Development and Validation of a Semi-quantitative Food Frequency Questionnaire to Assess Dietary Intake of Adult Women Living in New Zealand

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Abstract

Background: There has been an increase in diet-related disease over the last decade (University of Otago & Ministry of Health, 2011). Food frequency questionnaires (FFQ) are commonly used to investigate the dietary intake of large populations, due to ease of administration and cost effectiveness. At present in New Zealand (NZ), an up-to-date, culturally appropriate food frequency questionnaire (FFQ) for assessing dietary intake is lacking.

Objectives: To develop and validate a culturally appropriate, computerised, semi-quantitative food frequency questionnaire to assess the dietary intake of young adult women living in New Zealand; to assess the dietary intake of this population using the questionnaire.

Methods: Participants (n = 110) were women (16 - 45 years) of Māori, Pacific or European ethnicity. They completed the New Zealand Women's Food Frequency Questionnaire (NZWFFQ) assessing dietary intake over the previous month, and a four-day weighed food record. Validity was evaluated by comparing nutrient intakes from the FFQ with the food record using paired t-tests, Pearson's correlation coefficients, cross-classification, weighted kappa and Bland-Altman analysis. Validity was assessed for raw data, and data adjusted to account for fruit and vegetable intakes.

Results: Nutrient intakes were significantly higher from the NZWFFQ data compared with the food record for all nutrients except monounsaturated fat, polyunsaturated fat and alcohol ($p < 0.05$). Pearson's correlation coefficients ranged from 0.10 (iron) to 0.80 (vitamin A) with an average of 0.39 ± 0.14. Correct quartile classification ranged from 22% (phosphorus) to 47% (saturated fat). Correct classification into same and adjacent quartiles ranged from 62% (iron) to 86% (saturated fat). Gross misclassification into opposite quartile ranged from 3% (saturated fat) to 10% (iron). For weighted Kappa, saturated fat had moderate agreement ($\kappa = 0.41 - 0.6$), and other nutrients had fair agreement ($\kappa = 0.21 - 0.4$). These findings only differed marginally following fruit and vegetable adjustment, with the exception of vitamin A in which validity measures decreased.

Conclusion: The NZWFFQ had good relative validity for ranking individuals by dietary intake, and was able to categorise participants with higher or lower intake than reference ranges. Similarly to previous literature, The NZWFFQ overestimated dietary intake. Therefore, it is not suitable for assessing absolute dietary intakes.

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Abbreviation List

4DFR	Four-day Food Record
AARP	American Association of Retired Persons (Cohort)
AI	Adequate Intake
AMDR	Acceptable Macronutrient Distribution Range
BF%	Body Fat Percentage
BIA[1]	Bioelectrical Impedance Analysis
BMI	Body Mass Index
BMR	Basal Metabolic Rate
BOD POD[1]	Air Displacement Plethysmography
CI	Confidence Interval
CVD	Cardiovascular Disease
DEXA[1]	Dual Energy X-ray Absorptiometry
EAR	Estimated Average Requirement
EXPLORE study	Examining Predictors Linking Obesity Related Elements
FFQ	Food Frequency Questionnaire

κ	Kappa statistic
LER	Low Energy Reporter (of dietary intake)
LOA	Limits of Agreement
NHMRC	National Health and Medical Research Council
NRV	Nutrient Reference Value
NZ	New Zealand
NZANS	New Zealand Adult Nutrition Survey
NZEU	New Zealand European
NZRD	New Zealand Registered Dietitian
NZWFFQ	New Zealand Women's Food Frequency Questionnaire
p	p-value (statistical analysis)
PAL	Physical Activity Level
$Pr(a)^2$	Relative observed agreement
$Pr(e)^2$	Hypothetical probability of chance agreement
r	Correlation coefficient (statistical analysis)
RDI	Recommended Daily Intake

RMR	Resting Metabolic Rate
SD	Standard Deviation
SOP	Standard Operating Procedure

Note. [1]Are methods of measuring body composition (BIA, BOD POD and DEXA); [2]Are components of Goldberg's cut-off method measuring under-reporters of dietary intake.

1. Introduction

1.1. Background

With growing evidence of the link between diet, health and disease, it is becoming increasingly important to assess dietary intake. For chronic diseases such as obesity, type 2 diabetes, cardiovascular disease (CVD) and some cancers, diet is a key modifiable risk factor (Alwan, 2001). Dietary assessment enables further exploration and understanding of the links between dietary intake, health and disease, with the potential to influence health status worldwide (Chiuve et al., 2011; Gonzalez, 2006).

There has been a considerable change in food availability and dietary patterns over recent years (University of Otago & Ministry of Health, 2011), with increases in portion sizes, snacking and consumption of meals prepared outside the home. These changes have resulted in a greater proportion of energy now being provided by foods that are nutrient-poor and energy-dense such as fast foods, sugar-sweetened drinks, cakes, salty snacks, biscuits and confectionary. It has been suggested that we now live in an 'obesegenic environment' in which weight gain is promoted (Giskes et al., 2011; Swinburn, 2008).

Furthermore, over the last decade there has been a concurrent increase in diet-related disease (Ministry of Health, 2013; Russell et al., 1999; University of Otago & Ministry of Health, 2011). Obesity (body mass index (BMI) over 30 kg/m^2) (World Health Organisation, 2007) in adult New Zealand (NZ) women (15+ years) has increased from 21% in 1997, to 32% in 2008/2009 (Statistics NZ, 2014). These rates are even higher within some ethnic groups, with 73% of Pacific, and 54% of Māori females now obese (Statistics NZ, 2014). Obesity has a negative impact on health; increasing the risk of developing type 2 diabetes, cardiovascular disease and some cancers (Statistics NZ, 2014). This negative impact is evident through the increased prevalence of Type 2 diabetes. Over 13% of Pacific females aged over 15 now have Type 2 diabetes; these rates are more than four times higher than those of non-Pacific females (Ministry of Health, 2013).

Paradoxically, micronutrient intake remains a problem. It is estimated that between 6 - 34% of females aged 15 - 50 years have an inadequate intake of dietary iron. Furthermore, iron deficiency (serum ferritin < 12 µg/L and zinc protoporphyrin > 60 µmol/mol) affects between 10 - 12% of this female age group (Otago University & Ministry of Health, 2011). Inadequate intake is even higher for the micronutrient calcium, with 56 - 88% of females aged 15 - 50 years not meeting national recommendations (Otago University & Ministry of Health, 2011).

In order to further establish associations between dietary intake, health and disease, it is important to develop validated dietary assessment tools. Traditionally, food records have been the preferred method of dietary intake assessment. The food record is a prospective method of dietary assessment, in which the participant records all foods and beverages consumed over a period of one or more days. Details that are recorded include; the types and brands of foods consumed, exact food quantities measured at the time of intake, food preparation and cooking methods. However, there is a large participant burden with this method, and multiple days of data collection and processing require extensive effort and cost to the research team (Willet, 2013).

Therefore, when investigating the dietary intake of large populations, the food frequency questionnaire (FFQ) is now commonly used as it is more cost effective and less time consuming for both the participant and research team (Gibson, 2005; Thompson & Subar, 2008; Willet, 2013; Willet, 1998). Usual intake is better approximated with the FFQ, a retrospective method which enables intake to be assessed over a longer period in comparison to the food record. It is important to note that the FFQ is not a suitable tool for estimation of actual nutrient intake, rather it is able to categorise participants based on their intake (high, moderate, low), and also identify those at the upper and lower extremes (Thompson & Subar, 2008; Willet, 2013; Willet, 1998).

The FFQ is provided in a survey format, often computerised, with a list of foods presented to the participant. Participants are required to select how often each food item is consumed (e.g. never, twice a month, once a week, once a day). Some FFQs have an additional component assessing the portion size of food items. In a quantitative FFQ, the participant is required to self-select their portion size, whereas a semi-quantitative FFQ provides a standard (albeit subjective) portion size. Although more dietary information may be ascertained with the inclusion of portion sizes, the estimation involved is one of the greatest sources of error in dietary assessment (Willet, 1998).

Food frequency questionnaires need to be current and specific for the population of interest, as food preferences, availability, dietary patterns and intake differ not only between individuals, but also over time (Cade et al., 2004; Cade et al., 2002; Willett, 1998). Furthermore, FFQs are culturally specific, performing differently across subcultures within a population. Mayer-Davis et al. (1999) found lower correlations between the FFQ and the reference method (24-hour recalls) in Hispanics and African Americans when compared to those found for non-Hispanic white populations, ranging between 0.21 - 0.72 and 0.24 - 0.89 respectively. A NZ study by Metcalf et al. (1997) also found lower correlations for Māori and Pacific subgroups which ranged between 0.36 - 0.63, in comparison to those for NZ Europeans between 0.41 - 0.65. These findings highlight the importance of including culturally relevant foods in a FFQ (Cade et al., 2002; Willet, 2013).

It is vital that a FFQ is assessed for validity in the population of interest before it is used. Even small, subtle design changes can affect the performance of a FFQ (Cade et al., 2004, 2002). Validity involves comparison with another dietary assessment method such as a food record, ensuring the FFQ measures what it is intended to measure (Willet, 2013). The comparison can be undertaken using a range of statistical methods including comparison of group means, correlation coefficients, cross-classification, weighted kappa statistics and Bland-Altman analysis. There is no single 'gold standard' method of statistical analysis, thus it is recommended that dietary validation studies use a combination of statistical methods, rather than one in isolation (Willet, 2013).

1.2. Purpose of the Study

At present in NZ, an up-to-date, culturally appropriate FFQ is lacking. Although FFQs have been developed to evaluate multi-nutrient intake in NZ adults, only five have investigated validity (Bell et al., 1999; Bolch, 1994; Metcalf et al., 1997; Sam et al., 2012; Sharpe et al., 1993). Four of these FFQs are not suitable for use, as validation was undertaken at least 15 years ago. The only recent FFQ evaluated the diet of a population who were male and female, aged 30 - 59 years and primarily NZ European (Sam et al., 2012). The total proportion of Māori and Pacific participants was 5%, much lower than the total NZ national representation of 22.3% (Statistics NZ, 2014). Therefore, this FFQ may not be suitable to assess varying nutrient intake across cultures in the NZ population. These limitations highlight the need for a validated, culturally appropriate FFQ to assess the nutrient intake of young adult women living in NZ. Such an FFQ will be able to be used in future studies, exploring associations between nutrient intake, health and disease in young adult women living in NZ.

1.3. Aim

To develop and validate a culturally appropriate semi-quantitative food frequency questionnaire for use in young adult women living in NZ.

1.3.1. Objectives

- To develop a culturally appropriate, computerised, semi-quantitative food frequency questionnaire to assess the dietary intake of young adult women living in NZ.
- To assess the dietary intake of a convenience sample of young adult women living in NZ.
- To validate the computerised, semi-quantitative food frequency questionnaire (using a four day weighed food record) for dietary intake in young adult women living in NZ.

1.4. Thesis Structure

This study has been structured into six chapters. Chapter one introduces concepts covered in this research and highlights the purpose of the study. The second chapter is a review of the literature, covering the relationship between diet and health, dietary assessment methods and challenges, development and validation of a food frequency questionnaire (FFQ), and a review of previously validated FFQs. The third chapter details and justifies the methodology used to develop and validate a FFQ. Chapter four reports the results of this study. This is followed by chapter five which discusses the findings from this study. To conclude, chapter six is a summary of the study, including a reflection of strengths, limitations and recommendations for future use and research.

1.5. Researchers' Contributions

Table 1.1: Researchers Contributions to this Study

Researchers	Contributions to the Thesis
Zara Houston	Designed and led the NZWFFQ validation study, developed the NZWFFQ recruited participants, screened participants, supervised participant testing, data collection of the NZWFFQ and 4DFR, data entry of the NZWFFQ and 4DFR, data analysis, statistical analysis, interpretation of results.
Dr Kathryn Beck	Academic supervisor and assistance/ guidance of: research design, NZWFFQ development, methods and protocols, statistical analysis, results interpretation, thesis revision and approval.
Dr Rozanne Kruger	Application for ethics, Academic supervisor and assistance/ guidance of: research design, NZWFFQ development, methods and protocols, results interpretation, thesis revision and approval. Principal investigator for EXPLORE study.
Adrianna Hepburn and Sarah Philipsen	Assistance with data entry of the 4DFR.
Jenna Schrijvers and Chelsea Symons	Assistance with data entry of the NZWFFQ.
	Wider EXPLORE study Contributions ***(note: participants were recruited from this wider study and completed the semi-quantitative questionnaire during EXPLORE testing)***
EXPLORE co-ordinators: Wendy O'Brien and Shakeela Jayasinghe	Coordinated EXPLORE participant recruitment, screening and testing.
EXPLORE recruitment and screening: Wendy O'Brien, Shakeela Jayasinghe, Zara Houston, Sarah Philipsen, Adrianna Hepburn, Rozanne Kruger	Participant recruitment and screening across Auckland.
EXPLORE testing: Wendy O'Brien, Shakeela Jayasinghe, Zara Houston, Pam von Hurst, Cathryn Conlon, Richard Swift, Owen Mugridge, Maria Casale, Andrea Fenner, Adrianna Hepburn, Sarah Philipsen, Jenna Schrijvers, Rozanne Kruger, Kathryn Beck	Participant testing which included eight stations measuring: blood pressure, taste perception, three measures of body composition and three dietary questionnaires (one of which was the semi-quantitative questionnaire).
PC Tong	Assistance with Survey Monkey, equipment for data collection.

Note. NZWFFQ = New Zealand Women's Food Frequency Questionnaire; 4DFR = four day weighed food record.

2. Literature Review

2.1. Introduction

This review of literature explores several aspects related to dietary assessment in young women. Within this literature review, associations between dietary intake, health and disease outcomes in young women are reviewed, emphasising the importance of accurate dietary assessment methodology. The various methods and challenges of assessing dietary intake in individuals and groups are then explored, with a particular focus on the use of food frequency questionnaires (FFQs). This is followed by a review of the factors to consider when developing a FFQ, and methods of validation for a newly developed FFQ.

The following online databases were systematically searched for relevant literature: PubMed, Web of Science and Google Scholar. The publication period ranged from 1961 to 2014. The search was undertaken in reverse chronological order using the key search terms: food frequency questionnaire, diet assessment, valid, female, disease, health, diet trends and New Zealand. Key terms were also used in combination with the two functions; 'AND' 'OR'. Full text English journal articles that matched the search criteria were reviewed, as were relevant citing articles. A manual search was also undertaken using reference lists from recent review articles and validation studies to identify further literature.

2.2. Dietary Intake and Health in Young Women Introduction

There is a growing body of evidence regarding the relationship between diet, health and disease. One of the key determinants of health is nutrition, therefore, it is important to be able to assess dietary intake accurately to further explore this relationship in young women. Nutrition-related risk factors (such as Body Mass Index (BMI), blood pressure, fruit and vegetable intake, and total blood cholesterol) are known to cause diabetes, cancer, stroke, heart disease and other major health issues (Ministry of Health, 2013). These dietary risk factors collectively account for over 11% of health loss in New Zealand (NZ) i.e. healthy life that is lost to illness, premature death or disability (Ministry of Health, 2013; World Health Organisation, 2002). Obesity in NZ women has increased by 150% from 21 to 32% over the last decade, and diabetes in Pacific women is now at an all-time high of 13% (Statistics NZ, 2014). By assessing dietary intake, there is potential to improve these modifiable risk factors in young NZ women, reducing the future burden of disease.

Paradoxically, micronutrient intake remains a problem. The results of the New Zealand Adult Nutrition Survey 2008/09 (NZANS) found the prevalence of iron deficiency (i.e. serum ferritin < 12 µg/L, and zinc protoporphyrin > 60 µmol/mol) in NZ females to have doubled from 2.9% to 7.2% since 1997 (Otago University & Ministry of Health, 2011). Rates are highest in females aged 15 - 18 (10.6%) and 31 - 50 (12.1%) years. These groups also had the lowest dietary intake of iron, with an estimated 34.2% and 15.4% respectively, not meeting national daily recommendations (Otago University & Ministry of Health, 2011).

Dietary calcium intake is also an issue for NZ females. The NZANS (08/09) found that 73% of females had an inadequate intake of calcium. Of particular concern is the sub-group of 15 - 18 year old Pacific and Māori females, in which 95% had an inadequate intake of calcium (Otago University & Ministry of Health, 2011). Young adulthood is the period where peak bone mass is developed. A low calcium intake puts these females at greater risk of osteoporosis in later life (Mann & Truswell, 2007; Ministry of Health, 2013).

2.3. Dietary Assessment Methods

The four main dietary assessment methods that are commonly used include food records, 24-hour recall, diet history and the food frequency questionnaire (FFQ). The advantages and disadvantages of the four dietary assessment methods are outlined in table 2.1.

Food records and 24-hour recalls often assess dietary intake over short periods, capturing the specific foods an individual has consumed over the duration of one or more days. With a weighed food record, the participant is required to directly weigh and record all of the food and beverages they consume, ideally completed at the time of consumption to remove reliance on memory. With an estimated food record the participant simply records food and beverages in terms of household portion sizes, ideally as they are consumed. Reported intakes may decrease due to fatigue if recording is required longer than four consecutive days (Gersovitz et al., 1978; Gibson, 2005; Willet, 2013). Non-consecutive days of reporting can be beneficial to reduce participant burden.

The 24-hour recall is used to assess what the participant has consumed during the previous 24 hours. This method relies on memory, and is conducted in an interview format, usually by a trained interviewer (Thompson & Subar, 2008).

In contrast, the FFQ and diet history explore the individual's usual food intake over a longer period of time (Willet, 2013). The FFQ is used to assess how frequently a list of food items is consumed over a given period i.e. a month. It is provided in a survey format and is often self-administered. The diet history is usually performed by a trained interviewer, who conducts a structured interview of questions regarding habitual food intake from the core food groups (e.g. fruit and vegetables, bread and cereals etc.) over the past seven days. A cross check is then conducted, where further detail is obtained about usual intake over the past three to 12 months. The cross check may also explore the makeup of meals and cooking techniques (Thompson & Subar, 2008). A diet history is often used by dietitians in the clinical setting.

In recent years as technology has developed, new dietary assessment methods are emerging e.g. the use of digital images and mobile phone applications. Digital images can be taken using mobile phones or digital and disposable cameras to capture food selection, meals and plate waste. Some validity studies assessing digital images have found energy and nutrient intakes to be significantly underestimated in comparison to the reference method (Kikunaga et al., 2007; Lassen et al., 2010; Martin et al., 2009). Other emerging tools are phone applications that function as food records. They use built-in cameras, integrated image analysis and a nutrient database that allows users to record foods that have been consumed (Zhu et al., 2010). At present, these methods are very time consuming for the researcher, but with future technological advancement their use may become more common.

Table 2.1: Advantages and Disadvantages of Various Dietary Assessment Methods (adapted from Thompson & Subar, 2008)

Dietary Assessment Methods	Advantages	Disadvantages
FFQ	• Total dietary information obtained over the past 1 month to 1 year • Lower comparative participant burden • Assesses usual individual dietary intake • Eating behaviour is not affected • Lower cost to researcher • Lower researcher and participant burden	• Intake may be misreported • Precision is not quantifiable • Cognitively difficult for participants • Dependent on participants' memory • Researcher burden for quality control of data capturing and entering/ cleaning of data
Food records	• Not reliant on memory • Often used in validation studies as a reference method - least correlated errors with other methods dependent on memory e.g. FFQ • Quantifiable dietary intake • Potential to enhance behaviour change or weight control through self-monitoring	• Participant and researcher burden is high • Participant training required, must be motivated and literate • Potential non-response bias thus non-representative sample • Cost to researcher high • Usual intake requires many record days • Reduction of intake reporting with time • An increase in days recorded increases attrition • Eating behaviour may be affected • Under-reporting of intake is common
24 hour recalls	• Eating behaviour not affected • Low participant burden • Quantifiable dietary intake • Reduced non-response bias, as performed by interviewer/ researcher • Appropriate across populations	• High cost to researcher • Under-reporting of dietary intake • Usual intake requires many recall days • Dependent on participants memory
Diet history	• Total dietary information obtained over the past 1 month to 1 year • Food consumption information per meal • Assesses usual individual dietary intake • Eating behaviour is not affected	• High burden to researcher • Dependent on participants' memory • Often intake is misreported • Precision is not quantifiable • Cognitively difficult for participant

2.4. Dietary Assessment Challenges in the Adult Population

There are a number of challenges associated with assessing the dietary intake of adult populations. These include under-reporting, dietary variation, quantifying supplement use, participant and researcher error, analysis of dietary intake and selecting a dietary assessment method. These challenges are reviewed in the following sections.

2.4.1. Under-reporting

Under-reporting (or mis-reporting) is a common problem with dietary surveys. In Western populations there has been an increase in the degree of under-reporting over the last two-to-three decades (Heitmann & Lissner, 1995; Hirvonen et al., 1997; Ministry of Health, 2013), with some studies describing levels of under-reporting as high as 25% in some participants. Furthermore, 77% of women were identified as under-reporters in the study by Rennie et al. (2007). This increase is believed to reflect not only the increased obesity prevalence, but also increased awareness of what constitutes a healthy diet i.e. social desirability bias (Ministry of Health, 2003).

Current national data on dietary intake is provided by the New Zealand Adult Nutrition Surveys (NZANS). These surveys are undertaken every 10 years, using either FFQs or 24-hour dietary recalls (Otago University & Ministry of Health, 2011). Under-reporting in the most recent NZANS was investigated by Gemming et al. (2014). The study found reported energy intake had decreased from 1997 to 2008/09 however, body weight and Body Mass Index (BMI) of the NZ population markedly increased over this time (Statistics NZ, 2014). Analysis identified respondents that were low energy reporters (LERs) i.e. participants whose ratio of energy intake to estimated Resting Metabolic Rate (RMR) was less than 0.9. More women (25%) than men (21%) from the NZANS 08/09 were classified as LERs. The prevalence of LERs was significantly greater in people who were either obese (BMI ≥ 30 kg/m² (30%) or overweight (BMI 25 - 29.99 kg/m²) (25%), in comparison to those with a normal BMI (18.5 - 24.99 kg/m²) (16%) ($p < 0.001$). These findings are supported by other studies in women living in developed countries (Olafsdottir et al., 2006; Kretsch et al 1999). There was also a significantly greater LER prevalence in Pacific people (33%) in comparison to Māori (26%) ($p < 0.01$), and NZEU (23%) ($p < 0.001$). Furthermore, there was a substantial increase in LER prevalence from the NZANS 97/98 to the NZANS 08/09 across most population groups (Gemming et al., 2014). These findings highlight the need for studies to take under-reporting into account when assessing dietary intake in populations.

2.4.2. Dietary Variation

Dietary intake varies from day to day in free-living individuals, over and above an underlying consistent dietary pattern (Willet, 2013). If daily intake was random, with no element of consistency, then it would not be possible to measure nutrient effects epidemiologically. Dietary variation can be influenced by systematic factors such as season and days of the week e.g. fruit and vegetable intake can vary depending on the season (Ziegler et al., 1984), and intake can differ between week days and the weekend (Willet, 2013). Some studies suggest variations in total energy intake also occur during the menstrual cycle (Davidsen et al., 2007) however, this influence is minor in comparison to other dietary intake factors such as physical activity (Willet, 2013).

