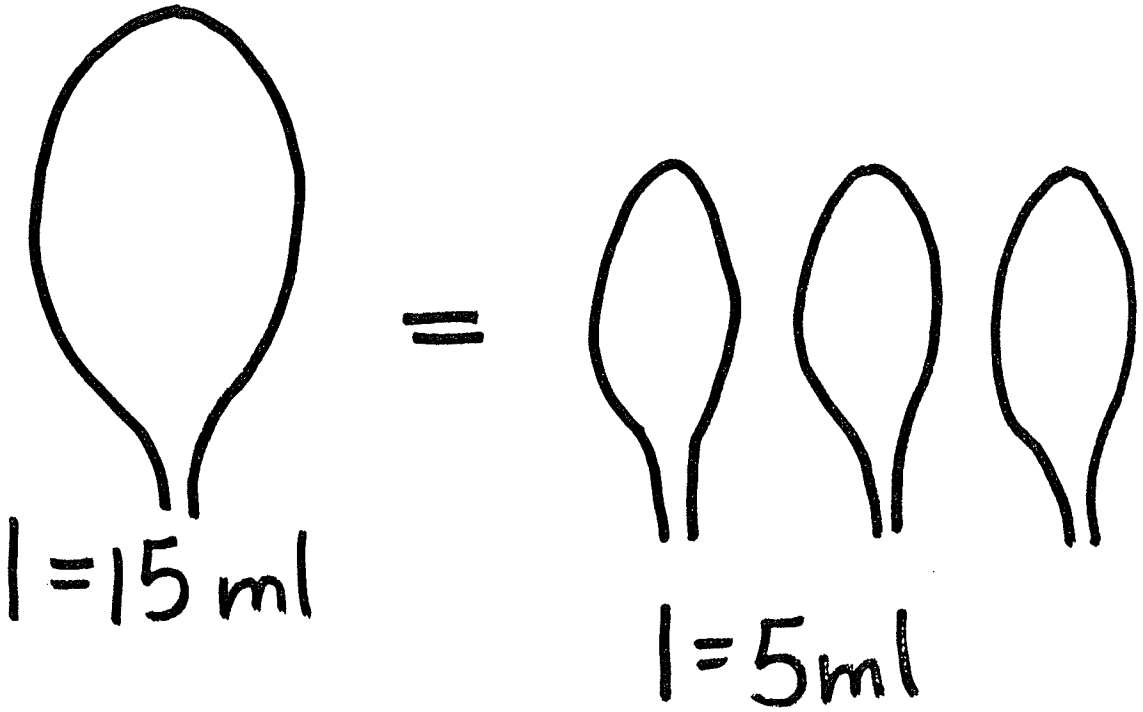
DATE: _____ Student #: _____

Food Item	Description (brand name; fresh/ frozen/canned; cut cut of meat; fat intake of milk, etc.)	Method of Cooking	Amount Eaten	OFFICE USE ONLY CNF CODE

Appendix C

HOUSEHOLD MEASURE GUIDE

1 Tablespoon = 3 Teaspoons



1 = 15 ml

1 = 5 ml

1 cup = 8 ounces
= 240 ml

½ cup = 4 ounces
= 240 ml

Appendix D

CONSENT FORM

CONSENT FORM

VALIDATION OF A FOOD FREQUENCY RECALL

The research project has been explained to me.

I agree to participate in a research project being conducted in the Department of Foods and Nutrition at the University of Manitoba.

I understand that I will be asked to complete a total of 3 questionnaires.

I can withdraw from the study at any given time during data collection.

I understand that my decision to participate or not participate in this study will not affect any of my academic activities or evaluations, including those of 28.101 (Human Needs in the Near Environment).

Date _____

Name _____