Variation in day-to-day intake also differs across nutrients, and this needs to be considered when assessing dietary intake (Cade et al., 2002). For example, total energy varies the least due to well-regulated physiological mechanisms. Macronutrients vary moderately day-to-day, and contribute largely to energy intake. In contrast, micronutrients have a large variation as they are often concentrated in particular foods. Daily intakes of these nutrients can be high or low depending on an individuals' food selections, requiring multiple days of dietary assessment to determine 'usual intake' across nutrients (Willet, 2013). Willet recommends at least 28 days for assessment of vitamin A intake due to seasonal differences in intake, and concentrations in specific foods e.g. liver that are not eaten daily. Although long periods of dietary assessment are ideal, this is often not feasible in epidemiologic research due to the increased burden on participants, and the duration required for researchers to process the data (Cade et al., 2002). Therefore, samples of one or a few days are usually measured. Short sampling methods influence the distribution or spread of intakes across a population, increasing the standard deviation. This effect is demonstrated with participants on the extremes; those with low true intakes will have days when intake is lower than their long-term average, and those with high true intakes will have days when intake is above their long-term average. When only a short duration of intake is assessed, the likelihood of this effect is greater, thus, the distribution of intakes across the population will increase (Willet, 2013).

2.4.3. Quantifying Supplement Use

Dietary supplements are becoming increasingly popular, with thousands of commercial products now readily available in pharmacy's, supplement stores, supermarkets and online. The nutrients in these products come in varying quantities and different chemical forms (Zerwekh, 2008). Therefore, it is difficult to quantify how much supplements contribute to an individual's measured dietary intake. Although consideration of supplements is recommended when assessing dietary intake (Roswall et al., 2010), the FFQ validation studies included in this literature review did not investigate supplement use.

2.4.4. Participant and Researcher Error

Systematic and random errors occur in all methods of dietary assessment. These can include errors in recording, estimation of portion sizes and using national food composition tables. The quality of data collected depends on the processes used, ensuring the assessment method is suitable for the population, having trained staff, and using standardised protocols i.e. standard operating procedures (SOPs) (Willet, 2013).

2.4.5. Analysis of Dietary Intake

A common error that applies to both food records and FFQs is the food composition database which is used for dietary analysis. Ideally, the same composition database should be used for both dietary methods, as this will match errors, and decrease the effect of such errors on the validity assessment. Selection of an appropriate database should consider the following: using a national database, relevant population-specific foods, and appropriate nutrients for local foods. This database should be regularly updated as the composition of foods change frequently through continuous development of new foods, and changes in food preparation methods (Margetts & Nelson, 2010). Between databases there will be variations in what foods have been included, and also the nutrient content of foods due to differences in analysis methods (Greenfield & Southgate, 2003). Thus, the importance of the nutrients' accuracy and completeness should be considered when selecting the database (Thompson & Buyers, 1994).

Accuracy will be reduced if too many foods need to be substituted because their absent from the database (Greenfield & Southgate, 2003).

2.4.6. Selecting a Dietary Assessment Method

The choice of which dietary assessment method to use is largely dependent upon the purpose and objectives the study. Time and budgetary considerations are often factors, with FFQ's typically imposing less researcher and participant burden compared to food records. Characteristics of the target population should be considered (Willet, 2013). For example, the pilot investigation from the Nurses' Health study revealed that after undertaking an FFQ, only 40% of participants would complete a one week food record (Stryker et al., 1991). Furthermore, a food record was only provided by 14% of participants from the American Association of Retired Persons (AARP) cohort who took part in a small pilot investigation (Willett, 2008). Willet (2013) believes the perceived burden for participants to complete a food record or 24-hour diet recall is exacerbated by the rigorous procedures they involve. It is thought that motivation may be enhanced by the introduction of an engaging or fun element to electronic versions, such as creating avatars (Willet, 2013).

When investigating large populations in epidemiological studies, the FFQ is now commonly used as it is cost effective to process and distribute in comparison to other more intensive dietary assessment methods (Gibson, 2005; Thompson & Subar, 2008; Willet, 1998). Willet (2013) states that "Since the 1980s, substantial refinement, modification, and evaluation of food frequency questionnaires have occurred, so that data derived from their use have become considerably more interpretable" (Willet, 2013, p. 71).

2.4.6.1. The Food Frequency Questionnaire

The FFQ is provided in a survey format, where a list of foods is presented to the participant. Participants are required to select how often each food item is consumed e.g. never, twice a month, once a week, once a day etc. The food list should be specific to the purpose of the study, and to the population of interest (Thompson & Subar, 2008).

Traditionally, the descriptive qualitative design of the FFQ provided information on food consumption patterns. These simple frequency questionnaires assessed how often a given list of foods was consumed. Developments were then made by adding portion sizes to provide nutrient information, encompassing a quantitative design. Quantitative FFQs are discussed in further detail in section 2.6.3. 'Portion Size Estimation'.

Supplementary questions may be included in the FFQ. These often cover preparation methods, cooking methods, food types and brands. Cross-check questions can also be included, which assess how frequently whole food groups are consumed e.g. 'how many serves of vegetables do you usually eat each week'. The agreement between this cross-check question and individual vegetable item questions can then be assessed. Some FFQs provide an open-ended section, allowing participants to report foods and frequencies of items not included on the food list. This ensures that the participant's total diet is captured, and it may identify individuals who consume foods that are not included in the FFQ (Calvert et al., 1997).

Average long-term or usual dietary intake is better approximated with an FFQ, which assesses a longer period of diet exposure compared with other dietary assessment methods that only assess a few specific days (e.g. food record or 24-hour recall). The trade-off is that crude information is gathered over an extended duration in exchange for precise information over a very short duration. A description of the usual frequency that a food is consumed relies on *generic* memory, and is believed to be easier for participants as opposed to describing specific foods that were consumed during a past meal, which relies on *episodic* memory. Cognitive research supports this concept (Bradburn et al., 1987; Smith, 1993; Smith et al., 1991). This method also captures nutrients where intake varies from day-to-day such as iron. Such nutrients are difficult to measure with the 24-hour recall and food record (Willet, 2013).

Literate participants can complete the FFQ on paper or online in a self-administered format. Alternatively, the FFQ can be administered by an interviewer, although this is associated with cost and time implications. The FFQ can be difficult to administer for populations with low literacy. It has been suggested by Cade et al (2002) that in these populations, a 24-hour recall may be a more suitable dietary assessment method.

As outlined in table 2.1 above, there are weaknesses in all methods of dietary assessment. The FFQ is a retrospective method, dependent upon the participant's memory and accuracy in estimating portion sizes. Therefore, the food categories should be clear and familiar to the population of interest (Sam et al., 2012), and it is also crucial to include ethnically traditional foods which contribute significantly to nutrient intake (Willet, 2013).

2.5. Development of a food frequency questionnaire

There are multiple stages involved in the development of any dietary assessment method. Initially a literature review is undertaken; the stages that then follow depend on the method selected and the purpose of the investigation. These are outlined in figure 2.1.

Stages to Consider in the Development of a Food Frequency Questionnaire

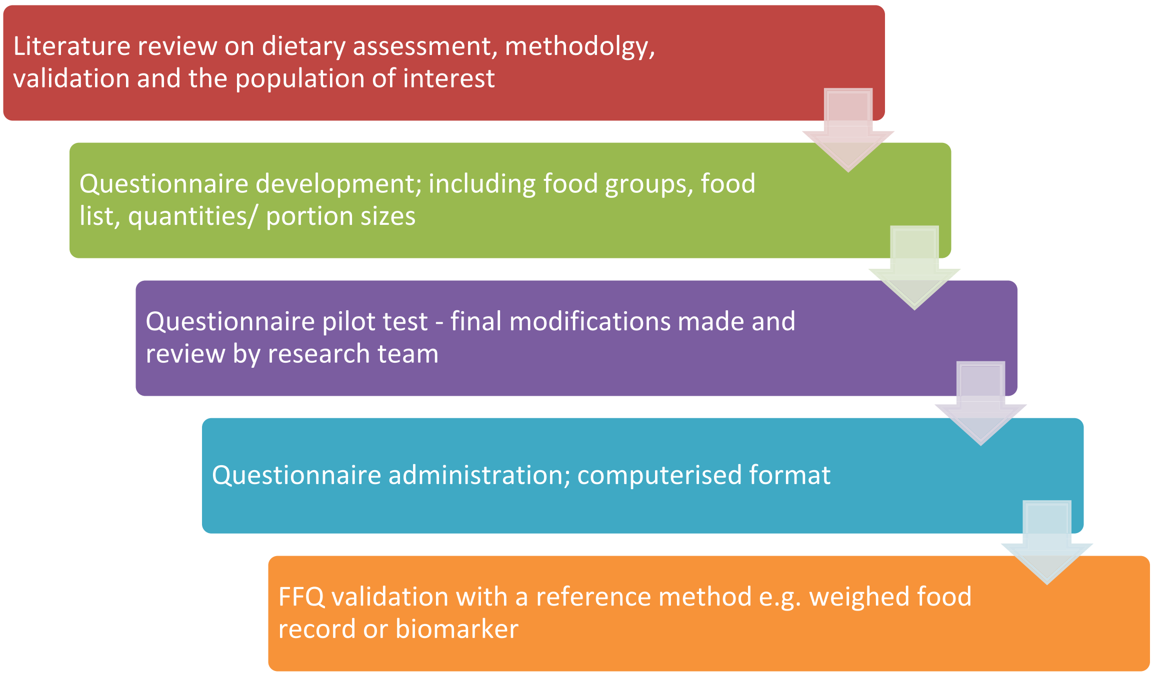


Figure 2.1: Process involved in the development of an FFQ.

2.6. Components of a Food Frequency Questionnaire a FFQ

The questionnaire design is dependent upon the objectives of the study i.e. whether intake of specific foods will be measured (single-nutrient FFQ) or conversely, whether a more comprehensive dietary intake assessment will be undertaken (multi-nutrient FFQ). Multi-nutrient FFQs are usually the most desirable option due to difficulties anticipating which dietary questions will be important upon analysis. For example, some important food items may be excluded in overly restrictive food lists (Willet, 2013).

Another questionnaire design consideration is whether ranking individuals dietary intake is the primary objective, or alternatively, measuring absolute intake. Ranking of intake is often used in epidemiological research, and enables categorisation of participants with higher or lower intake than reference ranges, and identification of those at the extreme ends of nutrient intake distribution. Ranking is performed using statistical methods, for example correlation coefficients (r) can be used to express the accuracy of ranking between the dietary tool (e.g. the FFQ), and the reference method (e.g. food record). The r values can then be interpreted in relation to the proportion of participants who are correctly classified into the bottom or top quartile of the distribution of energy or nutrient intakes. For studies comparing health characteristics and diet within groups, correct classification is important (Nelson et al., 1989). In contrast, absolute intake compares the actual intake obtained from the dietary tool with the reference method. Statistical methods can be used to assess the agreement between two dietary methods, and include mean nutrient data and Bland-Altman statistics.

Once the objectives of the FFQ design have been established, the development of the FFQ involves three main components; the food list, frequency-response options and portion size estimation (Willet, 2013). The following sections explore factors that need to be considered within each of these three components.

2.6.1. The Food List

The food list is the first step in developing an FFQ. It is important to consider food groups, the number of foods items within each group and the order of such food items.

It is critical that the food list is assembled in an unambiguous and clear format. The FFQ should aim to capture the required information from a minimal amount of questions (Cade et al., 2004), with careful selection of the most informative food items (Willet, 2013). Willet (2013) has suggested that there are three general characteristics of an ‘informative’ food: that it is used often by a number of participants, that it has a substantial nutrient content for that being investigated, and that variations in use differ across participants. Some examples of informative foods include bread varieties, cheese or bananas. Participants may fatigue with a FFQ which contains too many food items; losing interest and or focus, leading to mistakes (University of Otago & Ministry of Health, 2011). The food list is designed to capture both the key nutrients of interest, and commonly eaten foods of the population. Cade et al. (2002) performed a review of over 200 FFQs and found that FFQ food lists had a median of 79 items, and varied from between 5 to 350 items. The main determinant of the questionnaire length was the number of nutrients that the FFQs were designed to assess e.g. single versus multi-nutrient. It was previously suggested by Willet et al. (1998) that 100 food items represented the cut-off point at which the quality of answers would reduce thereafter due to boredom and fatigue. Willet (2013) now believes the limit may be approached at 130 food items, and that participants who are willing to undertake long dietary questionnaires often have a strong interest in nutrition.

It is also important to have an ordered and structured food list, as the interpretation of a food item can be influenced by another. Related food items need to be clustered together in same food category (Willet, 2013). For example, within these food categories, specific foods e.g. chocolate muesli bar should appear before general foods e.g. the standard muesli bar (Cade et al., 2004).

The most important food groups should be found near the start however, they also should not be the very first questions. This is due to the high question error rate initially, until participants understand how to respond. Further errors rise again at the end of the questionnaire when fatigue sets in (de Castro, 1991). Comprehension and interpretation is enhanced when single foods are questioned in a simple and clear manner, in comparison to long complex questions that include multiple foods (Andersen et al., 2002; Bascand, 2011; Cena et al., 2008; Peterson et al., 2008; Thompson et al., 2008, 1994; Thurnham, 1988; Willet, 2013). For example, if the researcher wanted to know how often plums, peaches and apricots were consumed it would be easier to ask the participants three simple questions on each food item, rather than having to consider the fruits separately, integrating all three frequencies and provide an average frequency (Willet, 2013). Whilst having three separate questions in this example does make the FFQ longer, it may in fact be quicker for the participant to complete due to ease of comprehension.

Following these considerations, the food list can be compiled using several approaches. The food list from a pre-existing FFQ can be modified to include or exclude food items relevant to the population of interest. Alternatively, published food composition tables can be used to identify foods containing the nutrients of interest. However, this method will include foods which have a high concentration of some nutrients e.g. iron in black pudding, but that are not consumed frequently enough to contribute to the data. It has been suggested that pilot testing the questionnaire in a similar population (to that of interest) can help this issue, as infrequently consumed foods can be deleted, or a stepwise regression analysis can be undertaken to identify discriminating foods (Heady, 1961).

2.6.2. Frequency Response Options

The next step in development of the FFQ is the frequency response options. These can either be given in a closed or open-ended format. The closed format often uses multiple choice questions asking participants how often they consume the item with given responses e.g. ranging from never through to multiple times daily. This reduces coding time, and increases the completion rate. Whilst open-ended questions have the potential to obtain more information, they often have lower completion rates, more transcription errors, and increase the coding time. Due to this, the preferable option is multiple choice responses (Bascand, 2011; Cade et al., 2004; Thurnham, 1988).

Throughout the literature, multiple choice questions usually offer between five to ten frequency options. The FFQ must capture inter-subject variation; including foods frequently consumed e.g. bread, through to foods rarely eaten with high nutrient contents e.g. liver. Due to this, the range of frequency options generally start from 'never' and progress to 'six plus times daily'. However, it has been suggested that non-beverage items are sufficiently captured with a maximum frequency option of 'two plus times daily' (Bascand, 2011; Cade et al., 2004). Nutrient intake is primarily provided by commonly consumed foods, therefore, it is important to ensure higher weekly frequencies are emphasised, and that gaps are not present between the frequency options (Thurnham, 1988; University of Otago & Ministry of Health, 2011).

Multiple choice questions can be presented in either a horizontal or vertical format. The horizontal layout provides the frequency options beside the food item. In contrast, the vertical layout provides a vertical list of frequency options below each food item. It is easier for the elderly, children and populations of lower education to complete these questions as a vertical list (Willet, 2013).

2.6.3. Portion Size Estimation

The final step of FFQ development is the allocation of a portion size to food items. This depends on whether the FFQ is a simple, semi-quantitative or quantitative FFQ. The simple FFQ does not collect any additional portion size information, participants are simply required to select how frequently each food item is consumed (Willet, 2013).

A semi-quantitative FFQ uses a given portion size, and requires the participant to report how often the given portion is consumed (Cade et al., 2002). The total question number, and therefore length of the questionnaire can be reduced through the incorporation of portion sizes into frequency response questions. This does not necessarily reduce the duration of the questionnaire however, as some participants may find the two-part (combination) question confusing, particularly when the given portion size differs from what they consume. The semi-quantitative FFQ assumes that the participant will account for differing portion sizes by adjusting their frequency response. In reality, this does not always occur, and numerous participants disregard the given portion size (Cade et al., 2004).

Additional clarity can be provided from the question when the food items are those with natural units, for example one egg, glass of milk, cup of coffee. Willet (2013) suggest questions should be posed in this way for such food items, as additional information is provided without having to add another question for unit size specification. Using a ‘palm size’ or ‘palm volume’ to estimate portion size may be easier for participants to visualise, particularly in NZ where nutritional food magazines such as the Healthy Food Guide often use this as a portion guide. However, the validity of this measure is yet to be proven.

A quantitative FFQ uses either open-ended portion size questions or multiple choice portion options e.g. small, medium, and large (Block et al., 1986; Hankin et al., 1983). However, participant interpretation of these portion sizes is subjective, and may differ significantly between participants (Willet et al., 1985). Open-ended questions may include measurement aids that are provided in relation to the portion size description (Cade et al., 2002) e.g. photographs, household measures such as measuring cups and spoons or lifelike food models (Morgan et al., 1978). Open-ended questions are not often used however, due to the expense of coding and processing the responses (Willet, 2013).

2.6.3.1. Errors in Estimation of Portion Size

It is the quantification of portion size that produces the largest error of all (Gibson, 2005; Young & Nestle, 1995). Issues often arise for food items that do not have natural or typical units i.e. pasta or meat. When a portion is given for these items, e.g. 100 g meat, the participant is expected to adjust their reported frequency of consumption if it differs from that provided. Therefore, someone that usually consumes twice this quantity *should* double their reported frequency. Thompson & Subar (2008) informally evaluated this semi-quantitative approach in the Nurses' Health Study Cohort. Although they found consistent, correct interpretation for the food items with natural units e.g. an apple, participants often ignored the specified portion size for the food items without natural units e.g. grapes.

The literature suggests that use of measurement aids such as food photographs, result in fewer errors in comparison to unaided responses. Furthermore, when multiple portion sizes are displayed, even fewer errors occur (Baranowski et al., 2010; Contento, 2008; Katsouyanni et al., 1997; Longnecker et al., 1993; Subar et al., 2010; University of Otago & Ministry of Health, 2011). Willet (2013) found that when multiple food images (up to eight) were presented to participants on a computer in successively larger portions, accuracy was markedly improved.

Alternatively, 'quantity ranges' can be used to define the portion size. For example, in a study by Subar et al. (1995) participants were required to select their usual portion size from ranges of categories e.g. rice: less than 1/2 cup, 1/2 - 1 cup or more than 1 cup. They found that providing a range for the portion size improved clarity for participants in comparison to providing a medium size reference and having to select small, medium or large. However, for self-administered questionnaires, they found that portion size questions in both formats were frequently ignored.

In order to obtain useful portion size information, participants need to be able to relate their own dietary habits to the questionnaire at hand, conceptualising portion sizes clearly (Willet, 2013). This is difficult to achieve, as demonstrated by Guthrie (1984) who found that participants generally could not describe their usual portion size. Upon cessation of a meal, participants described portion sizes of the foods consumed; accuracy to within 25% was achieved by less than half the participants.

Studies have found little difference in dietary intake results between different methods used to assess portion sizes within food frequency questionnaires (Willet, 2013). In a study by Samet et al. (1984), correlations for a simple frequency questionnaire versus a quantitative format using food models were 0.86 and 0.91 respectively. These findings indicate that both dietary tools performed well, with the quantitative tool only marginally better than the simple questionnaire. Similar findings were observed in the large German Cohort by Nothlings et al. (2007), suggesting that minimal information is obtained from additional portion size questions. In contrast, some authors suggest that the largest inter-subject variation arises from portion size, thus disputing the value of gathering any data on portion size (Ajani et al., 1994; Molag et al., 2007). However, in theory greater accuracy is provided when more information is obtained. The inclusion of portion size and hence, accuracy improvement, could potentially be masked by errors from portion estimation. This leads to the suggestion that portion sizes do not need to be removed from FFQs, but further investigation is required into methods to improve the accuracy for participant's estimates of their food portions. This may involve measurement aids, which have shown some improvement in accuracy in several studies (Baranowski et al, 2010; Contento, 2008; Katsouyanni et al, 1997; Longnecker et al, 1993; Subar et al, 2010; University of Otago & Ministry of Health, 2011;). There is however, no single recommendation on the best measurement aid and further research is required.

2.7. Assessing the Validity of an FFQ

"Validity refers to the degree to which the questionnaire actually measures the aspect of diet that it was designed to measure. This implies that a comparison is made with a superior, although always imperfect, standard" (Willet, 2013, p. 96).

Assessing dietary intake in epidemiological studies requires a quick, easily applied method that is able to obtain accurate information. Validation studies are undertaken to determine the method's accuracy, by comparing the test method to that of a reference method. Validity of the dietary method is reflected in the degree of closeness from the test method and reference method. This relationship depicts 'relative validity' as the reference method is not absolutely valid itself. Therefore, relative validity can ascertain whether the FFQ's answers compare to that from the reference method (Cade et al., 2004)

It is crucial to validate an FFQ before use in the target population, ensuring it measures what it is intended to measure. False associations may occur between disease markers and dietary intake if the information is incorrect (Cade et al., 2002). Investigations into diet and disease associations have the potential to influence health status worldwide; these can be examined at the level of dietary patterns, food groups, individual foods and nutrients. Therefore, it is important that the FFQ is validated at the level for which it was intended (Willet, 2013).

There are several factors to consider in the design of a validation study to ensure that the data collected represents the results that will be obtained when the FFQ is used in the population of interest (Cade et al., 2002). These factors are described in the following sections and include the following: study population, sample size, reference methods, recording days required, sequence of administration and the statistical analysis.

2.7.1. Study Population

Validation of the FFQ needs to be undertaken in a sample which represents the population that it has been intended for use in. The performance of an FFQ can be affected by even small, subtle design changes (Willet, 2013). Due to this specificity, the FFQ may not be appropriate for use in differing populations. Therefore, new questionnaires should be validated, as should previously validated questionnaires when the target population differs (Willet, 2013). Question responses are influenced by age, gender, health status, and demographics (Cade et al., 2002). Foods within the FFQ should be culturally specific, as the FFQ may perform differently across subcultures within a population (Willet, 2013). The levels of food consumption reported in the FFQ may be influenced by differing food perceptions between cultures i.e. healthy versus unhealthy foods (Margetts & Nelson, 2010). Furthermore, ethnicity and socioeconomic status influence diversity in the diet and hence, affect validity. A highly diverse diet decreases agreement, as the opportunities for mistakes are greater when compared to a less diverse diet.

2.7.2. Sample Size

The requirement for sample size is influenced by precision requirements, statistical methods assessing validity, daily nutrient variation, number of recorded days from the reference method and the total duration of these recorded days (Thompson & Buyers, 1994; Willet, 1998). Furthermore, across different populations the variation both between- and within-subjects differs. Accurately determining the required sample size is therefore difficult. A minimum of 50 participants is required if Bland-Altman statistics are to be used, with the suggestion that studies preferably use over 100 (Cade et al., 2002). For correlation coefficients, it has been suggested that 150 participants are required as it is only at this point that the confidence interval (CI) precision stops increasing (Willet, 1998). However, such sample sizes are based on the presumption that food intake has been recorded for more than 12 days (Cade et al., 2002; Willet, 1998). For most validation studies this is not feasible. There is a general consensus that the number of participants required does not need to exceed 100-200 participants, ensuring that the amount of recorded days is sufficient to describe the participant's usual diet accurately (Cade et al., 2002; Henriquez-Sanchez et al., 2009; Serra-Majem et al., 2009a; Serra-Majem et al., 2009b; Willet, 1998).

2.7.3. Reference Methods

There is no dietary assessment method that enables usual dietary intake to be measured with absolute accuracy (Cade et al., 2004). A reference method is used for comparison with the FFQ to assess its validity. When selecting the reference method, it is crucial that the error sources are independent of those found with a FFQ (Cade et al., 2002). The weighed food record has the least correlated errors with the FFQ therefore, this dietary tool is most commonly used as the reference method used in validation studies (Margetts & Nelson, 2010). A food record involves weighing and recording all foods and drinks participants consume at that given time. Thus, with the food record, errors with estimation of portion size, restricted food lists and memory are limited (Cade et al., 2002). With food records however, issues can arise when the participant is unable to weigh their food, relying on estimation of portion size. Participant burden is high with this method, therefore, validation studies often keep recording days to a minimum (Cade et al., 2002; Willet, 2013). This is discussed in further detail in the following section 2.7.4. 'Recording days required'.

The use of biomarkers is one approach which is independent of dietary intake and thus, not associated with FFQ errors. The key limitation of using biomarkers is their nutrient specificity, assessment can only be undertaken with some nutrients, as the biomarker must reflect dietary intake over the same period as dietary assessment method (Gibson, 2005). For example, nutrient levels of vitamin C, vitamin B6 and fat-soluble vitamins are found in plasma or serum. Plasma and serum reflect recent intake therefore, the biomarker can only be used to validate a short period e.g. that covered by a 24-hour recall or a short food record (Gibson, 2005). Furthermore, errors arise with biomarkers from food metabolism, influencing the relationship with usual dietary intake (Cade et al., 2002). This method is invasive, costly, and increases the burden on the participant. Rather than use on its own as a reference method, biomarkers are more suitable for use in conjunction with another method.

In populations where literacy is limited, the dietary recall method can be useful (Cade et al., 2002). When the participant is unaware that the recall will be undertaken, the likelihood of the dietary method influencing the participant's actual diet is reduced. However, dietary recalls depend on estimation of portion size and memory, similar to the FFQ. Due to this, they are a less suitable reference method for the FFQ (Cade et al., 2002).

In a review of over 200 FFQ validation studies, Cade et al. (2002) found that food records were the most frequently used validation method (51%). However, only half of these food records were weighed. The 24-hour recall was used by 22% of studies; the diet history by 6%, and 12% used another FFQ. The majority of these validation studies (64%) used only one reference method. Only 3% of studies used two methods, both the 24-hour recall and weighed food record.

In general, FFQ errors arise from the dependence on estimation of the portion size, food consumption recall, and food lists which are incomplete. Due to this, the most suitable comparative method is the weighed food record, which is unlikely to have errors which correlate with the FFQ (Cade et al., 2002; Willet, 2013).

2.7.4. Recording Days Required

The variance ratio, e.g. the intra- to inter-participant variation, influences how many days are required for estimation of usual dietary intake (Livingstone et al., 2004). The dietary intake is likely to vary less over a month than it would over a year, as the availability of some foods e.g. fruit and vegetables depend on the season. Stram et al. (1995) compiled data from two studies to calculate the 'ideal' duration of dietary recording for validation studies. They found that across most settings, having more than four to five food record days was rarely required. Willet (1998) also found that five represents an ideal number of reporting days. Participant burden increases above five days, and collection of dietary data becomes less accurate (Stram et al., 1995; Willet, 1998). A collection period of more than five days results in lower participant completion rates, increased awareness of consumed foods, affecting FFQ responses, and an increased likelihood of alterations in the foods consumed (Willet, 1998). However, it is important to note that the number of recording days required differs between nutrients. For example, nutrients such as vitamin A are found concentrated in specific foods, and can be influenced by the season. Studies have found that higher correlations for vitamin A are found when at least four weeks of dietary intake data are collected (Willet, 2013).

It has been suggested that the period in which the FFQ covers i.e. one month, should also cover the same period of days recorded by the food record i.e. the recorded days spread over a month. Furthermore, these days of food recording should not be consecutive, with an even spread over the month and across various days of the week. Regarding usual diet, the true variability for each participant is better provided by non-consecutive days as dietary intake on consecutive days is shown to be correlated. For example, people often eat similar foods on consecutive days due to the groceries they have in the house, or leftovers from meals consumed the following day (Hartman et al, 1990; Thompson & Buyers, 1994).

2.7.5. Sequence of Administration

The order of the FFQ and reference method administration is important, as they may influence one another. The period over which the methods are administered is important as the participant's awareness of food consumption may be increased with the effort of the food record to weigh all food and drinks consumed. This in turn could increase the FFQ accuracy if it was undertaken afterwards. In contrast, if the FFQ is administered prior to the food record, it would relate to a different period of dietary assessment with a possible low association of dietary intake between the two methods. To reduce the disadvantages from this, the FFQ could be administered both prior and post completion of the reference method (Willet, 1998). The average of the result can be used, or alternatively, a random selection of either the first or second FFQ for each participant could be compared with the reference method. However, this is not always feasible for validation studies, due to cost and time implications.

2.7.6. Statistical Analysis

The validity of an FFQ can be assessed using a variety of statistical techniques. However, there is no consensus on the most appropriate technique to use (Masson et al., 2003). Therefore a combination of approaches is commonly used. These methods are discussed in the following sections.

2.7.6.1. Correlation Coefficients

For validation of dietary assessment methods, the most common statistical technique used are correlation coefficients (Altman & Bland, 1983). The data distribution will determine whether Pearson's' or Spearman rank correlations are used (normal or non-normal data respectively). Spearman correlations enable participants to be ranked, an approach which reduces sensitivity to extreme values (Masson et al., 2003). The correlation will reduce between the two dietary assessment methods when a large intra-participant variation in nutrient intakes exists. From an FFQ review, Cade et al. (2004) have found that when nutrient correlations exceed 0.4, validity is accepted. Furthermore, Cohen (1988) and Hopkins et al. (2009) have described the following descriptors for correlation coefficients: 0.9 - 1 almost perfect; 0.7 - 0.9 very high; 0.5 - 0.7 high; 0.3 - 0.5 moderate; 0.1 - 0.3 low and 0 - 0.1 insubstantial. There is controversy however, regarding the use of correlations to measure validity. It has been argued by Bland & Altman (1986) that a positive correlation will always exist when the same thing is measured by the two dietary assessment methods. Furthermore, they believe that only associations can be shown by correlations, not agreement. A high correlation can still have poor agreement (Altman & Bland, 2002). It is only when very similar results are produced that high agreement will exist (Bland & Altman, 1986). In addition, correlations are affected by the range of sample values i.e. a large sample will result in a lower correlation (Cade et al., 2002; MacIntyre et al., 2007). Due to these factors, some believe validity assessment is too flawed using correlation coefficients (Bland & Altman, 1999; Bland & Altman, 1986; Cade et al., 2002). They may be more useful when used alongside other statistical techniques (Cade et al, 2002; Masson et al, 2003). To date however, correlation coefficients have been used in the majority of validation studies, which enables comparisons across studies (Cade et al, 2004).

2.7.6.2. Paired t-test (Comparison of Means)

The relative validity can be assessed at a group level by comparing medians or means for nutrients obtained from the FFQ and food record (Gibson, 2005). The data distribution will determine whether the paired t-test or Wilcoxon’s signed rank test is used for this (normal or non-normal data respectively) (Lee, 1980). It is important to highlight that a group mean comparison such as this, will not provide information at an individual level on the questionnaire’s quality, nor the capability of the FFQ to describe the distribution of dietary intake (Block & Hartman, 1989).

2.7.6.3. Cross-classification and Weighted Kappa Statistic

Cross-classification enables classification of the participant’s nutrient intake into categories e.g. quintiles, quartiles or tertiles based on the two dietary assessment methods (Gibson, 2005). The term ‘correctly classified’ encompasses the participants who had the same category classification by the two dietary methods, given as percentage value. The term ‘grossly misclassified’, also given as a percentage value, encompasses those with opposite categories. However, within the percentage agreement, participants will be included when their classification was based on chance alone (Willet, 1998). To account for both the correctly classified percentage, and the expected participant proportion classified by chance, the Kappa statistic is used (Cohen, 1968). The weighted Kappa is suggested for use when assessing ordinal variables, as larger differences are given greater emphasis. The Kappa statistic is dependent on category weightings, and the category number used. Due to this, limitations arise when the category number is high, as the potential for disagreement increases. This results in a lower Kappa value, and thus, understates the agreement (Sim & Wright, 2005). Across studies the category number and weightings will differ, therefore, comparisons can be limited.

2.7.6.4. Bland-Altman Analysis

For studies involving method comparison, Bland-Altman (1999) has suggested using the limits of agreement. This technique requires plotting the difference of the two dietary methods for each nutrient against the average from the two dietary methods. The limits of agreement are then calculated with their 95% confidence interval. Outliers are easily observed on the plot, as are trends when intake is increased. It has been suggested that with increased nutrient intake, a greater difference may be observed between the two methods, in contrast to that from participants with smaller nutrient intakes (Cade et al., 2002). This results in the FFQ appearing less reliable, with participants consuming a higher nutrient intake in comparison to those with lower intakes. In support of Bland & Altman (1986), Cade et al. (2004) also recommend that the agreement between dietary assessment methods should be considered using this technique.

2.8. International FFQ's Exploring Dietary Intake

Worldwide there has been a considerable change in food availability and dietary patterns in recent years (Swinburn, 2008). Furthermore, nutrition related issues such as obesity are also a global problem, with the highest rates of obesity found in the U.S, Mexico and New Zealand (Statistics NZ, 2014). A large amount of epidemiological research investigating the relationship between diet and disease is being undertaken internationally. The number of FFQ validation studies undertaken in NZ is limited. Hence, it is advantageous to review findings from international studies on dietary assessment. A small collection of validated FFQs have been reviewed in table 2.2. FFQs of primary interest were those with similar demographics to the FFQ validation study at present e.g. young female, no chronic disease nor pregnant, and a range of ethnicities.

Across the validity studies, there was a large range of nutrient correlations from comparisons of the FFQ with the reference method. Although the majority of studies validated their FFQ against a food record, some studies used diet recalls.

Validity correlations for macronutrients ranged from weak to very high across the nutrients (Cohen, 1988; Hopkins et al., 2009). Protein, polyunsaturated fat, carbohydrate and cholesterol were commonly found in studies to have the lowest correlations; between -0.04 to 0.29 (Boucher et al., 2005; Brunner et al., 2005; Friis et al., 1997; Kumanyika et al., 2003; Mayer-Davis et al., 1999). Stronger correlations (over 0.5) were found for fat, saturated fat and sucrose (Bingham et al., 1997; Friis et al., 1997; George et al., 2004).

Validity correlations for micronutrients ranged from weak to strong (Cohen, 1988; Hopkins et al., 2009). Vitamin E, A, C, β-carotene, thiamine, folate and sodium were commonly found in studies to have the lowest correlations; between -0.04 to 0.27 (Masson et al., 2003; Boucher et al., 2005; Brunner et al., 2005; Friis et al., 1997; George et al., 2004; Kumanyika et al., 2003; Mayer-Davis et al., 1999). Stronger correlations (over 0.5) were found for calcium, folate and vitamin A, C and E (Bingham et al., 1997; Boucher et al., 2005; George et al., 2004; Masson et al., 2003; Mayer-Davis et al., 1999).

George et al. (2004) found that the FFQ overestimated energy intake by 5.5% in the validation study, and 3.4% in the cross-validation study when compared to food records (Cross-validation involved the use of two reference methods in comparison to one method used in the validation study). The two studies had different populations, the validation study included college students with a lower average BMI than the cross-validation participants who were post-partum, low income mothers. The differences in FFQ energy overestimation may be due to under-reporting in the higher BMI cross-validation group. Under-reporting is a common issue with dietary assessment, particularly participants with an overweight or obese BMI (Cade et al., 2002). In further support of differences between BMI sub-populations, Kumanyika et al. (2003) found lower energy correlation coefficients (representing possible under-reporting) in a group of black Africans with a BMI over 27 kg/m².

Dietary tools also perform differently across ethnicities, as observed in the study by Mayer-Davis et al. (1999). They found lower correlations between the FFQ and reference method (24-hour recalls) in Hispanics and African Americans, in contrast to those found for white

Hispanics. These findings are supported by Cade et al. (2002) and Willet (2013) who have stated that FFQs are culturally specific, performing differently across subcultures within a population. Validity is often lower in subcultures due to a lack of culturally specific food items in the FFQ food list.

Differences within a population were further observed when participants were stratified by education level. Mayer-Davis et al. (1999) found the median correlation coefficient across nutrients was 0.49. However, within the subpopulation of participants with less than 12 years of education, the median correlation coefficient was much lower at 0.25. Kumanyika et al. (2003) also reported lower correlation coefficients for calcium, β-carotene and fibre in participants with less than 16 years education compared with participants with more than 16 years education.

Table 2.2: International Food Frequency Questionnaire Validation Studies

Reference	Population Characteristics	FFQ Design	Study Design	Findings
Boucher et al. (2005)	96F, 25-74y, general population, Ontario, Canada	-126 item FFQ modified from Block's full-diet FFQ -Canadian relevant foods -9 frequency options & 4 standardised portion sizes provided -Self-administered	Over 6m period -FFQ -14d interval - 1st diet recall (1 week day + 1 weekend) -18d interval - 2nd diet recall (1 week day + 1 weekend)	-Macronutrient CC range: 0.07 (cholesterol) - 0.41 (carbohydrate) -Micronutrient CC range: 0.27 (β-carotene) - 0.63 (folate) -Deattenuated validity CC: moderate to high – median of 0.59
George et al. (2004)	-95F, mean of 20y -Southwestern US college students -Mean BMI 22kg/m² Cross-validation (using two reference methods) -50F postpartum, low-income, mean of 23y -Mean BMI 28.3kg/m²	-195 item semi-quantitative FFQ -Food list modification of Health Habits and History Questionnaire (HHHQ) -9 frequency options -4 portion size options; small, medium, large, extra-large	Over 6m period -FFQ -1w interval - 3-day food record (2 week days + 1 weekend) Cross- validation: -3m postpartum - 1st diet recall & 2-day food record -6m postpartum – FFQ, 2nd diet recall & 2-day food record	-Macronutrient CC range: 0.34 (cholesterol) – 0.53 (SFA) -Micronutrient CC range: 0.24 (sodium) - 0.65 (vit A) -Correct classification: 76% -FFQ energy overestimation (vs. food record) = 5.5% Cross Validation: -Macronutrient CC range: 0.36 (MUFA) – 0.48 (SFA) -Micronutrient CC range: 0.45, range of 0.28 (sodium) to 0.59 (vit E) -Correct classification: 79% -FFQ energy overestimation (vs. food record) = 3.4%
Masson et al. (2003)	-40F, 19-58y -Mean BMI 25.1kg/m²	-150 item semi-quantitative Scottish Collaborative Group FFQ	-FFQ completed -4-day food record (3 week days + 1 weekend day)	-Macronutrient CC range: 0.39 (cholesterol) – 0.71 (SFA) -Mirconutrient CC range: -0.04 (thiamine) – 0.75 (calcium) -Correct classification: 35 (cholesterol) – 78% (magnesium)

Reference	Population Characteristics	FFQ Design	Study Design	Findings
	-Participants from Alberdeen, Scotland	-FFQ used coloured photographs of food portions -Completed at home -9 frequency options Intake over 2-3m	Completed either 9 days before or 9 days after the FFQ	-Gross misclassification: 0 (alcohol & NSP) - 30% (thiamine) -Weighted kappa: - 0.08 (thiamine) – 0.66 (magnesium)
Kumanyika et al. (2003)	-245F, 21-69y -Black Africans, US -Four subgroups by BMI & age: ≥ 27 kg/m², < 27 kg/m², 30-41y, 42+ y -Stratification by residence (West, Midwest, Northeast, South) -Stratification by education (≥ 16 years or < 16 years)	-68 item FFQ -Food list modification of Blocks National Cancer Institute (NCI) FFQ - BWHS (Black Women's Health Study) -9 frequency options -Portion size selection; small, medium, large -Self-administered	-Over 12m -FFQ -3m interval (seasonal) – 1st & 2nd 24h-diet recall -3m interval – 1x 3-day food record (2 weekdays + 1 weekend) -3m interval – 3rd 24h-diet recall	-Macronutrient CC range: 0.20 (protein & carbohydrate) – 0.23 (SFA) -Micronutrient CC range: 0.06 (vit E) – 0.23 (β-carotene) Stratification: -Energy CC: lower for BMI ≥ 27 vs. BMI < 27 kg/m² (r = 0.09 vs. 0.29) -Fibre CC: lower for <16 years education group -Calcium & β-carotene (EAD) CC: lower for < 16y education vs. 16+ as follows (r = 0.01 vs. 0.37 & 0.23 vs. 0.53 respectively)
Brunner et al. (2001)	-403F, 39-61y -Participants from the Whitehall II longitudinal study, British civil servants -UK	-127 item semi-quantitative FFQ -Food list modifications to the US Nurses' Health Study FFQ -Completed at home -9 frequency options	-Over 1 year -FFQ completed + 7-day food record	-Macronutrient CC range: 0.29 (protein) – 0.56 (SFA) -Micronutrient CC range: 0.22 (folate) – 0.41 (vit C) (alcohol 0.85) -Energy adjusted CC: 0.33 (vit E) - 0.58 (SFA) (alcohol 0.83) -Correct classification: 32 (PUFA) – 41% (SFA) (alcohol 64%) -Gross misclassification: 0 (alcohol) - 8% (vit E & protein)

Reference	Population Characteristics	FFQ Design	Study Design	Findings
Mayer-Davis et al. (1999)	-186F -African American Oakland, Hispanic Colorado, non-Hispanic white Colorado & Oakland, USA -Insulin-Resistance Atherosclerosis Study (IRAS)	-114 item FFQ, semi-quantitative modifications to NCI-HHHQ -9 frequency options -Portion size selection; small, medium, large	-Over 1 year -8x 24h-diet recalls completed every 6 weeks over 1y (Day of week randomly selected - computer generated) -Then FFQ completed	White - Oakland -Macronutrient CC range: 0.3 (PUFA) – 0.77 (SFA) -Micronutrient CC range: 0.4 (vit A &E) – 0.48 (vit C) African-American - Oakland -Macronutrient CC range: 0.38 (carbohydrate) – 0.62 (SFA) -Micronutrient CC range: 0.22 (vit A& C) – 0.67 (vit E) White - Colorado -Macronutrient CC range: 0.29 (PUFA) – 0.63 (SFA) -Micronutrient CC range: 0.24 (vit A) – 0.89 (vit E) Hispanic – Colorado -Macronutrient CC range: 0.21 (PUFA) – 0.44 (oleic acid) -Micronutrient CC range: 0.21 (vit E) – 0.72 (vit C) -Lower CC for <12y education vs. >12y (CC = 0.25 vs. 0.30)
Friis et al. (1997)	-122F, 20-29y -General population, Copenhagen, Denmark	-Semi-quantitative FFQ -Food list modifications to validated Danish FFQ – Diet, Cancer & Health study -Completed at home -9 frequency options	-Over 1 year -FFQ -3m interval – 1st 4-day food record (3 weekdays + 1 weekend) -4m interval – 2nd & 3rd 4-day food records (3 weekdays + 1 weekend)	-Macronutrient CC range: 0.28 (protein) – 0.63 (sucrose) -Micronutrient CC range: 0.21 (vit E) – 0.59 (vit C) -Correct classification : 32 (vit A) – 64% (riboflavin) -Gross misclassification : 0 (sucrose, vit A & E, calcium) – 8% (protein, carbohydrate, cholesterol)
Bingham et al. (1997)	-127F, 50-65y -Norfolk general population, US	-61 item semi-quantitative FFQ -Food list modifications to US Nurses' Health Study FFQ -Completed at home	-Over 1 year -1st 4-day food record -3m interval – 2nd 4-day food record -3m interval – FFQ completed & 3rd 4-day food record -3m interval – 4th 4-day food record	-Macronutrient CC range: 0.43 (protein) – 0.55 (fat) -Micronutrient CC range: 0.39 (potassium) – 0.55 (vit A) (alcohol - 0.90) -Correct classification: 35 (potassium) - 47% (vit A & fibre) (alcohol 75%)

Reference	Population Characteristics	FFQ Design	Study Design	Findings
			(food records = varied week days)	-Gross misclassification: 0 (alcohol) - 6% (potassium & β-carotene)

Note. CC = Correlation Coefficient; PUFA = Polyunsaturated Fatty Acid; MUFA = Monounsaturated Fatty Acid; SFA = Saturated Fatty Acid; NSP = Non-starch Polysaccharide; vit = vitamin; d = days; m = month; y = year; EAD = Energy Adjusted Data.

2.9. FFQ's Available for Use in Adult Female New Zealanders

It is important that the FFQ reflects the current availability of food and consumption patterns of the population, as these do change over time (Cade et al, 2002; Willet, 1998). From the literature search, there were only five FFQs found that had been developed to assess multi-nutrient intake in NZ adults (Bell et al., 1999; Bolch, 1994; Metcalf et al., 1997; Sam et al., 2012; Sharpe et al., 1993). The characteristics of these studies have been outlined in table 2.3. There has been other FFQs developed in NZ e.g. Beck et al. (2012) – iron in young women, Braakhuis et al. (2014) – antioxidants in athletes, and Boniface (2014) – sugar intake in the Pacific population. However, these were not included in the review as they were designed for other purposes.

The findings from the multi-nutrient FFQ validation studies in table 2.3 generally show that nutrient intakes are overestimated with the FFQ when compared to reference methods. Bolch (1994) found that the FFQ overestimated most nutrients by 10% when compared to a seven-day food record. However, the following nutrients were overestimated by more than 30%; ascorbic acid, thiamine and folate. Data from this study and Sam et al. (2012) was adjusted for total energy intake to improve results.

Cross-classification was examined by Sam et al. (2012) and Bolch (1994), using quartiles and quintiles respectively. In the study by Sam et al. (2012), 77.9% of participants were correctly classified into the same and adjacent quartiles following energy adjustment, and 4.5% were grossly misclassified. For Bolch (1994), 60% were correctly classified into the same and adjacent quintiles, with 10% grossly misclassified.

Across the studies, there was a large range between the validity correlations for nutrients, from 0.11 to 0.70. The weakest correlations were found for calcium, vitamin A and riboflavin, with correlations ranging from 0.11 to 0.21 (Bolch et al. 1994; Sam et al., 2012; Sharpe et al., 1993). The nutrients with the strongest correlations were energy, saturated fat, zinc and cholesterol ranging from 0.6 to 0.7 (Sam et al., 2012; Sharpe et al., 1993; Bolch et al. 1994). The study by Metcalf et al. (1997) assessed nutrient intake across Māori, Pacific and NZ Europeans. The lowest correlation found by this study was 0.36 (fibre) which is much higher than other studies. The FFQ included culturally relevant food items which may have improved validity across the nutrients.

Metcalf et al. (1997) also found differences across ethnicities. They found lower correlations between the FFQ and reference method (three-day food record) in the Māori and Pacific population in comparison to those found for NZ Europeans. They concluded that the FFQ performed better with the NZ European group.

Further differences within subpopulations were observed by Bell et al. (1999). They found that energy intake was underestimated in their Samoan population, particularly in obese participants with a BMI over 30 kg/m^2. FFQs are culturally specific, and these findings support the need for validity assessments before use in the target population (Willet, 2013).

Under-reporting is a common issue in dietary assessment, with higher rates in overweight and obese populations (Cade et al., 2002; University of Otago & Ministry of Health, 2011; Willet, 2013). The findings from Bell et al. (1999) of underestimation with obese participants are similar to those reported in the most recent NZANS (08/09); under-reporting was higher in those with a BMI over 25 kg/m^2 (Gemming et al., 2014). Furthermore, Gemming et al. found under-reporting in the NZANS (08/09) to be higher in Māori in Pacific than NZ European. Of the NZ validation studies in table 2.3 below, only two adjusted for energy intake (Bell et al, 1999; Sam et al, 2012). Although no NZ adult multi-nutrient studies adjusted for fruit and vegetable intake, this was undertaken in the NZ toddler validation study by Watson (2012) who found improvements in validity following adjustment.

Table 2.3: Food Frequency Questionnaires Available for Use in New Zealand Adult Females

Reference	Population Characteristics	FFQ Design	Study Design	Findings
Sam et al. (2012)	-132M&F, 30-59y -General population, Dunedin, NZ	-154 item FFQ -Food list modification of UK-EPIC FFQ -Pre-test: 21M&F, 30-59, focus group interviews -FFQ modified from feedback -7 frequency options	-Over 12m -FFQ completed -2 week interval – 1st 2-day weighed food record -3m interval – 2nd 2-day weighed food record -6m interval – 3rd 2-day weighed food record -9m interval – 4th 2-day weighed food record + 2x 10ml samples at 9m	-Macronutrient CC range: 0.23 (MUFA) – 0.60 (cholesterol) -Micronutrient CC range: 0.11 (calcium) – 0.50 (selenium) (0.74 alcohol) -CC (EAD) range: 0.24 (zinc & vit E - 0.65 (cholesterol) -Correctly classified: 77.9% -Gross misclassification: 4.5% -Bland-Altman: High agreement - total fat & protein -Biomarkers: CC (EAD) - β-carotene: 0.34, Vit C: 0.33
Bell et al. (1999)	-437F&M, 20-40y - Samoan church communities, Auckland NZ -Validation: 55 participants	-89 item quantitative FFQ -Food list modification of Willets shortened questionnaire (New York) -Portion size: food portion photographs - ½, same, double, triple -7 frequency options -Self-administered	-Over 12m -7-day food record -Analysis: NZ & Pacific Island food composition tables	-No statistical analysis performed for validity -Energy intake was underestimated particularly in obese participants (BMI > 30kg/m²) -FFQ was a better measure of energy intake than the diet record in both men and women
Metcalf et al. (1997)	-176F&M, 40-65y -Local workforce, Auckland, NZ -High normal / impaired glucose tolerance -3 Ethnicities: NZ European 101 Māori 15	-142 item FFQ -Food list: Local NZ foods, published portion sizes, food composition tables	-Over 36m -FFQ1 -36m interval – FFQ2 & 3-day food record (2	European: -Macronutrient CC range: 0.41 (fat) – 0.57 (fibre) -Micronutrient CC: 0.65 (calcium). (0.81 alcohol) Māori & Pacific Island:

Reference	Population Characteristics	FFQ Design	Study Design	Findings
	Pacific Island 22	-Portion sizes: photos of a standardised portion - options to select less, same or more (scaled as 0.5, 1.0 & 1.6)	week days + 1 weekend)	-Macronutrient CC range: 0.36 (fibre) – 0.63 (cholesterol) -Micronutrient CC: 0.38 (calcium). (0.56 alcohol) -3-day food records - underestimated in obese & Māori & Pacific participants
Bolch (1994)	-101F, mean age 21y -Students (undergraduate nutrition), Dunedin, NZ -80F&M, 25-49y, (general population), Dunedin, NZ	-132 item FFQ -Nutrients of interest were those highlighted by the Nutrition Taskforce (1991)	-Not available -Reference method = 7-day diet record	-CC range: -0.20 (thiamine) - 0.70 (zinc) Correctly classified: 60% Gross misclassification: 10%
Sharpe et al. (1993)	-102 (50M, 52F), 25-75y, North Island, NZ, predominantly NZEU -Designed for cardiovascular risk assessment in literate New Zealanders	-75 item FFQ -6 frequency options -Portion sizes: four options based on line drawings of standard servings – half size, same size, twice size, triple + size -Self-administered	-FFQ was given to participants across 3 worksites & also mailed to other participants -FFQ & food record given to participants at same time -7-day food record Over 2-weeks: 4 consecutive days in first week & 3 consecutive days in second week	-Macronutrient CC range: 0.55 (fibre) - 0.70 (saturated fat) -Micronutrient CC range: 0.21 (vit A) - 0.65 (calcium) (0.71 alcohol) -Correctly classified: 35 (β-carotene) - 75% (Caffeine) -Gross misclassification: 0 (>50% of nutrients) - 10% (protein & potassium) 0.265

Note. CC = Correlation Coefficient; PUFA = Polyunsaturated Fatty Acid; MUFA = Monounsaturated Fatty Acid; SFA = Saturated Fatty Acid; NSP = Non-starch Polysaccharide; vit = vitamin; d = days; m = month; y = year; EAD = Energy Adjusted Data.

2.9.1. Summary of FFQ Validation Studies

For an FFQ to be of any relevance in assessing a population's dietary intake, it must be current and culturally appropriate. Of the five FFQs assessing energy and multiple nutrients in table 2.3, four were validated over 15 years ago (Bell et al., 1999; Bolch, 1994; Metcalf et al., 1997; Sharpe et al., 1993). Food availability and dietary patterns have changed over the last decade. Therefore, the food lists from these five FFQs may no longer be appropriate for assessment of the NZ population. Furthermore, the majority of these studies were undertaken in Dunedin with predominately NZ European populations. Metcalf et al. (1997) found lower correlations for Māori and Pacific subgroups ranging from 0.36 (fibre) to 0.63 (cholesterol) in comparison to NZ Europeans who ranged from 0.41 (fat) to 0.81 (alcohol). Mayer-Davis et al. (1999) also found lower correlations between the FFQ and the reference method (24-hour recalls) in Hispanics and African Americans, when compared to those found for white Hispanics. These findings highlight the importance of including culturally relevant foods in a FFQ (Cade et al., 2002; Willet, 2013).

The only recently validated multi-nutrient FFQ from table 2.3 was by Sam et al. (2012). This study however, had a population that was primarily NZ European (95%). FFQs are culturally specific, performing differently across subcultures within a population (Willet, 2013). Māori and Pacific make up 22% of the NZ population, a marked difference from the Māori and Pacific population from the Sam et al. (2012) study of just 5%. This suggests that the validated FFQ from Sam et al. (2012) may only be suitable for use in New Zealand Europeans, not across the wider ethnically diverse NZ population. Validation of the FFQ needs to be undertaken in a sample which represents the population that it has been intended for use in.

These limitations highlight the need for a validated, culturally appropriate FFQ to assess the nutrient intake of young adult women living in NZ. Therefore, this study is based on the development and validation of a multi-nutrient, culturally appropriate semi-quantitative food frequency questionnaire for use in young adult women (NZ Māori, Pacific and European) living in New Zealand. Such an FFQ will be able to be used in future studies exploring associations between nutrient intake and health and disease in this population.

3. Methods

3.1. EXPLORE Study

The New Zealand Women's Food Frequency Questionnaire (NZWFFQ) validation study was undertaken as part of the women's EXPLORE study (Examining Predictors Linking Obesity Related Elements) at Massey University (MU), Auckland. The EXPLORE study aimed to recruit over 1,000 participants of NZ European, Māori and Pacific ethnicity, and to investigate how weight (body mass index) and body fat profiles in women are related to chronic disease risk, as well as to investigate associations between body composition profiles, diet and physical activity. The NZWFFQ was used as part of dietary analysis in the EXPLORE study.

3.2. Ethical Approval

Ethical approval for the EXPLORE study was obtained from Massey University Human Ethics Committee, Southern A, Application 13/13. Written informed consent was obtained from all participants. Two cultural advisors, Dr Lily George and Dr Ridvan Firestone formed part of the larger EXPLORE study team.

3.3. Development of the New Zealand Women's Food Frequency Questionnaire

The final NZWFFQ was designed to assess usual macronutrient and selected micronutrient (vitamins: A, D, E, B1, B2, B3, B6, B12, folate; minerals: zinc, calcium, iron, phosphorus, magnesium) intake of NZ women aged 16 - 44 years over the previous month. Data was collected over one year, between July 2013 and July 2014, ensuring all four seasons were captured.

There were five key stages involved in the development and validation of the NZWFFQ; these are outlined in figure 3.1 of the study process below.

Study Process for Questionnaire Development and Validation

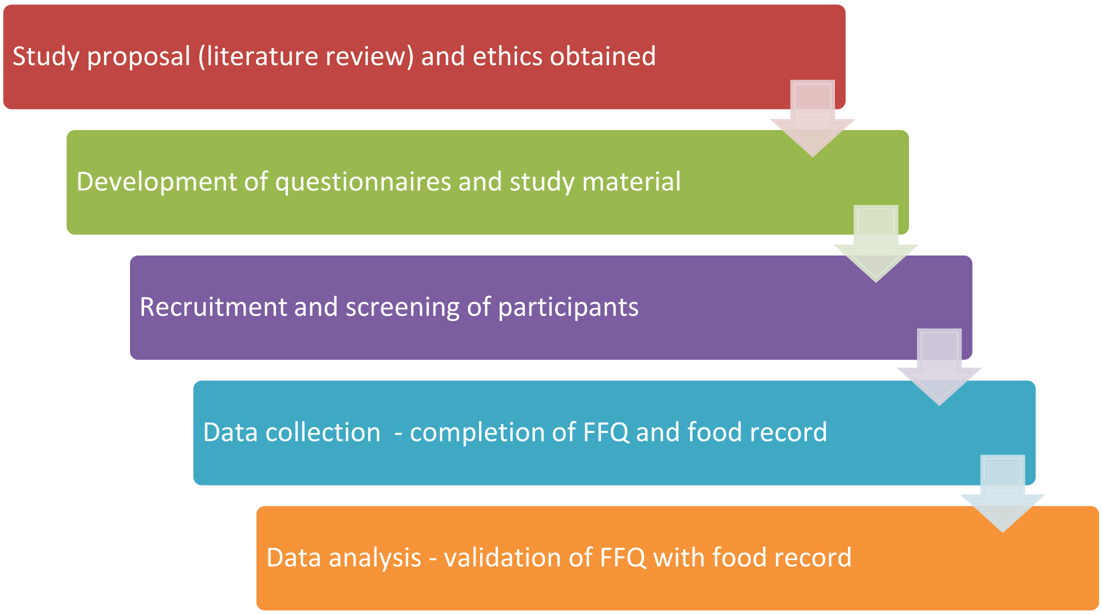


Figure 3.1: Stages involved in development and Validation of the New Zealand Women's Food Frequency Questionnaire.

There were three key components in the development of the NZWFFQ; the food list, frequency response options and portion sizes. These are discussed in the following sections.

3.3.1. Development of the Food List

Development of the NZWFFQ commenced with modification and extension of the 1997/98 National Nutrition Survey (Ministry of Health, 1999) food list. Current dietary intake and commonly consumed foods were identified using data collected using 24 hour recalls from the 2008/09 National Nutrition Survey (08/09 NNS) (University of Otago & Ministry of Health, 2011); the most recent nationally representative data set available at the time. The 08/09 NNS was used to identify commonly consumed foods by analysing food intake data on the population as a whole, and also within ethnicities separately (Māori and Pacific) to ensure culturally specific foods were included. Furthermore, supermarket visits and online web searches were conducted to check that the food list included readily available foods in New Zealand. Two supermarket visits were undertaken on non-consecutive days in Auckland by two members of the EXPLORE research team, in addition to web searches using 'Countdown online'. To ensure all relevant food items had been included, the food list was extensively discussed with the pilot sample (which included NZ European, Māori and Pacific students) and the research team which included dietitians and nutritionists.

The foods identified were categorised to fit within the following 16 food categories: dairy, bread, breakfast cereals and porridge, starchy foods, meat, poultry, fish and seafood, fats and oils, eggs, legumes, vegetables, fruit, drinks, dressings and sauces, miscellaneous, and other.

Within the food categories, foods were grouped according to their composition (e.g. whole grain versus white bread), nutrient content (e.g. whole milk versus low fat milk), and frequency of consumption (e.g. bananas grouped separately from other fruit due to a higher frequency of consumption) (Ministry of Health, 1999).

The final question of the NZWFFQ prompted participants to incorporate any food items they would usually consume, if they were not covered in prior questions. For this question, participants were asked to report the serving size of this food item and their frequency of consumption. An example of how to answer was provided, and this followed the format of the previous questions.

3.3.2. Frequency Response Options

Frequency of intake was assessed using nine categories. These included: never, less than once a month, one to three times per month, once per week, two to three times per week, four to six times per week, once per day, two to three times per day, and four plus times per day. Participants selected the frequency category that best described their intake over the last month for each food item.

3.3.3. Estimation of Portion Size

Participants need to be able to conceptualise food portions clearly in order to relate their own habits to the food frequency questionnaire (FFQ) (Gutherie, 1984). To enhance accuracy of the NZWFFQ, the items in the food list were quantified with a given serving size e.g.

strawberries ½ cup. A standard serving size for each food item was ascertained using the NZ food composition tables (Ministry of Health, 1998) and 'The Photographic Atlas of Food Portion Sizes' (Neslon et al., 1997). Where possible, the aim was to keep the serving size consistent within each food category. For food categories, two quantity descriptions were used to enhance familiarity of the serving size to participants. For example, meat, poultry and seafood had the description 'palm size' stated alongside half a cup e.g. chicken breast ½ cup / palm size. For beverages and fluid based foods (e.g. custard), one cup or 250 mL was used as a standard quantity.

3.3.4. Supplementary Questions

In addition to the food list tables, supplementary questions were included within each food category. These questions included assessment of the following: usual additions to foods during cooking (e.g. oil), usual food preparation methods (e.g. trimming fat off meat), usual cooking methods (e.g. frying or baking), and food brands / types usually consumed (e.g. green top trim milk). These additional questions were used to assist data entry of the FFQ, helping with selection of specific food items choices from the nutrient database. For example, the food item 'chicken breast lean & fat trimmed' would be selected from the database for someone who trims the fat off the meat. Participants also selected how frequently whole food groups were consumed on a weekly basis. This question was added to enable cross-checking of food consumption during data analysis.

3.3.4.1. Instructions for Completing the Questionnaire

Instructions were provided at the start of the NZWFFQ, alongside two example questions. Participants were required to work through these with a supervisor from the EXPLORE research team. Commonly consumed foods were used (sugar and bread) to ensure participants understood how to complete the questionnaire. This was done to minimise the errors that are common in the first few questions of dietary assessment when participants take time to familiarise themselves with the process. Including examples can reduce such errors (Cade et al., 2002; Willet, 2013).

3.4. Pre-testing the Questionnaire

The NZWFFQ was pilot tested among 60 second year nutrition students based at Massey University (MU). The majority of this pilot sample had similar demographics to those required for the NZWFFQ validation as they were predominantly female, premenopausal, healthy, aged between 18 - 44 years and included NZ European, Māori and Pacific students. The objective of the pilot study was to assess the completeness of the NZWFFQ including: the food list, comprehension of questions and question formatting, portion sizes, frequency categories and the overall suitability of the NZWFFQ for the target population. After they completed the NZWFFQ, an open focus group discussions was conducted to obtain direct feedback on their experience of completing the NZWFFQ. Following review, several new food items were incorporated into the final NZWFFQ were, namely seeds, quinoa and almond milk. Furthermore, sentence structure was also modified to improve comprehension. The final NZWFFQ was discussed and finalised with the EXPLORE research team.

3.5. Computerised Format

The finalised NZWFFQ was placed online onto SurveyMonkey, an online survey development programme. For each food category, a new page in the survey was created i.e. there were 16 pages. This ensured complete data capture, as participants could not progress onto the following food category until all questions had been completed on the current page. Results were collected as soon as the participant completed the NZWFFQ, and were stored on the MU SurveyMonkey server.

The final NZWFFQ consisted of 16 food categories, with a total of 220 food items. It took participants approximately 25 minutes to complete. The NZWFFQ contained more food items that that recommended by Willet (2013) (less than 130), as a greater number of food items were required to cover the cultural diversity of the NZ population. The effect of fatigue with the longer FFQ was reduced by using an online format (Heath et al., 2000), requiring less time to complete than a hardcopy paper version. Furthermore, participants were provided with breakfast and beverages prior to completing the NZWFFQ, and encouraged to take breaks when required. See Appendix B for the final version of the NZWFFQ.

3.6. Validation of the NZ Women's Food Frequency Questionnaire

3.6.1. Recruitment of the Study Population

Participants were recruited from the general population in Auckland, NZ as part of a larger study. The inclusion criteria were: female, 16 - 45 years, and being of NZ European, Māori or Pacific ethnicity. The exclusion criteria were: post-menopausal, currently pregnant or breastfeeding, or chronic disease. Validation of dietary assessment methods requires a sample size greater than 100 participants (Serra-Majem et al., 2009; Willet, 1998). A convenience sample was recruited using email distribution, magazine and local paper advertisements. Eligibility was confirmed through an online health screening and demographics questionnaire, at which time written informed consent was obtained for study participation. The NZWFFQ study aimed to recruit a convenience sample of the population that included NZ European, Māori and Pacific participants. Participants for the NZWFFQ study were recruited during the early stages of the wider EXPLORE study, when mainly NZ European women were responding to the recruitment strategy described above. Due to this, the recruitment period for the NZWFFQ was extended to 10 months, with the aim to increase the number of Māori and Pacific women participating.

3.6.2. Collection of Data

Eligible participants visited the Human Nutrition Research Unit (HNRU) at MU for data collection on two occasions – once for anthropometric screening, and once for the main data collection (at which time the NZWFFQ was completed). Completion of a weighed food record was undertaken at home, within the next seven days directly after the main data collection appointment, to validate the NZWFFQ.

3.6.2.1. Main Data Collection (Questionnaire Completed)

The main data was collected during the participants' second visit to the HNRU for the EXPLORE study. This involved eight testing stations: blood samples; body composition using e bioelectrical impedance analysis (BIA), air displacement plethysmography analysis (BODPOD), and dual energy x-ray absorptiometry (DEXA); blood pressure; taste testing (creamy and sweet samples); three online dietary questionnaires, one being the NZWFFQ; and the take-home station, where participants were fitted with an accelerometer to wear for the following seven days, and were given electronic scales and a food diary in order to complete the weighed food record for four days.

Verbal instructions were given to participants before commencing the NZWFFQ, with all staff following standardised protocol from an up-to-date Standard Operating Procedure (SOP) which can be found in Appendix A. This helped to ensure consistency of delivery and appropriateness of instructions. The NZWFFQ was completed online; however hardcopies of the NZWFFQ were available to fill in manually by participants if required. A member of the EXPLORE research team read through the first page of the NZWFFQ with the participant, emphasising keys aspects e.g. that is the FFQ is asking about usual intake over the past month, and working through the two example questions to ensure participant comprehension. The researcher also checked the participant's identification number. The researcher was available to answer questions whilst the NZWFFQ was being completed.

3.6.2.2. Weighed Food Record (Reference Method)

Selecting an appropriate reference method to assess the NZWFFQ was a key component of the validation process. The reference methods' measurement errors should be independent to those of the NZWFFQ. As portions are weighed in food records, this method is not reliant on memory and thus, it has the least correlated errors with FFQs (Cade et al., 2001). Therefore, this method was used to validate the NZWFFQ. A four-day food record (4DFR) was completed by participants, and can be found in the Appendix D. Participants were advised that the weighed food record component was voluntary. Participants were required to watch a food record video developed by dietitians and nutritionists at the HNRU, at MU. Verbal instructions for the weighed food record were also provided. All participants were given a food record diary, electronic scales, and a supplementary booklet "The Food Record Guide" (Nelson, et al., 1997) to assist food recording during occasions where scales could not be used e.g. eating out. The booklet contained photographs of food or meals with eight different portion sizes. These were accompanied with a coded number and letter so that the participant could describe their food item or meal with an approximate portion size. The researcher was then able to identify the portion size from the code allocated. Participants were allocated four consecutive days in which to complete the food record, these dates were recorded in the front of their food record diary. Although Willet (2013) recommend recording of food intake over non-consecutive days, this was not feasible in the present study as participants were required to record physical activity data for the wider EXPLORE study during this period. All participants recorded their food intake on at least one weekend day, as dietary intake has been shown to change from that on weekdays (Willet, 2013). All seven days of the week were covered across the participants. Participants were advised to record all the food consumed at the time of eating as follows: record the time of each eating occasion, weigh all food items consumed, provide as much detail as possible regarding the type and/or composition of the food consumed. For food consumed outside of the home, the participant was encouraged to use the supplementary tool to aid the description. Completion of the weighed food record began as soon as the participant woke and consumed food or fluid each day.

Tanita KD-200 electronic scales were provided as these are more precise than standard kitchen scales and reduce recorder error (Willet, 2013). These scales could measure up to 2000 g with 2 g increments. The participant was given a pre-paid courier bag for the return of records and electronic scales. As diaries were returned in the courier bags, they were reviewed for completion by a member of the EXPLORE research team. If there was missing information, the participant was contacted to provide further detail before the food record was entered into Foodworks 7.

3.6.3. Analysis of the Questionnaire

The NZWFFQ data was exported from SurveyMonkey into an Xcel spreadsheet (2008 Microsoft Office Corporation). All Xcel data was checked by a member of the research team to ensure there was no missing data and that participant ID numbers corresponded with the weighed food records that had been completed. Only NZWFFQs with corresponding food records were analysed in the validation study. This NZWFFQ data was then entered into the programme Foodworks 7 (FoodWorks Professional, 2013) for analysis. Foodworks uses the New Zealand Food Composition Database (NZ, FOODfiles 2010) to determine energy, macro- and micronutrient intake. The data was entered by two MSc students in Nutrition and Dietetics, and a research assistant. To ensure accuracy, all NZWFFQ foodworks data was checked twice by one of these MSc students, with 15% undergoing random spot checks. When food items were absent from the database either a recipe was entered from the NZ Edmonds cookbook, or a composite item was selected e.g. a Weight Watchers cereal bar was replaced with a Cereal soft bar, fruit flavoured. These composite food items are a combination of multiple foods determined using an average nutrient line (Greenfield & Southgate, 2003). The study also asked participants additional information on food preparation and cooking methods. This information was used to guide decisions on food items that required substitution.

3.6.4. Data Adjustment

Actual intake can be overestimated when there is a large list of food items within the same category (Willet, 2013). A review article by Cade et al. (2002) found that fruit and vegetables are often over-reported in FFQs, due to the long list of food items included in these categories. Healthier food items are also more likely to be over-reported than foods such as takeaways that are known to be higher in energy and fat. To account for this, studies such as Watson (2013) have adjusted their raw data to provide two sets of results. Within the fruit and vegetable categories, the NZWFFQ contained 15 questions on fruit, and 24 questions on vegetables. Each food category of the NZWFFQ also included a cross-check question. The cross-check question asked how many serves of the whole food group were consumed on a weekly basis e.g. 'How many serves of fruit do you usually eat per week?' The answer to this question was then compared to the sum of all the individual food item frequencies within that food category, enabling a cross-check of the responses.

The raw FFQ data was multiplied by an adjustment factor (determined for each participant separately) for the vegetable and fruit sections. The responses from the cross-check questions were first converted from serves per week into serves per day. Then the adjustment factor was calculated as the total serves of vegetables per day (cross-check), divided by the sum of all the individual food item frequencies within the vegetable section. This was repeated to determine an adjustment factor for each participant for the fruit section of the FFQ. Dietary intake could then be analysed for validity as 'Raw' and 'Adjusted' data. Adjustment was based on methodology discussed in Calvert et al. (1997).

3.6.5. Goldberg Cut-off for Energy Intake

Under-reporting is a term frequently used with dietary assessment. Data from self-reported dietary methods often have a marked bias to under-estimation of food intake. This occurs from both conscious and unconscious food omission when reporting, and also from under-eating i.e. dieting. Under-reporting can result in poor validity. To account for this, the Goldberg cut-off method was used.

This method assesses dietary intake in relation to participants' basal metabolic rate (BMR). Appropriate age and gender related Schofield equations were used to determine BMR, and the mean energy intake for each participant was used from the NZWFFQ. Values for basal metabolic rate variation, inter-subject physical activity variation and intra-subject energy intake variation were determined using the reference paper by Black (2000). Under-reporting in individuals was identified if their ratio of energy intake to basal metabolic rate was below the cut-off value of 1.49 (cut-off value for a lightly active physical activity level of 1.55), based on four days of dietary intake (Black, 2000; Goldberg et al, 1991; World Health Organisation et al., 2004).

Although the Goldberg cut-off method identifies under-reporters, there is no consensus as to whether under-reporters should be omitted from the data analysis (Heath et al., 2000).

3.6.6. Analysis of Food Records (Reference Method)

Information from the weighed food record was also entered into Foodworks 7 (FoodWorks Professional, 2013) for the analysis of energy, macro- and micronutrient intakes. For homemade recipes, all individual ingredients were entered into Foodworks as a 'recipe' taking into account the number of serves it provided. Conversion factors were used for raw ingredients, to ensure the cooked proportion was used for analysis (FSANZ, 2002). The data was entered by two Master of Science (nutrition and dietetic) students, and one Master of Science (human nutrition) nutrition student. All food records were checked by one of these MSc students, as above for the NZWFFQ, including spot checks on 15% of the food records to enhance accuracy and consistency.

Data entry for both the NZWFFQ and food records was supervised by two registered NZ dietitians (NZRD), with weekly meetings between the two NZRDs and all three students throughout the data entry process.

3.6.7. Statistical Analysis

All statistical analyses were conducted using SPSS 21.0 for windows (SPSS Inc, Chicago IL). Data was checked for normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests; values over 0.05 suggest there was no significant differentiation of the test distribution from the normal distribution. Furthermore, normality was assessed visually using; a superimposed normal curves on a histogram, box plot, de-trended plot and the Q-Q normality plot. Some variables required normality improvements using natural logarithmic transformations (Bland & Altman, 1999; Sam et al., 2012). The descriptive statistics of continuous variables were reported as means and standard deviations (SD) for normal data, and geometric means and 95% confidence intervals (CI) for log transformed data. Variables that could not be normalised were reported as medians with the 25th and 75th quartiles, and categorical variables were reported as numbers and percentages.

To assess relative validity of NZWFFQ, energy and nutrient intakes were compared with corresponding weighed food record data. The nutrients of interest were: energy; protein; total fat, saturated fat, polyunsaturated fat, monounsaturated fat, cholesterol; carbohydrate, sugar, fibre; alcohol; vitamin A, D, E, C, B_1, B_2, B_3, B_6, B_{12}, folate; minerals calcium, iron, magnesium, phosphorus and zinc. The following statistical methods were used to assess validity of the NZWFFQ: Paired t-tests, effect size, Pearson's Correlation Coefficients (due to normal distribution of the data), cross-classification with quartiles, weighted kappa statistic, and Bland-Altman analyses.

Paired t-tests were used to compare the means of the NZWFFQ and food records, with the significance level of the p-value set at less than 0.05, two tailed. The effect size was calculated as an objective measure of the importance of an effect using the formula: $r = \sqrt{} t^2 / t^2 + df$ where t is the test statistic from the paired t-test, and df the degrees of freedom.

Determination of effect size was based on recommendations from Cohen (1988, 1992) and Field (2009); small effect when $r = 0.1$, medium effect when $r = 0.3$, and a large effect when $r = 0.5$.

To assess the association for each nutrient between the NZWFFQ and food record, Pearson's Correlation Coefficients were determined. The relationship between the two dietary assessment tools for each nutrient was reported in accordance with Cohen (1988) and

Hopkins et al. (2009) descriptors for correlation coefficients: 0.9 - 1 almost perfect; 0.7 - 0.9 very high; 0.5 - 0.7 high; 0.3 - 0.5 moderate; 0.1 - 0.3 low and 0 - 0.1 insubstantial with a 2-tailed significance level of the p-value set at 0.05 (Field, 2013).

Cross-classification was undertaken, dividing the absolute intake of each nutrient into quartiles for both the NZWFFQ and food records. This was reported as a percentage demonstrating participants who were classified into; the same quartile, the same and adjacent quartiles, those that were grossly misclassified, and those into extreme quartiles. Correct classification into the same quarter should occur for > 50% of participants, and gross misclassification into the opposite quarter should be < 10% (Masson et al., 2003).

Levels of agreement for cross-classification were further investigated using the kappa (κ)-statistic, which is believed to take chance agreement into account (Cohen, 1968). The formula used to determine the κ-statistic was: $\kappa = Pr(a) - Pr(e) / 1 - Pr(e)$ where Pr(a) is the relative observed agreement among the FFQ and food record, and Pr(e) is hypothetical probability of chance agreement. If the two dietary methods completely agree then $\kappa = 1$, and if there's no agreement between the two methods other than that expected by chance (Pr(e)) then $\kappa = 0$.

Using the formula, correct classification into same quartile was given a factor of one; two-thirds for adjacent quartiles; one-third for adjacent plus one quartile; and zero for opposite quartiles. Agreement levels for the κ-statistic are as follows; very good agreement for κ values greater than 0.80, good agreement for values between 0.61 - 0.80, moderate agreement for values 0.41 - 0.60, fair agreement for values 0.21 - 0.40, and poor agreement when less than 0.20 (Masson et al., 2003).

Finally, the strength of agreement between the NZWFFQ and food record was assessed using Bland–Altman analyses. The limits of agreement were determined by computing the mean difference ± 2 standard deviations of the differences (Bland & Altman, 1999).

4. Results

4.1. Participant Characteristics

One hundred and eleven participants completed both the New Zealand women's food frequency questionnaire (NZWFFQ) and a four-day food record (4DFR). One participant did not complete the NZWFFQ correctly; therefore this data was excluded from the final analysis. A total of 110 participants were included in the validity analysis.

The characteristics of the population are outlined in table 4.1. The majority of participants were of NZ European ethnicity, with an average age of 32.4 years. The median body mass index (BMI) of the women was 23.22 kg/m².

Table 4.1: Participant Characteristics (n = 110)

Characteristics	Mean ± SD, Median (25th, 75th percentile) or n (%)
Age[a] (years)	32.41 ± 7.56
Ethnicity[b]	
NZEU n (%)	89 (80.9)
Māori n (%)	13 (11.8)
Pacific n (%)	8 (7.3)
BMI[c] (kg/m²)	23.22 (21.10, 26.10)
Normal BMI[bd] 18.5 - 24.99 kg/m² n (%)	73 (66.4)
Overweight & obese BMI[bd] ≥ 25 kg/m² n (%)	37 (33.6)

Note. BMI = Body Mass Index; NZEU = New Zealand European. [a]Mean ± SD; [b]Proportion (%) of participants; [c]Median (25th, 75th quartiles); [d]BMI cut-off points for all ethnic groups: Ministry of Health (2008).

4.2. Energy, Macro and Micronutrient Intake

Mean daily energy and nutrient intakes have been compared in table 4.2 between the NZWFFQ, the 4DFR and the most recent New Zealand adult nutrition survey (NZANS 08/09) (University of Otago & Ministry of Health, 2011). Furthermore, nutrient intake from the NZWFFQ and 4DFR have been compared with Nutrient Reference Values for Australia and New Zealand (females 19 - 30 years and 31 - 50 years) (National Health and Medical Research Council, 2006). These have been reported as the proportion of participants below the recommended nutrient reference values (NRVs) which include dietary intake (RDI), acceptable macronutrient distribution range (AMDR) or estimated average requirement (EAR).

The mean energy intake from the NZWFFQ was 8936 kJ. This value was higher than that from the 4DFR of 7845 kJ and that from the NZANS (08/09) of 8174 kJ. The mean intakes of protein, fat and carbohydrate from the NZWFFQ were 98.8 g, 86.8 g and 230.4 g respectively. These values were also higher than the mean intakes of protein, fat and carbohydrate from the 4DFR, which were 85.7 g, 75.9 g and 199.8 g respectively; and from the NZANS (08/09) of 76.0 g, 74.0 g and 229.5 g respectively.

For protein intake, the AMDR of 15 - 25% of energy was met by 83% of participants from the NZWFFQ, and 75% of women from the 4DFR. The minimum AMDR for fat (20% of energy) was met by all participants from the NZWFFQ and 4DFR; however, the upper range of recommended intake (35% of energy) was exceeded by 54% from the NZWFFQ and 58% from the 4DFR.

Mean carbohydrate intake was highest from the NZWFFQ, which at 230.4 g was only slightly higher than that from the NZANS (08/09) of 229.5 g. However, both values were markedly higher than that from the 4DFR of 199.8 g. Of all the macronutrients, carbohydrate had the highest proportion of participants below the AMDR, with 60% from the NZWFFQ and 55% from the 4DFR, consuming less than 45% of their total energy intake from carbohydrate. However, the 2003 recommendation for sugar intake to be less than 15% of total energy intake (Ministry of Health, 2003) was exceeded by 94% of participants from the NZWFFQ and 81% from the 4DFR.

For micronutrient intake, the highest proportion of participants below the RDI and EAR was found for iron, calcium, folate and vitamin D. For iron, 91% of participants from the 4DFR and 88% from the NZWFFQ did not meet the RDI of 18 mg/d. For calcium, 64% of participants from the 4DFR and 33% from the NZWFFQ did not meet the RDI of 1000 mg/d. Daily iron and calcium intake from the NZANS (08/09) was also well below the RDI at 10.4 mg, and 794.5 mg respectively (University of Otago & Ministry of Health, 2011).

Table 4.2: Mean Daily Dietary Intake from the Questionnaire and Food Record vs. New Zealand National Recommendations (NHMRC, 2006) (n = 110)

	NZWFFQ Mean daily intake (mean ± SD)	4DFR Mean daily intake (mean ± SD)	NRVs[abc]	EAR[d]	Proportion (%) below NRV – NZWFFQ	Proportion (%) below NRV – 4DFR	Proportion (%) below EAR – NZWFFQ	Proportion (%) below EAR – 4DFR	NZANS (08/09)[f]
Energy (kJ)	8935.5 ± 2741.4	7844.6 ± 1716.0	na	na	na	na	na	na	8174.0
Protein (g)	98.8 ± 34.0	85.7 ± 24.8	46[a] 15-25% of total energy[c]	37	2[a] 5% under 12% over[c]	0[a] 17% under 8% over[c]	0	0	76.0
Total fat (g)	86.8 ± 34.0	75.9 ± 23.3	20-35% of total energy[c]	na	0% under 54% over[c]	0% under 58% over[c]	na	na	74.0
Saturated fat (g)	34.4 ± 16.4	27.9 ± 10.8	<12% of total energy[e]	na	76% over[c]	62% over[c]	na	na	29.4
Polyunsaturated fat (g)	13.1 ± 5.1	12.5 ± 6.2	6-10% of total energy[e]	na	70[e]	63[e]	na	na	10.2
Monounsaturated fat (g)	29.6 ± 11.6	27.7 ± 9.0	10-20% of total energy[e]	na	15[e]	20[e]	na	na	27.2
Cholesterol (mg)	292.5 ± 152.3	251.9 ± 140.5	na	na	na	na	na	na	248.0
Carbohydrate (g)	230.4 ± 75.3	199.8 ± 56.9	45-65% of total energy[c]	na	60[c]	55[c]	na	na	229.5
Sugars (g)	120.4 ± 42.9	93.5 ± 30.5	<15% of total energy[e]	na	94[e] over	81[e] over	na	na	110.5
Alcohol (g)	7.7 ± 9.7	9.2 ± 13.7	na	na	na	na	na	na	11.3
Dietary-fibre (g)	30.3 ± 8.8	26.3 ± 16.3	25[b]	na	29[b]	61[b]	na	na	17.7
Thiamine (mg)	1.8 ± 0.9	1.4 ± 0.7	1.1[a]	0.9	25[a]	34[a]	12	17	1.2
Riboflavin (mg)	2.7 ± 1.0	2.1 ± 0.7	1.1[a]	0.9	5[a]	5[a]	3	1	1.8
Niacin (mg)	22.9 ± 8.2	17.8 ± 6.1	14[a]	11	10[a]	25[a]	4	9	32.3
Vitamin-C (mg)	157.5 ± 74.0	99.4 ± 55.7	45[a]	30	0[a]	17[a]	0	8	108.5
Vitamin-D (µg)	4.7 ± 2.8	4.4 ± 3.4	5[b]	na	65[b]	68[b]	na	na	na

	NZWFFQ Mean daily intake (mean ± SD)	4DFR Mean daily intake (mean ± SD)	NRVs[abc]	EAR[d]	Proportion (%) below NRV – NZWFFQ	Proportion (%) below NRV – 4DFR	Proportion (%) below EAR – NZWFFQ	Proportion (%) below EAR – 4DFR	NZANS (08/09)[f]
Vitamin-E (mg)	13.5 ± 5.2	10.5 ± 4.8	7[b]	na	7[b]	18[b]	na	na	9.3
Vitamin-B6 (mg)	2.5 ± 0.9	2.1 ± 1.0	1.3[a]	1.1	5[a]	13[a]	4	6	2.1
Vitamin-B12 (µg)	4.9 ± 2.5	4.4 ± 4.9	2.4[a]	2.0	9[a]	16[a]	6	11	3.7
Total-folate (µg)	445.9 ± 160.6	402.5 ± 168.4	400[a]	320	45[a]	55[a]	25	37	na
Total-vitamin A equivalents (µg)	1543.5 ± 581.6	942.7 ± 935.2	700[a]	500	4[a]	42[a]	0	17	723.0
Magnesium (mg)	416.7 ± 117.2	369.4 ± 162.7	310-320[a]	255-265	16[a]	35[a]	9	15	na
Calcium (mg)	1254.7 ± 540.8	942.8 ± 340.2	1000[a]	840	33[a]	64[a]	21	43	794.5
Phosphorus (mg)	1794.7 ± 575.4	1497.6 ± 484.3	1000[a]	580	5[a]	7[a]	0	0	na
Iron (mg)	13.1 ± 4.0	13.0 ± 4.7	18[a]	8	88[a]	91[a]	7	6	10.4
Zinc (mg)	12.3 ± 4.1	10.6 ± 3.5	8[a]	6.5	12[a]	20[a]	2	5	9.6

Note. NZWFFQ = New Zealand Women's Food Frequency Questionnaire; 4DFR = Four-Day Food Record; RDI = Recommended Daily Intake; AI = Adequate Intake; AMDR = Acceptable Macronutrient Distribution Range; EAR = Estimated Average Requirement; NZANS (08/09) = New Zealand Adult Nutrition Survey; na = not available. [a]Nutrient Reference Values (NRVs): Recommended Dietary Intake; [b]NRVs: Adequate Intake; [c]NRVs: Acceptable Macronutrient Distribution Range; [d]NRVs: Estimated Average Requirement; all NRVs used were for women 19-30 and 31-50 years (National Health and Medical Research Council, 2006); [e]Food and Nutrition Guidelines for Healthy Adults (Ministry of Health, 2003); [f]Mean dietary intakes among New Zealand women aged 19 to 30 years, as reported in the NZANS (08/09) (University of Otago & Ministry of Health, 2011).

4.3. Validity of the New Zealand Women's Food Frequency Questionnaire

Validation of the NZWFFQ with the weighed food record was undertaken using the following statistical methods; paired t-tests, Pearson's correlation coefficients, cross-classification using quartiles and weighted κ-statistic, and Bland-Altman. Energy and twenty-five nutrients were analysed. A secondary analysis was undertaken on the NZWFFQ, in which dietary intake was adjusted for fruit and vegetable intake based on cross-check questions included in the NZWFFQ. Validity for this secondary analysis was assessed by comparison with the weighed food record using paired t-tests, Pearson's correlation coefficients and cross-classification. The findings from these statistical analyses are reported in table 4.3 and 4.4, and figure 4.1.

4.3.1. Validation Step 1 – Paired t-tests and Effect Size

The average energy and nutrient intakes from the NZWFFQ and food records are presented in table 4.3 as means with their corresponding SD. Using paired t-tests, it was found that energy and nutrient intakes were significantly higher from the NZWFFQ data in comparison to the food record for energy and all nutrients except polyunsaturated fat and alcohol ($p < 0.05$). Alcohol was the only nutrient with a higher intake from the food record. Adjustment for fruit and vegetable intake resulted in decreased dietary intake for energy and all nutrients from the NZWFFQ, except for saturated fat and vitamin A. Using paired t-tests, dietary intake from the adjusted NZWFFQ was still significantly higher than the food record for energy and all nutrients, with the exception of polyunsaturated fat, alcohol, fibre, vitamin B6 and magnesium.

The effect size was used to ascertain whether these t-test findings were substantive. A large effect (r = 0.5) was found for energy, total fat, monounsaturated fat, carbohydrate, sugars, fibre, vitamins B3, B6, A, C and E, calcium and iron. A medium effect (r = 0.3) was found for protein, saturated fat, cholesterol, vitamins B1 and B12, magnesium, phosphorus and zinc; and a small effect (r = 0.1) was found for folate, vitamin D and vitamin B2.

Table 4.3: Comparison of Mean Daily Intakes from the Questionnaire and Food Record (n = 110)

	4DFR Mean daily dietary intake (mean ± SD)	NZWFFQ Mean daily dietary intake (mean ± SD)		Paired t-test (p value)		Effect size (*r*)
		Unadjusted[a]	*Adjusted*[b]	*Unadjusted*[a]	*Adjusted*[b]	*Unadjusted*[a]
Energy (kJ)	7844.6 ± 1716.0	8935.5 ± 2741.4	8579.3 ± 2643.6	<0.001[1]	<0.001[1]	0.98
Protein (g)	85.7 ± 24.8	98.8 ± 34.0	96.0 ± 33.3	<0.001[1]	0.004[1]	0.34
Total fat (g)	75.9 ± 23.3	86.8 ± 34.0	84.9 ± 33.7	<0.001[1]	<0.001[1]	0.95
Saturated fat (g)	27.9 ± 10.8	34.4 ± 16.4	34.9 ± 17.4	<0.001[1]	<0.001[1]	0.45
Polyunsaturated fat (g)	12.5 ± 6.2	13.1 ± 5.1	12.8 ± 5.1	0.07	0.265	0.17
Monounsaturated fat (g)	27.7 ± 9.0	29.6 ± 11.6	29.1 ± 12.1	<0.001[1]	<0.001[1]	0.94
Cholesterol (mg)	251.9 ± 140.5	292.5 ± 152.3	292.5 ± 152.3	<0.001[1]	<0.001[1]	0.34
Carbohydrate (g)	199.8 ± 56.9	230.4 ± 75.3	216.1 ± 68.9	<0.001[1]	<0.001[1]	0.95
Sugars (g)	93.5 ± 30.5	120.4 ± 42.9	110.2 ± 37.7	<0.001[1]	<0.001[1]	0.52
Alcohol (g)	9.2 ± 13.7	7.7 ± 9.7	7.7 ± 9.7	0.273	0.15	0.14
Dietary-fibre (g)	26.3 ± 16.3	30.3 ± 8.8	25.6 ± 6.6	<0.001[1]	0.65	0.95
Thiamine (mg)	1.4 ± 0.7	1.8 ± 0.9	1.7 ± 0.9	<0.001[1]	<0.001[1]	0.39
Riboflavin (mg)	2.1 ± 0.7	2.7 ± 1.0	2.5 ± 1.0	<0.001[1]	<0.001[1]	0.20
Niacin (mg)	17.8 ± 6.1	22.9 ± 8.2	21.6 ± 7.8	<0.001[1]	<0.001[1]	0.53
Vitamin-C (mg)	99.4 ± 55.7	157.5 ± 74.0	118.0 ± 51.9	<0.001[1]	<0.001[1]	0.86
Vitamin-D (µg)	4.4 ± 3.4	4.7 ± 2.8	4.7 ± 2.8	0.005[1]	<0.005[1]	0.27
Vitamin-E (mg)	10.5 ± 4.8	13.5 ± 5.2	12.4 ± 4.9	<0.001[1]	<0.001[1]	0.52
Vitamin-B6 (mg)	2.1 ± 1.0	2.5 ± 0.9	2.2 ± 0.8	<0.001[1]	0.106	0.90
Vitamin-B12 (µg)	4.4 ± 4.9	4.9 ± 2.5	4.9 ± 2.5	0.01[1]*	0.001[1]	0.32
Total-folate (µg)	402.5 ± 168.4	445.9 ± 160.6	407.8 ± 151.2	0.004[1]	<0.001[1]	0.27
Total-vitamin A equivalents (µg)	942.7 ± 935.2	1543.5 ± 581.6	1160.0 ± 382.2	<0.001[1]	<0.001[1]	0.94
Magnesium (mg)	369.4 ± 162.7	416.7 ± 117.2	387.6 ± 106.8	<0.001[1]	0.053	0.36

	4DFR Mean daily dietary intake (mean ± SD)	NZWFFQ Mean daily dietary intake (mean ± SD)		Paired t-test (p value)		Effect size (*r*)
Calcium (mg)	942.8 ± 340.2	1254.7 ± 540.8	1209.5 ± 537.8	<0.001[1]	<0.001[1]	0.94
Phosphorus (mg)	1497.6 ± 484.3	1794.7 ± 575.4	1727.7 ± 557.8	<0.001[1]	<0.001[1]	0.44
Iron (mg)	13.0 ± 4.7	13.1 ± 4.0	12.3 ± 3.7	<0.001[1]	<0.001[1]	0.94
Zinc (mg)	10.6 ± 3.5	12.3 ± 4.1	11.7 ± 4.0	<0.001[1]	0.006[1]	0.37

Note. 4DFR = Four-Day Food Record; NZWFFQ = New Zealand Women's Food Frequency Questionnaire. [a]Unadjusted, raw dietary data; [b]Adjusted for fruit and vegetable intake; [1]Significant difference between the two dietary methods (NZWFFQ and 4DFR) $p < 0.05$ (Paired t-test, two-tailed).

4.3.2. Validation Step 2 – Pearson's Correlation Coefficients

Table 4.4 presents Pearson's correlation coefficients for the NZWFFQ and the 4DFR. The correlations had a large range from 0.10 (iron) through to 0.80 (vitamin A), with an average correlation of 0.39. All correlations were significant (p-value < 0.05) with the exception of iron (p = 0.29). Based on the correlation coefficient descriptors from Cohen (1988) and Hopkins et al (2009), a very high correlation (r = 0.7 - 0.9) was found for vitamin A; and a high correlation (*r* = 0.5 - 0.7) was found for saturated fat, cholesterol and alcohol. The majority of nutrients had a moderate correlation (*r* = 0.3 - 0.5) protein, total fat, monounsaturated fat, polyunsaturated fat, carbohydrate, vitamins B1, B2, B3, B6, B12, folate, C, D and E, minerals phosphorus and calcium. The remaining nutrients had a low correlation (0.1 - 0.3). Following data adjustment for fruit and vegetable intake, there was minimal change in correlation coefficients between the NZWFFQ and 4DFR, with differences ranging from 0 – 0.05. There was however, a marked decrease for vitamin A which dropped from 0.80 to 0.27.

4.3.3. Validation Step 3 – Cross-classification and Weighted Kappa Statistic

The percentage of correctly classified participants using quartiles ranged from 22% (phosphorus) through to 47% (saturated fat), with an average of 35%. The results are outlined in table 4.4 below. Correct classification into the same and adjacent quartiles ranged from 62% (iron) to 86% (saturated fat), with an average of 75%. Gross misclassification into the opposite quartile ranged from 3% (saturated fat) to 10% (iron), with a median of 6%.

In conjunction with the cross-classification analysis, the weighted κ-statistic was calculated for each nutrient to assess the agreement between the NZWFFQ and the food record. Saturated fat was the only nutrient that had moderate agreement (κ = 0.41 - 0.6), the majority of nutrients had fair agreement (κ = 0.21 - 0.4).

Cross-classification also changed minimally following adjustment for fruit and vegetable intake. Although the adjustment process reduced participant's intake of fruit and vegetables, each food item in the section was reduced by the same amount. Therefore, most participants remained in the same quartile.

Table 4.4: Pearson's Correlation Coefficients, Cross-classification and Weighted Kappa for Dietary Intake between the Questionnaire and Food Record (n = 110)

	Unadjusted[a]					***Adjusted***[b]			
	Pearson's Correlation coefficients	Cross-classification			Weighted kappa statistic	Pearson's Correlation coefficients	Cross-classification		
Nutrients	*r*	Correctly classified into same quartile (%)	Classified to within one adjacent quartile (%)	Grossly misclassified (%)	κ-statistic	*r*	Correctly classified into same quartile (%)	Classified to within one adjacent quartile (%)	Grossly misclassified (%)
Energy	0.29[2]	33	71	7	0.178	0.30[3]	35	72	5
Protein	0.30[2]	32	75	7	0.208	0.29[2]	31	75	5
Total fat	0.46[3]	39	79	4	0.323	0.45[3]	39	79	4
Saturated fat	0.57[3]	47	86	3	0.453	0.52[3]	48	86	4
Polyunsaturated fat	0.44[3]	41	75	5	0.293	0.45[3]	43	75	5
Monounsaturated fat	0.45[3]	37	82	5	0.324	0.40[3]	41	76	5
Cholesterol	0.52[3]	35	77	4	0.280	0.52[3]	35	77	4
Carbohydrate	0.40[3]	34	80	6	0.266	0.41[3]	37	78	5
Sugars	0.29[1]	34	78	6	0.251	0.29[2]	35	80	6
Alcohol	0.59[3]	34	81	4	0.295		40	80	4
Dietary-fibre	0.25[2]	35	70	8	0.178	0.19[1]	38	72	8
Thiamine	0.46[3]	42	78	5	0.323	0.46[3]	45	77	5
Riboflavin	0.34[3]	35	75	5	0.236	0.32[3]	35	74	5
Niacin	0.31[3]	33	68	8	0.149	0.33[3]	30	69	8
Vitamin-C	0.48[3]	32	79	4	0.266	0.46[3]	44	78	4
Vitamin-D	0.44[3]	38	69	4	0.235	0.44[3]	37	68	4
Vitamin-E	0.35[3]	33	72	6	0.193	0.37[3]	35	75	8

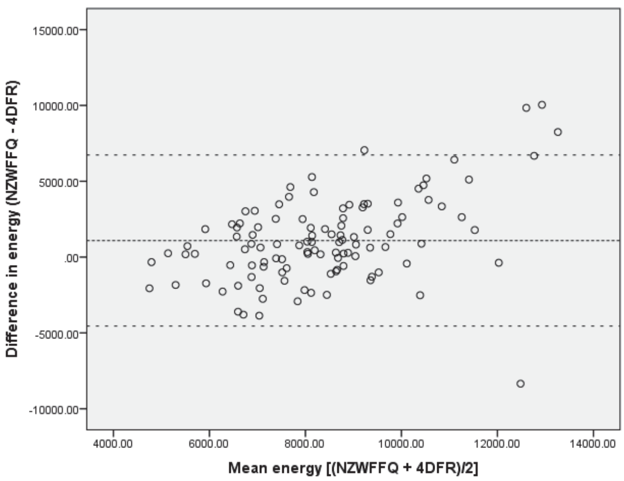
	Unadjusted^a					*Adjusted*^{b}			
Vitamin-B6	0.34^3	39	75	6	0.265	0.35^3	35	75	5
Vitamin-B12	0.31^3	35	72	4	0.235	0.31^3	35	72	4
Total-folate	0.42^3	37	73	5	0.250	0.39^3	35	75	4
Total-vitamin A equivalents	0.80^3	26	68	7	0.106	0.27^2	33	73	7
Magnesium	0.27^2	38	78	9	0.266	0.26^2	43	78	8
Calcium	0.45^3	39	80	5	0.323	0.42^3	39	80	4
Phosphorus	0.30^3	22	71	7	0.092	0.29^2	23	74	7
Iron	0.10	34	62	10	0.090	0.09	35	66	9
Zinc	0.25^2	25	66	8	0.077	0.26^2	30	68	7

Note. NZWFFQ = New Zealand Women's Food Frequency Questionnaire; 4DFR = Four-Day Food Record; ^{a}Unadjusted, raw dietary data; ^{b}Adjusted for fruit and vegetable intake; ^{123}Significant difference between the two dietary methods (NZWFFQ and 4DFR) $p < 0.05$ (Paired t-test, two tailed): ^{1}Correlation is significant at the level of 0.05 (two-tailed); ^{2}Correlation is significant at the level of 0.01 (two-tailed); ^{3}Correlation is significant at the level of 0.001 (two-tailed).

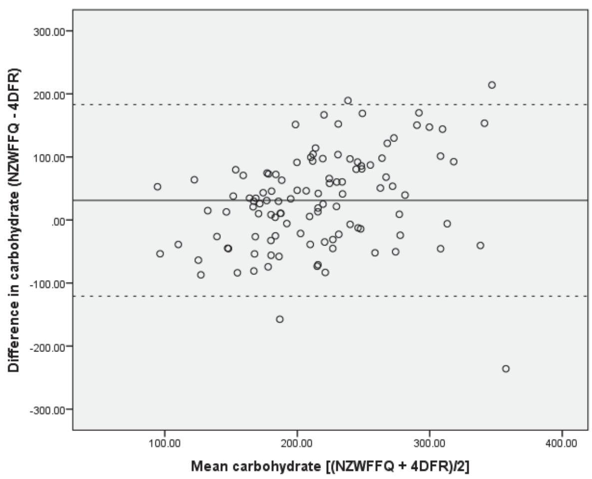
4.3.4. Validation Step 4 – Bland-Altman Analysis

Bland-Altman plots were constructed to assess the strength of agreement between dietary intake data from the NZWFFQ and 4DFR (Bland & Altman, 1999). Plots were created for energy and nutrients with a normal distribution, or nutrients that could be transformed into approximately normal distributions. Examples of Bland-Altman plots are shown in figure 1 from A to D, with a solid line representing the mean difference between the two dietary methods, and dashed lines representing the limits of agreement (LOA = mean difference ± 2 standard deviations). Visual inspection of the Bland-Altman plots suggest that the difference between the NZWFFQ and the 4DFR increased as the mean dietary intake increased. For energy and these nutrients, the majority of measures fell between the limits of agreement.

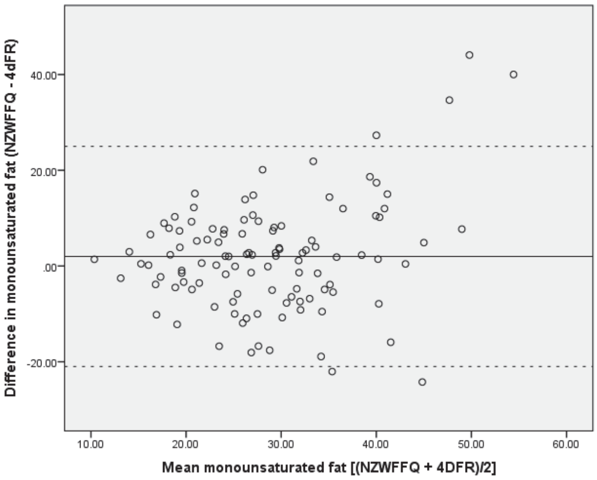
Bland-Altman plots of Relative Validity for Dietary Intake from the Questionnaire and Food Record



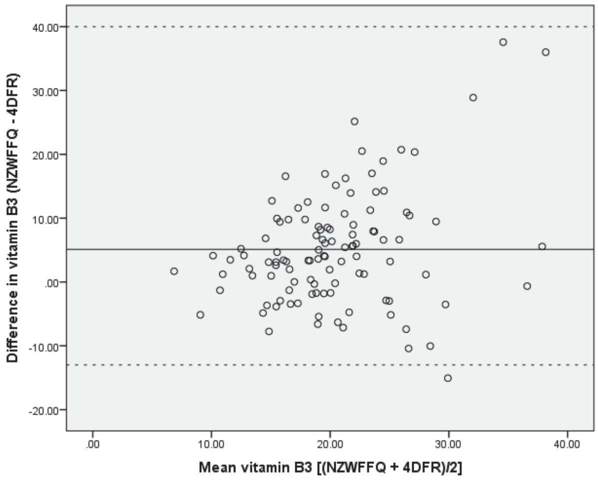
(A): Bland-Altman plot of Energy



(B): Bland-Altman plot of Carbohydrate



(C): Bland-Altman plot of Saturated Fat



(D): Bland-Altman plot of Vitamin B3

Figure 1: Bland-Altman plots of the agreement between intakes for (A) energy, (B) carbohydrate, (C) monounsaturated fat, (D) vitamin B3. The mean difference is represented by the solid line, and the limits of agreement (LOA) by the dashed lines (LOA = mean difference ± 2 standard deviations).

4.4. Goldberg Equation for Under-reporters

The Goldberg equation was used to assess dietary intake in relation to participants' basal metabolic rate (BMR). Schofield equations were used based on individuals' age, either under 30 years (62 × weight + 2036) or over 30 years (34 × weight + 3538), to determine BMR in kilojoules. The BMR was then multiplied by 1.55, which is the physical activity level (PAL) for a lightly active individual (National Health and Medical Research Council, 2006; World Health Organisation et al., 2004). The average energy intake of this study population was 8936 kJ, in comparison to an estimated energy expenditure of 9350 kJ per day. Under-reporting in individuals was identified if their ratio of energy intake to basal metabolic rate was below the cut-off value of 1.49 (cut-off value for a lightly active PAL of 1.55), based on four days of dietary intake (Black, 2000; Goldberg et al., 1991; World Health Organisation et al., 2004). Based on these calculations, it was found that 55% of this study population under-reported their energy intake i.e. were low energy reporters (LERs). These 'under-reporters' were included in all data analyses.

5. Discussion

5.1. Overall Findings

The New Zealand women's food frequency questionnaire (NZWFFQ) was developed to assess dietary intake of young women living in NZ based on foods consumed over the past month. When compared to a four-day weighed food record (4DFR), the findings show that the NZWFFQ has good relative validity for ranking individuals by dietary intake, and it was able to categorise participants with higher or lower intake than reference ranges. There was minimal difference to the findings following fruit and vegetable adjustment, with the exception of vitamin A in which validity decreased. The NZWFFQ performed better than previous NZ multi-nutrient FFQs used within a culturally diverse population. However, similarly to the literature, the NZWFFQ overestimated nutrient intake when compared to the weighed food record. Therefore, it is not suitable for assessing absolute dietary intakes.

5.2. Energy, Macro and Micronutrient Intake

Energy and nutrient intake from the study population was assessed using the NZWFFQ and the 4DFR, then compared with the most recent New Zealand adult nutrition survey (NZANS 08/09) and Nutrient Reference Values for Australia and New Zealand (females 19 - 30 years and 31 - 50 years) (National Health and Medical Research Council, 2006). The findings can be found in table 4.2.

The mean energy intake from the NZWFFQ was higher than that from both the 4DFR and the NZANS (08/09) with values of 8936, 7845 and 8068 kJ respectively (University of Otago & Ministry of Health, 2011). Energy intake is often higher from an FFQ in comparison to the reference method (Cade et al., 2002), with this finding also supported by other FFQ validation studies (George et al., 2004; Sam et al., 2012). With a higher energy intake, it would be expected that the macronutrient intakes from the NZWFFQ would also be higher than the comparison dietary assessment methods.

Mean protein, fat and carbohydrate intake were all higher from the NZWFFQ than the 4DFR and NZANS (08/09) (98.8, 86.8 and 230.4 g; 85.7, 75.9 and 199.8 g; 76.0, 74.0 and 229.5 g respectively) (University of Otago & Ministry of Health, 2011).

Over half of the participants from the present study did not meet the AMDR for carbohydrate of 45 -65% of energy (NHMRC, 2006), 60% from the NZWFFQ and 55% of participants from the 4DFR had a carbohydrate intake less than 45% of their energy intake. However, when sugar intake was assessed in the study population, it was found that 94% of participants from the NZWFFQ and 81% from the 4DFR exceeded the 2003 recommendation of less than 15% of total energy intake from sugar (Ministry of Health, 2003).

In contrast to carbohydrate intake, the AMDR for protein of 15 - 25% of energy (NHMRC, 2006), was met by 83% of participants from the NZWFFQ, and 75% of women from the 4DFR. The mean protein intakes from the NZWFFQ, 4DFR and the NZANS (08/09) of 98.8, 85.7 and 74 g respectively, were all well above the RDI of 46 g.

The minimum AMDR for fat of 20% of energy (NHMRC, 2006), was met by all participants from the NZWFFQ and 4DFR, however, the upper range of the recommended intake (35% of energy) was exceeded by 54% from the NZWFFQ and 58% from the 4DFR. Furthermore, the 2003 recommendation of less than 12% of saturated fat from energy (Ministry of Health, 2003) was exceeded by 76% of participants from the NZWFFQ, and 62% from the 4DFR.

Micronutrient intake recommendations were also not met when assessing results across all three dietary assessment tools. The highest proportion of participants below the RDI and EAR was found for iron, calcium, folate and vitamin D. Of particular concern was iron, with the RDI (18 mg/d) not met by 91% from the 4DFR and 88% from the NZWFFQ; and calcium, with 64% of participants from the 4DFR and 33% from the NZWFFQ not meeting the RDI of 1000 mg/d. Daily iron and calcium intake from the NZANS (08/09) was also well below the RDI with values of 10.4 mg, and 794.5 mg respectively.

5.3. Validity of the New Zealand Women's Food Frequency Questionnaire

Relative Validity of the NZWFFQ assessed the ability of the dietary tool to rank participants in relation to their nutrient intake. The following statistical methods were used; paired t-tests, correlation coefficients, cross-classification, weighted kappa statistic and Bland-Altman analysis.

Using paired t-tests (table 4.3), it was found that energy and nutrient intakes were significantly higher from the NZWFFQ in comparison to the food record for all nutrients except polyunsaturated fat and alcohol ($p < 0.05$). Alcohol was the only nutrient with a higher intake from the 4DFR. The NZWFFQ overestimated energy intake by 14%, and all other nutrients were overestimated by less than 30% with the exception of vitamins C, A and calcium. These findings are similar to those found by other validation studies, where FFQs were found to overestimate dietary intake when compared to food records, sometimes by more than 30% (Bolch, 1994; Cade et al., 2002; Sam et al., 2012; Watson 2012; Willet, 2013). A study by George et al. (2004) in the US found their FFQ overestimated energy intake by 5.5% and 3.4% in a validation and cross-validation study respectively, when compared to food records. A NZ study by Bolch (1994) found that the following nutrients were overestimated by more than 30%, vitamin C, thiamine and folate. Data from this study and Sam et al. (2012) were adjusted for total energy intake to improve results.

The effect size was used to ascertain whether the t-test findings were substantive (table 4.3). A moderate to large effect size (*r* between 0.3 - 0.5) was found for energy and most nutrients.

The NZWFFQ correlation coefficients (table 4.4) were between 0.10 (iron) to 0.80 (vitamin A), which fall within or above ranges from previous adult FFQ validation studies in NZ (Bolch et al., 1994; Metcalf et al., 1997; Sam et al., 2012; Sharpe et al., 1993) and also international studies in similar population groups (Boucher et al., 2005; Brunner et al., 2005; George et al., 2004; Kumanyika et al., 2003). The correlation coefficient for vitamin A of 0.80 was higher than that found in previous studies, and was within the very high range reported by Cohen (1988) and Hopkins et al. (2009). With the exception of iron (0.10), all other correlations between the NZWFFQ and food record were significantly correlated, and within the moderate to high descriptor ranges of 0.30 to 0.70 reported by Cohen (1988) and Hopkins et al., (2009).

Cross-classification was also used to rank participants by nutrient intake (table 4.4). The percentage of correctly classified participants using quartiles ranged from 22% (phosphorus) through to 47% (saturated fat). Correct classification within one quartile ranged from 62% (iron) to 86% (saturated fat). Gross misclassification into the opposite quartile was low, ranging from 3% (saturated fat) to 10% (iron). These findings are similar to those reported by the NZ validation studies by Sam et al. (2012) and Bolch (1994), which used quartiles and quintiles respectively. Correct classification within one quartile ranged from 65.9 to 97% for the study by Sam et al. (2012), and Bolch (1994) found that for most nutrients, greater than 60% were correctly classified. Throughout the literature, studies have used tertiles, quartiles and quintiles for cross-classification analysis. It is important to note that increasing the number of segments used for cross-classification i.e. using quintiles instead of tertiles will decrease the proportion of participants misclassified, however, it will also reduce the proportion correctly classified (Willet, 2013). The majority of studies from the literature review used quartiles therefore; to enable direct comparison the present study also used quartiles. The findings suggest that use of either the NZWFFQ or 4DFR would rank young NZ women into similar quartiles.

The kappa statistic for energy and each nutrient was used in conjunction with the cross-classification analysis (table 4.4), to assess agreement between the NZWFFQ and the food record, and to overcome the effect of chance. Saturated fat had moderate agreement, with a kappa value between 0.41 - 0.60. The majority of nutrients had fair agreement, with values between 0.21 - 0.40. The range of values compare with other studies such as Masson et al. (2003), in which kappa statistics ranged from 0.08 (thiamine) to 0.66 (magnesium).

Bland-Altman plots were performed to assess the strength of agreement between dietary intake data from the NZWFFQ and 4DFR (figure 4.1). It is recommended that only normally distributed or transformed data is used for Bland-Altman analysis (Bland & Altman, 1999), as skewed data will influence the plots. Therefore, only a small selection of nutrients was able to be assessed in this study. Bland-Altman plots were created for energy, monounsaturated fat, carbohydrate and vitamin B3. These plots are often used to assess the agreement between absolute intakes of two dietary assessment methods. Limits of agreement (LOA) are the mean difference ± two standard deviations. Discrepancies between methods can be observed when the LOA are not equally distributed in each direction of the mean difference, and when less than 95% of the data is within the LOA (Bland & Altman, 1999). For the plots in this study, most of the data was within the LOA. Visual inspection also suggested that the difference between the NZWFFQ and the 4DFR increased as the mean dietary intake increased. Most of the validation studies included in the literature review did not assess Bland-Altman statistics. Sam et al. (2012) found acceptable agreement between their two dietary methods for macronutrients; however, there were wide LOA for micronutrients. Wide

LOA between FFQs and the reference method are common, highlighting the limitation of the FFQ in assessing absolute nutrient intake (Cade et al., 2002).

5.4. Adjustment for Fruit and Vegetable Intake

Previous validation studies have suggested that fruit and vegetable intake is more likely to be over-reported in a FFQ than other food groups (Feskanich et al., 1993; Mullen et al., 1984). This has been shown to be related to the number of questions in these food group sections, short lists reduce over-estimation, whereas long lists result in greater over-estimation (Krebs-Smith et al., 1995). However, over-estimation from longer lists can be adjusted for through use of cross-check questions. These questions assess the total amount of food items consumed over a given period i.e. "how many servings of fruit are eaten each week?". By taking into account the total quantity consumed, the individual food items within that food group can be adjusted. Calvert et al. (1997) investigated mis-reporting of food groups from FFQ data, and the effect of using cross-check adjustments on nutrient intake. They found that cross-check adjustments had the largest effect on fibre and vitamins E, A, C and folate - nutrients found in fruit and vegetables. There was little effect on nutrient intake from adjustments made on meat and fish intake. These findings are supported by the FFQ validation studies Mullen et al. (1984) and Feskanich et al. (1993) who also found that fruit and vegetable intake is often mis-reported.

For the NZWFFQ, cross-check questions were included in each of the following food sections; milk, bread, butter/ margarine as a spreads, breakfast cereal/ porridge, starchy foods (rice, pasta, noodles, couscous), red meat, poultry, fish and seafood, fats and oils, eggs, legumes, vegetables, fruit, and drinks. The question asked how many servings of the food group were eaten each day or week, and portion size examples were also provided. From analysis of the cross-check questions it was found that servings from the following food groups were overestimated; fruit, vegetables, cereals, red meat, poultry and seafood. However, data adjustments were only made for the fruit and vegetable sections due to time constraints of the study and research showing that these food categories are most likely to overestimated (Krebs-Smith et al., 1995; Mullen et al., 1984; Feskanich et al., 1993; Calvert et al., 1997).

Fruit and vegetable adjustment resulted in decreased dietary intake for energy and all nutrients except for saturated fat and vitamin A. Using paired t-tests, dietary intake from the adjusted NZWFFQ was still significantly higher than the food record for energy and all nutrients except polyunsaturated fat, alcohol, fibre, vitamin B6 and magnesium.

Following data adjustment, there was also minimal change in correlation coefficients between the NZWFFQ and 4DFR, with differences ranging from 0 – 0.05. There was however, a marked decrease for vitamin A which dropped from 0.80 to 0.27. This finding is supported by Calvert et al. (1997), in which vitamin A also decreased more than any other nutrient. This is presumably due to the high concentration of vitamin A in fruit and vegetables.

Cross-classification also changed minimally following adjustment for fruit and vegetable intake. This finding is consistent with previous research (Calvert et al, 1997; Watson, 2013). The percentage of participants who were correctly classified into the same quartile remained between one-third and one-half. Gross misclassification of participants into opposite quartiles also remained below 10%. Although the adjustment process reduced participant's intake of fruit and vegetables, each food item in the section was reduced by the same amount. Therefore, most participants remained in the same quartile, even though their mean intake changed. This may explain the lack of an effect of adjustment on cross-classification.

The fruit and vegetable adjustment made no difference to the ability of the NZWFFQ to rank participants by nutrient intake. Therefore, it does not appear to be necessary to include a cross-check question within these food sections for future use of the NZWFFQ.

5.5. Energy Adjustment

When nutrient intake data has been adjusted for energy intake, previous FFQ studies have found that validity improves (Sam et al., 2012). Energy adjustment enables nutrient intake to be related with a particular outcome, independent of energy intake (Cade et al., 2002). The correlation coefficients between the FFQ and reference method of energy-yielding nutrients often increase after energy adjustment (Bingham, 1997). Although this may improve the validity of a study, Block (2001) cautions use of inflated correlation coefficients resulting from energy adjustment, and recommends that the intended application of the FFQ should be considered before applying energy adjustment (Block 2001; Subar et al., 2001). For example, FFQs developed to assess nutrient intake in community settings will give more insight into the health of the population using absolute values, rather than energy adjusted values. This study did not perform energy intake adjustment to the data, due to time constraints only an adjustment for fruit and vegetable intake was undertaken.

5.6. Under-reporting

Under-reporting is a common issue in dietary assessment; data from self-reported dietary methods often have a marked bias to under-estimation of food intake. This occurs from both conscious and unconscious food omission when reporting, and also from under-eating i.e. dieting. Under-reporting can result in poor validity. Under-reporting has been shown to be higher in overweight and obese populations (Cade et al., 2002; Ministry of Health, 2011; Willet, 2013). Findings from the NZ validation study by Bell et al. (1999) of underestimation with obese participants were similar to those reported in the most recent New Zealand Adult Nutrition Survey (NZANS) (08/09), in which under-reporting was higher in those with a BMI over 25 kg/m² (Gemming et al., 2014). Furthermore, Gemming et al. (2014) found under-reporting in the NZANS (08/09) to be higher in the Māori and Pacific population than NZ European.

The Goldberg cut-off method was used in the present study to assess the percentage of this population that were low energy reporters (LERs) i.e. under-reporters. This method assesses dietary intake in relation to participants' basal metabolic rate (BMR). Appropriate age and gender related Schofield equations were used to determine BMR, and the mean energy intake for each participant was used from the NZWFFQ. Under-reporting in individuals was identified if their ratio of energy intake to BMR was below the cut-off value of 1.49 (cut-off value for a lightly active physical activity level of 1.55), based on four days of dietary intake (Black, 2000; Goldberg et al., 1991; World Health Organisation et al, 2004). Based on these calculations, it was found that 55% of this study population under-reported their energy intake i.e. were low energy reporters (LERs). Participants identified as under-reporters were not excluded from data analyses, due to the lack of agreement across literature as to whether they should be omitted (Heath et al., 2000). It has been suggested that low energy reporting may also occur in participants with plausible energy intakes hence, excluding only those with implausible intakes may lead to biased results (Heath et al., 2000; Macdiarmid & Blundell, 1997). Furthermore, if these 'under-reporters' had been excluded from the analysis, the population sample would not have met the suggested sample size of more than 100 for validation studies (Bland & Altman, 1999).

6. Conclusions

6.1. Study Strengths and Limitations

There are a number of challenges associated with dietary assessment, particularly in ethnically diverse populations such as New Zealand. These challenges include selection of the study population, generalising study results, study design and reference method accuracy. Their potential effects on the results of the study are discussed in this section.

6.1.1. Questionnaire Development

Development of the New Zealand Women's Food Frequency Questionnaire (NZWFFQ) included a pilot test on 60 Massey University nutrient students, the majority of which had similar demographic characteristics to the study population i.e. 16 - 45 years, pre-menopausal, healthy and a variety of ethnicities including NZ European, Māori and Pacific. The pilot study enabled pre-testing of the food list and ensured comprehension of the FFQ. Adjustments to the food list and question structure were modified in response to the pilot study. The main limitation of this pilot was use of nutrition students as a representation of the NZ population. These students would have been likely to have higher nutrition knowledge and comprehension than the general NZ population. Furthermore, this pilot sample included a small number (approximately five) students who differed from the NZWFFQ study population as these students were either male or of a different ethnicity (e.g. Asian).

The finalised NZWFFQ was then transferred to SurveyMonkey, an online survey development programme. This was a strength of study as the computerised format ensured complete data capture, participants could not progress onto the following food category until all questions had been completed on the current page. Results were collected as soon as the participant completed the NZWFFQ, and were stored on the Massey University SurveyMonkey server. Other studies such as Heath et al. (2000) have validated questionnaires in computerised formats.

6.1.2. Study Population

Validity studies require between 100 - 200 participants (Cade et al., 2002), and this study involved 110 participants. Having a large sample size increased the likelihood that the study would truly represent the population of interest.

For a food frequency questionnaire (FFQ) to be validated, it must be tested on a sub-sample that represents the population of interest e.g. similar age, health status, gender and ethnicity. These demographic factors can influence the validation outcome (Nelson, 1997). Recruiting a representative sample of participants is an issue all FFQ validation studies face. A convenience sample was recruited in the present study from the general population in Auckland, NZ, using email distribution, magazine and local paper advertisements. The participants who responded are likely to be those who are more motivated and/ or interested in their health and nutrition than the general public, potentially biasing the sub-sample.

Dietary tools have been shown to perform differently across ethnicities (Bell et al., 1999; Mayer-Davis et al., 1999; Metcalf et al., 1997). Metcalf et al (1997) found lower correlations between their FFQ and a three-day food record in the Māori and Pacific population in comparison to those found for NZ Europeans. Bell et al. (1999) found that energy intake was underestimated in their Samoan population. These findings are also supported by international studies, for example Mayer-Davis et al. (1999) found lower correlations between the FFQ and 24-hour recalls in Hispanics and African American, in contrast to those found for white non-Hispanics. Lower validity in subcultures is thought to be due to limited or absent culturally relevant food items in the FFQ food list (Cade et al., 2002; Willet, 2013). FFQs should be culturally specific, and these findings support the need for validity assessments before use in the target population (Willet, 2013).

A limitation of this study was the small representation of Māori and Pacific participants. Over the 12 month data collection period, the majority of eligible participants were of NZ European ethnicity. However, the proportion of participants included from each ethnicity was a close representation of the NZ population, with 80.9% NZ European, 11.8% Māori and 7.3% Pacific versus the NZ population of 74.0% NZ European, 14.9% Māori and 7.4% Pacific (Statistics NZ, 2014). There is no other recently validated multi-nutrient FFQ for use in NZ that has a close representation of the NZ population. The only multi-nutrient FFQ validated over the last decade in NZ (Sam et al., 2012) had a population that was 95% NZ European and 5% Māori and Pacific.

The study population was not stratified by education level. Validity has been shown to differ within a population when participants are stratified by education level (Mayer-Davis et al., 1999). Therefore, with a larger sample in future studies, it may be beneficial to stratify participants by education level.

Males were not included in this study. Results may vary among gender, as the NZANS has shown differences from 24-hour dietary recalls (University of Otago & Ministry of Health, 2011). Energy intake is usually higher in males due to higher basal metabolic rates. An increased energy intake will result in increased macronutrients and almost certainly, micronutrients. Therefore, the FFQ should be validated in males if it is intended to be used within this population group in the future (Cade et al., 2002).

Body mass index (BMI) has also been shown to influence nutrient intake and measures of validity. Bell et al. (1999) found that energy intake was underestimated in obese Samoan participants with a BMI over 30 kg/m². Kumanyika et al. (2003) found lower energy correlation coefficients in the higher BMI group (over 27 kg/m²). George et al. (2004) conducted two validation studies with different populations. The higher BMI population overestimated their FFQ energy intake by 3.4% in comparison to the lower BMI population who overestimated their energy intake by 5.5%. The differences in FFQ energy overestimation may be due to under-reporting in the higher BMI population. A limitation of the present study was that the population's body composition was not representative of the NZ population, as shown by the anthropometric data. The proportion of participants with a normal BMI (18 - 24.99 kg/m²) was higher than that of the NZ population, 66.4% and 34% respectively (Statistics NZ, 2014). The participants who volunteered as participants for the study were likely to be interested in nutrition, and health conscious, which may explain why the study population had a lower BMI than the NZ population. Higher levels of under-reporting of dietary intake have been associated with overweight and obese populations, reducing validity in some studies (Bell et al., 1999; George et al., 2004; Kumanyika et al., 2003). Therefore, the decreased proportion of overweight and obese participants in the present study may have reduced under-reporting.

Under-reporting in this study was already high, with 55% of participants identified as low-energy reporters.

The Goldberg formula was used to determine under-reporting. A limitation of using this formula was that the participants physical activity level (PAL) was not known. It was estimated at 1.55, which is the WHO value for a lightly active individual (National Health and Medical Research Council, 2006; World Health Organisation et al., 2004). This value was selected based on previous literature which has used a PAL of 1.55 as a conservative measure (Black, 2000). If the average PAL of the population was higher, then the proportion of under-reporters would increase.

6.1.3. Choice of Reference Method

There is no dietary assessment method that enables usual dietary intake to be measured with absolute accuracy. The weighed food record has the least correlated errors with the FFQ (Margetts & Nelson, 2010), therefore this dietary tool was used as the reference method in this study.

All of the five New Zealand (NZ) FFQ validation used food records as a reference method (Bell et al., 1999; Bolch, 1994; Metcalf et al., 1997; Sam et al., 2012; Sharpe et al., 1993). Of the international studies undertaken in similar populations, five used food records (Bingham et al., 1997; Brunner et al., 2001; Friis et al., 1997; George et al., 2004; Masson et al., 2003) and four used diet recalls (Boucher et al., 2005; George et al., 2004; Kumanyika et al., 2003; Mayer-Davis et al., 1999). Diet recalls depend on memory, and require the participant to recall foods and portion sizes consumed over the previous 24-hours (Krall et al., 1988). This method is not appropriate as a reference method as it relies on memory, as does the FFQ (Cade et al., 2002; Willet, 2013).

In the present study, participants were asked to consume their normal diet over the recording period, to ensure this was a normal representation of their usual diet. The food record does however; still contain errors that can influence the agreement between the NZWFFQ and the four-day weighed food record (4DFR). Having to weigh every food item increases participant burden, and is a limitation of using the food record (Cade et al., 2002; Willet, 2013). This can lead to misreporting, or selection of foods that are not as difficult to weigh. The assumption of the weighed food record as a gold standard dietary assessment method in which to validate the NZWFFQ against is a limitation; this may have influenced the agreement with the NZWFFQ.

One the NZ validation studies, Sam et al. (2012) used blood biomarkers in addition to the food record as a reference method. Biomarkers are often used in validation studies with food records due to the limitations that arise in dietary assessment (Willet, 2013; Cade et al., 2002). Biomarkers are able to estimate dietary intake independently of the participants reported intake, therefore reducing errors from over- and under-reporting. However, this method is expensive, invasive for the participant and nutrient specific – assessment can only be undertaken with some nutrients, as the biomarker must reflect dietary intake over the same period as dietary assessment method (Cade et al., 2002; Gibson, 2005). There are also errors associated with biochemical markers, due to difficulties ascertaining a 'true relationship' with usual dietary intake. The relationship is complicated by digestion, absorption, metabolism and excretion factors. Furthermore, multiple measures must be taken, to account for variations in diurnal concentration (Cade et al., 2002). Due to these factors and increased participant burden, biomarkers were not used for this study.

A strength of this study was the duration of four recording days. Stram et al. (1995) calculated the 'ideal' duration of dietary recording for validation studies as four to five days, with more than this rarely required. Participant burden increases above five days, and dietary data becomes less accurate. This occurs due to lower participant completion rates, increased awareness of consumed foods which affects FFQ responses and an increased likelihood of alterations in the foods consumed (Stram et al., 1995; Willet, 1998). Other NZ FFQ validation studies recorded between five to eight days of food intake (Bell et al., 1999; Bolch, 1994; Metcalf et al., 1997; Sam et al., 2012; Sharpe et al., 1993).

There were however, limitations regarding that the period the FFQ covered. It has been suggested that the days recorded by the food record should cover the same period that the FFQ assesses i.e. one month for the present study. In this study, the NZWFFQ was completed first, then the 4DFR. Therefore, both methods did not assess the period. Previous studies have overcome this by having participants complete two FFQs, one before the reference method and one after (Cade et al., 2004). Furthermore, this study collected four consecutive days of food records, which covered a dietary assessment period of less than a week in comparison to the NZWFFQ, which collected dietary data based on a month of intake. It has been suggested that days of food recording should not be consecutive, with an even spread over the month and across various days of the week (Willet, 2013). Regarding usual diet, the true variability for each participant is better provided by non-consecutive days as dietary intake on consecutive days is shown to be correlated (Hartman et al, 1990; Thompson & Buyers, 1994). Of the NZ multi-nutrient validation studies, only Sam et al. (2012) used non-consecutive days for the reference method. Sam et al. achieved this by collecting two days of food record data over four weeks, resulting in eight days of food records that cover one month of dietary intake.

6.1.4. Food Composition Database

A common error that applies to both food record and FFQ is the food composition database which is used for dietary analysis. Ideally, the same composition database should be used for both, as this will match errors, and decrease the effect of such errors on the validity assessment. A strength of this study was that the same database, Foodworks 7 (FoodWorks Professional, 2013), was used for both dietary methods in this study. Foodworks uses the New Zealand Food Composition Database - NZ FOODfiles 2010 (NZ Institute for Crop & Food Research, 2010) to determine energy, macro- and micronutrient intake. Although this is the most current nutrient database for NZ, new food items are continuously being produced. Data for the NZWFFQ and the 4DFR was entered by same researchers who followed a 'Master of Assumptions' document, outlining specific substitutions to be made for food items absent from the database. This enabled consistency of data entry, and reduced subjective bias. The NZWFFQ also included additional questions on food preparation and cooking methods. This information was used to guide decisions on food items that required substitution.

6.1.5. Statistical Analysis

A strength of the study was the comprehensive statistical analysis, using a range of statistical methods; paired t-tests, correlation coefficients, cross-classification, weighted kappa statistics and Bland-Altman statistics. It has been recommended by Cade et al. (2002) that studies should include more than one statistical method for validity analysis. All data for this study was assessed for normality, with natural log transformations performed on data that was not normally distributed. Parametric analysis was then conducted (Field, 2013).

6.1.6. Reproducibility

A limitation of this study was that reproducibility of the NZWFFQ was not assessed. The main data collection was obtained on one occasion only, in which the participants completed the NZWFFQ on-site in the presence of a research assistant. It was beyond the scope the study to replicate these conditions and have the participants complete a second FFQ. Reproducibility is also known as 'reliability' and is used to assess associations between two responses i.e. whether the same responses are yielded from both administrations of the FFQ (Margetts & Nelson, 2010). Reproducibility was only assessed by 47% of the 200 validation studies reviewed by Cade et al. (2002). Reproducibility is not the same as validity, thus, having good validity does not translate to good reproducibility.

6.2. Recommendations for Future Research

- Assess the validity of the NZWFFQ within solely Māori and Pacific populations.
- Assess the validity of the NZWFFQ within other sub-groups of the population i.e. males, the elderly, other ethnic groups and populations with higher proportions of overweight and obese participants (as this influences reported dietary intake). The NZ validation studies by Metcalf et al. (1997) found that their FFQ performed differently when comparing sub-populations of ethnicity.
- Investigate the validity of a shortened version of the NZWFFQ to reduce participant burden.
- Assess the reproducibility of the NZWFFQ.
- Further research into portion size estimation would be beneficial, as there is still no consensus on whether the addition of portion size to FFQs enhances or reduces validity.
- The use of palm size/ palm volume as an estimation of portion size also warrants further research. A study in toddlers found adequate to good validity when using palm volume for portion estimation (Watson, 2012).

6.3. Conclusion

A comprehensive literature was conducted on food frequency questionnaire (FFQ) development and validation. A key finding was that at present in New Zealand, there are only five published food frequency questionnaires that have been assessed for relative validity in determining multi-nutrient intake of New Zealand adults (Bell et al., 1999; Bolch, 1994; Metcalf et al., 1997; Sam et al., 2012; Sharpe et al., 1993). Only one of these FFQs has been validated over the last 15 years (Sam et al., 2012). The total proportion of Māori and Pacific participants in this study by Sam et al. was 5%, much lower than the total NZ national representation of 22.3% (Statistics NZ, 2014). Therefore, this FFQ may not be suitable to assess varying nutrient intake across cultures in the NZ population.

These limitations formed the objectives of the present study, which were: to develop a culturally appropriate, computerised, semi-quantitative FFQ to assess the dietary intake of young adult women living in New Zealand; to validate the FFQ; and to assess the dietary intake of this population.

The final design of the New Zealand women's food frequency questionnaire (NZWFFQ) was a 220-item, multi-nutrient FFQ which was modified from the 97/98 NZ Adult Nutrition Survey (NZANS). The NZWFFQ had a food list that included culturally relevant foods for the NZ population.

When compared to a four-day weighed food record (4DFR), the findings show that the NZWFFQ has good relative validity for ranking individuals by dietary intake, and it was able to categorise participants with higher or lower intake than reference ranges. There was minimal difference to the findings following fruit and vegetable adjustment, with the exception of vitamin A in which validity decreased. The NZWFFQ performed better than previous NZ multi-nutrient FFQs used within a culturally diverse population. However, similarly to the literature, the NZWFFQ overestimated nutrient intake when compared to the weighed food record. Therefore, it is not suitable for assessing absolute dietary intakes.

The NZWFFQ is a valid tool for future use in the EXPLORE study and other research to assess the relationship between dietary intake, socio-demographics and nutrition-related risk factors (e.g. BMI, cholesterol levels).

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Appendices

Appendix A. Standard Operating Procedure for the New Zealand Women's Food Frequency Questionnaire

1. The questionnaires will be completed online using the computers in building 27. The two computers must first be turned on using the power button on the hard drive. You must then log in using the Explore network account, so that the computer is ready for the participants;

    Username: ********

    Password: ********

2. Once logged in please ensure that there are three questionnaire links on the desktop i.e. Food Frequency Questionnaire, Eating Habits Questionnaire, and the Eating Behaviour Questionnaire. Open up each link, ensuring there is access. If there are any issues, please ask Zara, AJ, Sara, Kathryn Beck, or PC to help. If the issue cannot be resolved, there are hardcopies for each of the questionnaires which are kept in the pink Explore questionnaire folder which is will be beside the computers at the questionnaire station. However, the hardcopy version must be a last resort as this will have to be put into surveymonkey manually by an Explore staff member at a later date, which is time consuming.

3. The next component to check is the guidelines for the weighed food record. There is a pdf on the desktop beside the questionnaire links called 'Weighed Food Record Guidelines', open this up and make sure it plays as a video. Check the sound, if there is no sound you may have to set up the headphones from the pink Explore folder. These can be plugged into the computer hard drive in the hole marked with a headphone symbol, plug in, put the earphones in your ears and check the sound again. If there are any issues, please see one of the team members listed above. If you are going to use earphones for participants, please ensure there are small steriliser wipes at the computer station. The earphones must be cleaned by the staff member managing the

questionnaire station with the wipes after each participant use. This is to maintain hygiene.

4. Participants will move to the questionnaire station after completing the BP station, this BP station is very quick (3-5minutes maximum) so ensure you are prepared by this stage. The participants are offered breakfast and a hot drink once BP has been recorded, if the participant declines please escort them straight to the questionnaire station. If the participant would like breakfast and/or a hot drink, please encourage them to consume this at the computer stations where they will begin the questionnaires (as time may be short with multiple participants on the testing days). The questionnaire station is time consuming (25-40 minutes) so it is important to get this underway as soon as possible.

5. Once the participant is seated infront of the computer, inform them that there are three questionnaires to complete, and a video to watch afterwards.

6. The first questionnaire to complete is the Food Frequency Questionnaire; open the link for the participant. Then read the first page to the participant, taking your time through the question examples, asking at the end if they have any questions.

7. Click ‘next’ at the bottom of the page and this will take you to the first questionnaire question which asks for the participant ID number, please insert this full number yourself i.e. 250018 and click ‘next’ at the bottom of the page.

8. The questionnaire is now ready for the participant to begin. Let the participant know that you will be there to answer any questions they have whilst completing it. Leave the participant and sit at the big round table behind the computer station, so that you are close enough for any possible questions, but so that you still give the participant some privacy.

9. It is important that conversation is kept to a minimum whilst participants are completing the questionnaires, they need full focus.

10. If any questions arise during this time from the participant that you are unsure of, please ask one of the team members stated above. It is important that we obtain the most accurate information possible from the questionnaires.

11. If the links (questionnaires) stop working at any time, please see a team member stated above. You may need to provide a hardcopy for the participant to complete. If so, please ensure they complete this hardcopy version from the beginning, as their questionnaire data will not be saved unless they have 100% completed it.

12. Once the participant has completed the food frequency questionnaire, please open the 'Eating habits' questionnaire for them to complete next. Again, open up link and read the initial statement(s) to the participant. Enter in their participant ID number at the top, and then remind the participant again that you are free to answer any questions they may have over this time.

13. If there are any complications/issues please contact one of the staff members stated, and provide a hardcopy version only as a last resort (to complete from question 1 to the end).

14. Once completed, open up the 'Dietary behaviours' questionnaire, entering in the participant ID again, with the instructions as above.

15. Upon completion of the third questionnaire, the participant must watch the food record video. Open this up for the participant, and provide cleaned earphones if required.

16. Once this is finished, close the video and escort the participant to the large round table for the take home package station. This package is already set up for the participant, you are required to take the participant through; the weighed food record diary, food record example booklet, allocate and record four days for them to complete this on,

electronic scales are provided if required, and then through the dietary diversity questionnaire, before the participant is equipped with the accelerometer.

17. Firstly, show the participant the weighed food record diary and explain this must be completed over the next four days i.e. if today's date of testing is Thursday the 12th of September, then the participant will complete a weighed food diary the following four days: Friday 13th, Saturday 14th, Sunday 15th and Monday 16th from when they wake up in the morning until when they go to bed at night. They must record the time of each meal, and weigh all food items they eat providing as much detail as possible when recording foods. We need four consecutive days of recording, which include at least one weekend day. If they go out for a meal, get them to describe the food as best they can, using the palm size as a portion tool or plate/bowel size.

18. Provide the participant with the food record example booklet, explain they can refer the picture numbers i.e. spaghetti bolognaise picture b.3 in their food diary if this helps for meals out or those they could not weigh.

19. Next, record the four days and dates (as explained above) in the participant's food diary record booklet, there are four lines at the beginning of the booklet to record this. Also record this on the calendar in the Explore pink folder. Explain that there are contact details on the front of the food record dairy which the participants can use if any questions arise while they are weighing their food and recording it.

20. If the participant does not have a set of electronic scales at home, please provide them with some. If there are none in building 27, please see PC. Check that the scales have batteries in them, and that they work. Record the scale ID number on the back of the calendar with the participant name and date. The participant will be given a courier bag to return the scales in.

21. Finally, go through the Dietary Diversity Questionnaire with the participant. This is to be completed in 7 days' time when they take the accelerometer off. They only

complete this questionnaire once, and emphasise how they must not look at their food record when completing this. The questionnaire is designed with a different purpose.

22. The weighed food record and the dietary diversity questionnaire need to be returned in the return envelope with the accelerometer after7 days. The courier bag with the scales can be sent back after the four days of recording.

23. Wendy will now complete the take home station setting the participant up with an accelerometer and petrol voucher.

Appendix B. New Zealand Women's Food Frequency Questionnaire

New Zealand Women's Semi-quantitative Food Frequency Questionnaire

Please make sure when filling out this questionnaire that you:

- Tell us what **YOU** usually eat (not someone else in your household!).
- Fill in the form **YOURSELF**.
- Are as accurate as possible, but don't spend too much time on each food.
- Answer **EVERY** question.

Please answer by **ticking the box** which best describes **how often you ate or drank** a particular **food or drink** in the **last month**.

For example:

In the past month I have eaten this food….

Food items	I never eat this food	Less than once a month	1 to 3 times a month	Once per week	2 to 3 times per week	4 to 6 times per week	Once per day	2 to 3 times per day	4 plus times per day
Sugar									✕

If every day you have 2 cups of coffee with 1 tsp sugar, 4 cups of tea with 1 tsp sugar, one bowl of cereal with 1 tsp sugar and sugar on pancakes at dinner, you would choose '4 Plus times per day'.

In the past month I have eaten this food….									
Food items	**I never eat this food**	**Less than once a month**	**1 to 3 times**	**Once per week**	**2 to 3 times per week**	**4 to 6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Pineapple					✕				

If you eat pineapple slices with a hamburger meal once a week at lunch and eat carrot and pineapple salad once a week at dinner you would choose '2 to 3 times per week'.

1. How would you describe your eating pattern? (*Please choose one only*)
   - ☐ Eat a variety of all foods, including animal products
   - ☐ Eat eggs, dairy products, fish and chicken but avoid other meats

☐ Eat eggs, dairy products, fish but avoid chicken and other red meats
☐ Eat eggs and dairy products, but avoid all meats, chicken and fish
☐ Eat eggs, but avoid dairy products, all meats and fish
☐ Eat dairy products, but avoid eggs, all meats and fish
☐ Eat no animal products
☐ Other (*please state*)____

Dairy Foods

2. Do you use milk?
   ☐ No
   ☐ Yes

   What type(s) do you have most often? *(You can choose more than one, but please only choose the ones you usually have)*

   ☐ Full cream milk (purple top): fresh, UHT or powdered
   ☐ Standard milk (blue top): fresh, UHT or powdered
   ☐ Skim milk (light blue top): fresh, UHT or powdered
   ☐ Trim milk (green top): fresh, UHT or powdered
   ☐ Super trim milk (light green top): fresh, UHT or powdered
   ☐ Calcium enriched milk (yellow top) e.g. Xtra, Calci-Trim
   ☐ Calcium and vitamin enriched milk e.g. Mega, Anlene
   ☐ Calcium and protein enriched milk e.g. Sun Latte
   ☐ Standard soy milk (blue)
   ☐ Light soy milk (light blue)
   ☐ Calcium enriched soy milk (purple) e.g. Calci-Forte, Calci-Plus

☐ Calcium, vitamin and omega 3 enriched soy milk e.g. Essential
☐ Calcium and high fibre enriched soy milk e.g. Calci-Plus High Fibre
☐ Rice milk
☐ Other *(please state)* ____

3. On average, how many servings of milk do you have per ***day***?

(*Please choose only one*)

(A 'serving' = 250 mL (1 cup/glass))

E.g. 5 cups of coffee/tea using 50mL of milk + ½ cup of milk on cereal = 1 ½ servings per day

Per Day

☐ Less than 1 serving
☐ 1-2 servings
☐ 3-4 servings
☐ 5 or more servings

4. How often do you usually eat these foods or drinks?

Dairy Foods										
Please fill in one category for each food or drink	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Flavoured milk (e.g. milkshake, iced coffee, Primo, Nesquik)	250ml or 1 cup/glass									
Milk as a drink	250ml or 1 cup/glass									
Milk on breakfast cereals	½ cup									
Milk added to hot drinks made with water (e.g. coffee, tea)	Please choose one Small serve Medium serve Large serve									
Hot drinks made with mainly milk (e.g. Latte)	250ml or 1 cup/glass									
Cream or sour cream	1 heaped Tablespoon									
Ice cream	2 scoops									
Custard or dairy food	1 pottle or ½ cup									
Yoghurt, plain or flavoured (including fromage frais)	1 pottle or ½ cup									

Dairy Foods										
Please fill in one category for each food or drink	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Milk puddings (e.g. rice, semolina, instant)	½ cup									
Fermented milk (e.g. buttermilk)	½ cup									
Evaporated milk	¼ cup									
Cheddar cheese (e.g. tasty, mild, gouda)	2 heaped Tablespoons or matchbox size									
Edam, mozzarella or feta cheese	2 heaped Tablespoons or matchbox size									
Processed/plastic wrapped cheese slices	1 slice									
Cream cheese	*Please choose one:* Thin spread Medium spread Thick spread									

Dairy Foods										
Please fill in one category for each food or drink	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Cottage or ricotta cheese	*Please choose one:* Thin spread Medium spread Thick spread									
Camembert	1 medium wedge (1/8 of a wheel) or 1 heaped Tablespoon									
Brie, blue and other specialty cheese	1 medium wedge or 1 heaped Tablespoon									

Bread

5. Do you eat bread?
   - ☐ No
   - ☐ Yes

What type(s) of bread, rolls or toast do you eat most often? *(You can choose more than one, but please only choose the ones you usually have)*

- ☐ White
- ☐ White – high fibre
- ☐ Wholemeal or wheat meal
- ☐ Wholegrain
- ☐ Calcium enriched bread e.g. Vital
- ☐ Omega 3 enriched bread e.g. Goodness Omega 3
- ☐ Other (*please state*) ____

6. On average, how many slices or rolls of bread (or toast) do you eat per ***day***?

Per Day

- ☐ Less than 1 serving
- ☐ 1–2 servings
- ☐ 3–4 servings
- ☐ 5–6 servings
- ☐ 7 or more servings

7. How often do you usually eat these foods?

Breads										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Plain white bread	*Please choose one:* 1 medium sandwich slice or 1 medium toast slice									
High fibre white bread	*Please choose one:* 1 medium sandwich slice or									

Breads										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
	1 medium toast slice									
Wholemeal or wheat meal	*Please choose one:* 1 medium sandwich slice or 1 medium toast slice									
Wholegrain bread	*Please choose one:* 1 medium sandwich slice or									

Breads										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
	1 medium toast slice									
Fruit bread or fruit bun	*Please choose one:* 1 medium sandwich slice or 1 medium toast slice or one bun									
Wrap	1 medium									
Focaccia, bagel, pita, panini or other speciality breads	1 medium									

Breads										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Paraoa Parai (fry bread)	*Please choose one:* 1 medium sandwich slice or 1 medium toast slice									
Rewena bread	*Please choose one:* 1 medium sandwich slice or 1 medium toast slice									

Breads										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Doughboys or Maori bread	*Please choose one:* 1 medium sandwich slice or 1 medium toast slice or 1 medium dough boy									
Crumpet or muffin split	1 crumpet or 1 whole muffin split									
Scone	1 medium									
Pikelet	2 small									

Breads										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Bran muffin or savoury muffin	1 medium									
Croissant	1 medium									
Waffle or pancakes	1 medium									
Iced buns	1 medium									
Crackers or crisp bread	2 medium crackers									

8. Do you have butter, margarine or spreads on bread or crackers?
   - ☐ No
   - ☐ Yes

What type(s) do you have most often? *(You can choose more than one, but please only choose the ones you usually have)*

- ☐ Butter (all varieties)
- ☐ Monounsaturated fat margarine e.g. Olive, Rice Bran, Canola Oil Spreads
- ☐ Polyunsaturated fat margarine e.g. Sunflower Oil Spreads

☐ Light monounsaturated fat margarine e.g. Olivio Spread Light
☐ Light polyunsaturated fat margarine e.g. Flora Spread Light
☐ Plant sterol enriched margarine e.g. Pro Active, Logical Spreads
☐ Light plant sterol enriched margarine e.g. Pro Active Spread Light
☐ Butter and margarine blend e.g. Country Soft, Butter Lea
☐ Other *(please state)* ____

9. On average, how many servings of butter, margarine or spreads do you have per ***week***? (*Please* ***choose one*** *only*)
(A 'serving' = 1 level teaspoon or 5 ml)

E.g. 1 sandwich with butter thinly spread on two pieces of bread = 2 servings

Per Week

☐ Less than 4 servings
☐ 4–6 servings
☐ 7–9 servings
☐ 10–12 servings
☐ 13–15 servings
☐ 16 or more servings

Breakfast Cereals and Porridge

10. Do you usually eat breakfast cereal and/or porridge?
☐ No
☐ Yes

What breakfast cereal(s) do you eat most often? (*You can choose more than one, but please only choose the ones you usually have*)

☐ Weetbix
☐ Refined cereals e.g. Cornflakes or Rice Bubbles
☐ Bran based cereals including fruity varieties e.g. Special K, Muesli, All Bran
☐ Sweetened e.g. Nutrigrain, Cocoa Pops
☐ Porridge
☐ Other (*please state*)____

11. On average, how many servings of breakfast cereal or porridge do you have per ***week***? (*Please* ***choose one*** *only*)
(A 'serving' = ½ cup porridge, muesli, cornflakes or 2 weetbix)

E.g. ½ cup of porridge 3 times per week + 2 weetbix 4 times a week = 7 servings per week

Per Week

☐ Less than 4 servings
☐ 4–6 servings
☐ 7–9 servings
☐ 10–12 servings
☐ 13–15 servings
☐ 16 or more servings

12. How often do you usually eat these foods?

Breakfast Cereals										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Porridge, rolled oats, oat bran, oat meal	½ cup									
Muesli (all varieties)	½ cup									
Weetbix (all varieties)	2 weetbix									
Cornflakes or rice bubbles	½ cup									
Bran cereals (e.g. All Bran, Bran Flakes)	½ cup									
Bran based cereals (e.g. Sultana Bran, Sultana Bran Extra)	½ cup									
Light and fruity cereals (e.g. Special K, Light and Tasty)	½ cup									
Chocolate based cereals (e.g. Milo cereal, Coco Pops)	½ cup									

Breakfast Cereals										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Sweetened cereals (e.g. Nutrigrain, Fruit Loops, Honey Puffs, Frosties)	½ cup									
Breakfast drinks (e.g. Up and Go)	Small carton or 250ml									

13. Do you usually have sugar, honey or sweetened condensed milk on your cereal?
    - ☐ No
    - ☐ Yes
    - ☐ Other (please state)____

14. How much sugar or honey or sweetened condensed milk do you usually have on you cereal? (*Please **choose one** only*) (A ‘serving’ = 1 heaped teaspoon)
    - ☐ Less than 1 serving
    - ☐ 1 serving

☐ 2 servings
☐ 3 servings
☐ 4 servings
☐ 5 or more servings

Starchy foods

15. Do you eat any type of starchy foods such as rice, pasta, noodles and couscous?
    ☐ No
    ☐ Yes

16. On average, how many servings of foods such as rice, pasta, noodles and couscous do you eat per ***week***? (*Please* ***choose one*** *only*)

(A 'serving' = ½ cup cooked rice/pasta)

E.g. ½ cup of rice + ½ cup of pasta included in a lasagne pasta dish = 1 ½ servings

Per Week

☐ Less than 4 servings
☐ 4–6 servings

☐ 7–9 servings
☐ 10–12 servings
☐ 13–15 servings
☐ 16 or more servings

17. How often do you usually eat these foods?

Starchy Foods										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Rice, white	½ cup									
Rice, brown	½ cup									
Rice, wild	½ cup									
Pasta, white (e.g. spaghetti, vermicelli, instant pasta)	½ cup									
Canned spaghetti (e.g. Watties)	½ cup									
Pasta, whole grain	½ cup									
Instant noodles (e.g. 2 minute noodles)	1 packet									

Starchy Foods										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Egg and rice noodles (e.g. hokkien noodles, udon)	½ cup									
Couscous	½ cup									

Meat

18. Do you eat pork, beef, mutton, hogget or lamb?
    - ☐ No
    - ☐ Yes

Do you trim any excess fat off these meats? *(Please **choose one** only)*

- ☐ Always
- ☐ Often
- ☐ Occasionally
- ☐ Never cut the fat off meat

19. On average, how many servings of meat do you eat per ***week***? (*Please* ***choose one*** *only*)

(A ‘serving’ = palm size not including fingers or ½ a cup of meat without bone)

E.g. ½ cup of savoury mince + 2 small lamb chops = 2 servings

Per Week

- ☐ Less than 1 serving
- ☐ 1-3 servings
- ☐ 4-6 servings
- ☐ 7 or more servings

20. How often do you eat the following?

Meat										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Canned corned beef	*Please choose one:* 1 small can or 1									

Meat										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
	medium can									
Beef mince dishes (e.g. rissoles, meatloaf, hamburger pattie)	1 slice or 1 patty or ½ cup									
Beef or veal mixed dishes (e.g. casserole, stir-fry)	½ cup									
Beef or veal - roast, chop, steak, schnitzel, corned beef	Palm size or ½ cup									
Hogget or mutton mixed dishes (e.g. stews)	½ cup									
Hogget or mutton - roast, chops	Palm size or ½ cup									
Lamb mixed dishes (e.g. casserole, stir-fry)	½ cup									

Meat										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Lamb - roast, chop, steak	Palm size or ½ cup									
Pork - roast, chop, steak	Palm size or ½ cup									
Sausage, frankfurter or saveloy	1 sausage/ frankfurter or 2 saveloys									
Bacon	2 rashers									
Ham	1 medium slice									
Luncheon meats or brawn	1 slice									
Salami or chorizo	1 slice or cube									

Meat										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Offal (e.g. liver, kidneys)	Palm size or ½ cup									
Venison/game	Palm size or ½ cup									

Poultry

21. Do you eat poultry e.g. chicken, turkey or duck?
    - ☐ No
    - ☐ Yes

Do you remove the skin from chicken? (*Please* ***choose one*** *only*)

- ☐ Always
- ☐ Often
- ☐ Occasionally
- ☐ Never remove the skin from chicken

22. On average, how many servings of chicken do you eat per ***week***? (*Please* ***choose one*** *only*)
(A 'serving' = palm size (not including fingers) of chicken or ½ cup of flaked chicken)

E.g. 1 chicken breast + 3 chicken drumsticks + 1 chicken thigh = 4 servings per week

Per Week

☐ Less than1 serving
☐ 1-3 servings
☐ 4-6 servings
☐ 7 or more servings

23. How often do you eat the following?

Poultry										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Chicken legs or wings	Palm size or ½ cup									

Poultry										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
	or 1 unit (wing, drumstick)									
Chicken breast	Palm size or ½ cup or ½ breast									
Chicken mixed dishes (e.g. casserole, stir-fry)	Palm size or ½ cup									
Crumbed chicken (e.g. nuggets, patties, pieces)	1 piece or 2 nuggets									
Turkey or quail	Palm size or ½ cup									
Mutton bird or duck	Palm size or ½ cup									

Fish and Seafood

24. Do you eat any type of fish or seafood?

- ☐ No
- ☐ Yes

25. On average, how many servings of fish and seafood do you eat per ***week,*** consider all types e.g. fresh, frozen or tinned?

(*Please* ***choose one*** *only*)

(A ‘serving’ = palm size not including fingers of fish or seafood)

E.g. 1 small tin of fish = 1 serving per week

Per Week

- ☐ Less than 1 serving
- ☐ 1-3 servings
- ☐ 4-6 servings
- ☐ 7 or more servings

26. How do you normally cook/eat fish (you can choose more than one box)?

- ☐ Raw/I don't cook it
- ☐ Oven baked
- ☐ Deep fried
- ☐ Grilled
- ☐ Micro waved
- ☐ Steamed
- ☐ Poached
- ☐ Smoked

27. How often do you eat the following?

Canned fish and seafood										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Canned Salmon	*Please choose one:* 1 small can or 1 medium can									

Canned fish and seafood										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Canned Tuna	*Please choose one:* 1 small can or 1 medium can									
Canned Mackerel, sardines, anchovies, herring	*Please choose one:* 1 small can or 1 medium can									

28. How often do you eat the following?

Fresh/Frozen/Smoked Fish										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Frozen crumbed fish patties /cakes / fingers/ nuggets/ portions	1 patty or cake, 2 nuggets or fingers									
Snapper, Tarakihi, Hoki, Cod, Flounder	Palm size or ½ cup									
Gurnard, Kahawai or Trevally										
Lemon fish or Shark	Palm size or ½ cup									
Tuna	Palm size or ½ cup									
Salmon	Palm size or ½ cup									
Trout	Palm size or ½ cup									

Fresh/Frozen/Smoked Fish										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Cod	Palm size or ½ cup									
Eel	Palm size or ½ cup									

29. How often do you eat the following?

Other Seafood										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Shrimp, prawn, lobster or crayfish	½ cup									

Other Seafood										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Crab or surumi	½ cup									
Scallops, mussels, oysters, paua or clams	½ cup									
Pipi or cockle	½ cup									
Whitebait	¼ cup									
Roe	¼ cup									
Squid, octopus, calamari, cuttlefish	½ cup									

30. Do you cook meat, chicken, fish and/or eggs with fat or oil?
- ☐ No
- ☐ Yes

What type(s) do you use most often? *(You can choose more than one, but please only choose the ones you usually have)*

☐ Butter (all varieties)

☐ Monounsaturated fat margarine e.g. Olive, Rice Bran, Canola Oil Spreads
☐ Polyunsaturated fat margarine e.g. Sunflower Oil Spreads
☐ Light monounsaturated fat margarine e.g. Olivio Spread Light
☐ Light polyunsaturated fat margarine e.g. Flora Spread Light
☐ Plant sterol enriched margarine e.g. Pro Active, Logical Spreads
☐ Light plant sterol enriched margarine e.g. Pro Active Spread Light
☐ Butter and margarine blend e.g. Country Soft, Butter Lea
☐ Saturated fat oils e.g. Lard, Dripping, Coconut oil, Ghee (clarified butter)
☐ Monounsaturated fat oils e.g. Olive, Canola, Avocado, Soybean, Peanut, Rice Bran oil
☐ Polyunsaturated fat oil e.g. Sunflower, Corn, Safflower, Cottonseed, Sesame seed, Grape seed oil
☐ Cooking spray
☐ Don't know
☐ Other *(please state)* ____

31. On average, how many times do you use fat or oil to cook per ***week***?

Per Week

☐ Less than 1 serving
☐ 1-3 servings
☐ 4-7 servings
☐ 8-10 servings
☐ 11-14 servings
☐ 15 or more servings

32. When you use fat or oil to cook how many servings of fat or oil do you use per ***dish***? (*Please* ***choose one*** *only*)
(A ‘serving’ = 1 level teaspoon or 5 ml)

Per Dish

☐ Less than 1 serving
☐ 1 serving
☐ 2 servings
☐ 3 servings
☐ 4 servings
☐ 5 or more servings

33. Do you have dressings or sauces with meat, chicken and/or fish?

☐ No
☐ Yes

What type(s) do you use most often?

(You can choose more than one, but please only choose the ones you usually have)

☐ Butter (all varieties)
☐ Monounsaturated fat margarine e.g. Olive, Rice Bran, Canola Oil Spreads
☐ Polyunsaturated fat margarine e.g. Sunflower Oil Spreads
☐ Light monounsaturated fat margarine e.g. Olivio Spread Light
☐ Light polyunsaturated fat margarine e.g. Flora Spread Light
☐ Plant sterol enriched margarine e.g. Pro Active, Logical Spreads
☐ Light plant sterol enriched margarine e.g. Pro Active Spread Light
☐ Butter and margarine blend e.g. Country Soft, Butter Lea

☐ Cream/sour cream
☐ Dressings e.g. Tartare, Mayonnaise, Thousand Island, Ranch
☐ Light dressings e.g. French and Italian dressing, Balsamic vinegar
☐ Yoghurt dressing
☐ Sauces e.g. Tomato, Barbeque, Sweet Chilli, Mint sauce
☐ Mustard
☐ Béchamel or white or cheese sauce
☐ Homemade gravy
☐ Premade gravy e.g. Maggi packet gravy
☐ Saturated fat oils e.g. Lard, Dripping, Coconut oil
☐ Monounsaturated fat oils e.g. Olive, Canola, Avocado, Soybean, Peanut, Rice Bran oil
☐ Polyunsaturated fat oil e.g. Sunflower, Corn, Safflower, Cottonseed, Sesame seed, Grape seed oil
☐ Don't know
☐ Other *(please state)* ____

34. On average, how many times do you have dressings and sauces with meat, chicken and/or fish per ***week***?

Per Week

☐ Less than 1 serving
☐ 1-3 servings
☐ 4-7 servings
☐ 8-10 servings
☐ 11-14 servings
☐ ≥ 15 servings

35. When you use dressings and sauces with meat, chicken and/or fish how many servings do you have per ***dish***?
(*Please* ***choose one*** *only*)

(A ‘serving’ = 1 level teaspoon or 5 ml)

Per Dish

☐ Less than 1 serving
☐ 1 serving
☐ 2 servings
☐ 3 servings
☐ 4 servings
☐ 5 or more servings

Eggs

36. Do you eat eggs?
☐ No
☐ Yes

37. On average, not counting eggs used in baking/cooking, how many eggs do you usually eat per ***week***? (*Please* ***choose one*** *only*)

Per Week

☐ Less than 1egg
☐ 1 egg
☐ 2 eggs
☐ 3 eggs
☐ 4 eggs
☐ 5 or more eggs

Legumes

38. Do you eat legumes e.g. chickpeas/dried peas, soybeans, dried/canned beans, lentils or Dahl?
☐ No
☐ Yes

39. On average, how many servings of legumes (fresh, frozen, canned) do you eat per week? (*Please **choose one** only*)
(A 'serving' = ½ cup or 125g of cooked legumes)

Per Week

☐ Less than 1 serving
☐ 1 serving
☐ 2 servings
☐ 3 servings
☐ 4 or more servings

40. How often do you usually eat these foods?

Eggs										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Whole eggs (e.g. hard-boiled, poached, fried, mashed)	1 egg									
Scrambled egg	1 egg									
Omelette	1 egg									
Mixed egg dish (e.g. quiche, frittata, other baked egg)	1 slice									

Legumes										
Soybeans	½ cup									
Tofu	½ cup									
Dahl	½ cup									

Legumes										
Canned beans (e.g. baked beans, chickpeas, lentils)	½ cup									
Dried legumes (e.g. lentils, dried peas, soup mixes)	½ cup									

Vegetables

41. Do you eat vegetables?

- ☐ No
- ☐ Yes

42. On average, how many servings of vegetables (fresh, frozen, canned) do you eat a ***day***?
Do not include vegetable juices. (*Please **choose one** only*)

(A 'serving' = 1 medium potato/kumara or ½ cup cooked vegetables or 1 cup of salad vegetables)

E.g. 2 medium potatoes + ½ cup of peas = 3 servings

Per Day

☐ Less than 1 serving

- ☐ 1 serving
- ☐ 2 servings
- ☐ 3 servings
- ☐ 4 or more servings

43. How often do you usually eat these foods?

Vegetables										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Potato - boiled, mashed, baked or roasted	1 medium or ½ cup									
Pumpkin - boiled, roasted or mashed	½ cup									
Kumara - boiled, roasted or mashed	1 medium or ½ cup									
Mixed frozen vegetables	½ cup									
Green beans	½ cup									
Silver beet, spinach	½ cup									

Vegetables										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Carrots	1 medium or ½ cup									
Sweet corn	1 medium cob or ½ cup									
Mushrooms	½ cup									
Tomatoes	1 medium or ½ cup									
Beetroot	1 medium or ½ cup									
Taro	1 medium or ½ cup									
Green bananas (e.g. plantain)	1 medium or ½ cup									
Sprouts (e.g. alfalfa, mung)	½ cup									

Vegetables										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Pacific Island yams	1 medium or ½ cup									
Turnips, Swedes, Parsnip or Yams	½ cup									
Karengo (seaweed)	½ cup									
Onions, celery or leeks	¼ cup									
Cauliflower, Broccoli or broccoflower	½ cup									
Brussel sprouts, Cabbage, Red Cabbage or Kale	½ cup									
Courgette/zucchini, marrow, eggplant, squash, kamo kamo, asparagus or cucumber	½ cup									

Vegetables										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Capsicum (or peppers)	½ medium or ¼ cup									
Cassava	½ cup									
Breadfruit	½ cup									
Avocado	¼ avocado									
Lettuce greens (e.g. mesculin, cos, iceberg)	½ cup									
Other green leafy vegetables (e.g. Whitloof, watercress, taro leaves, puha)	½ cup									

44. Do you cook vegetables with fat or oil e.g. deep fry, butter on carrots, or stir fry?

- ☐ No
- ☐ Yes

What type(s) do you use most often?

(You can choose more than one, but please only choose the ones you usually have)

☐ Butter (all varieties)
☐ Monounsaturated fat margarine e.g. Olive, Rice Bran, Canola Oil Spreads
☐ Polyunsaturated fat margarine e.g. Canola, Sunflower Oil Spreads
☐ Light monounsaturated fat margarine e.g. Olivio Spread Light
☐ Light polyunsaturated fat margarine e.g. Flora Spread Light
☐ Plant sterol enriched margarine e.g. Pro Active, Logical Spreads
☐ Light plant sterol enriched margarine e.g. Pro Active Spread Light
☐ Butter and margarine blend e.g. Country Soft, Butter Lea
☐ Saturated fat oils e.g. Lard, Dripping, Coconut oil, Ghee (clarified butter)
☐ Monounsaturated fat oils e.g. Olive, Canola, Avocado, Soybean, Peanut, Rice Bran oil
☐ Polyunsaturated fat oil e.g. Sunflower, Corn, Safflower, Cottonseed, Sesame seed, Grape seed oil
☐ Cooking Spray
☐ Don't know
☐ Other *(please state)* ____

45. Do you have dressings or sauces with vegetables?
☐ No
☐ Yes

What type(s) do you use most often?

(You can choose more than one, but please only choose the ones you usually have)

- ☐ Butter (all varieties)
- ☐ Monounsaturated fat margarine e.g. Olive, Rice Bran, Canola Oil Spreads
- ☐ Polyunsaturated fat margarine e.g. Sunflower Oil Spreads
- ☐ Light monounsaturated fat margarine e.g. Olivio Spread Light
- ☐ Light polyunsaturated fat margarine e.g. Flora Spread Light
- ☐ Plant sterol enriched margarine e.g. Pro Active, Logical Spreads
- ☐ Light plant sterol enriched margarine e.g. Pro Active Spread Light
- ☐ Butter and margarine blend e.g. Country Soft, Butter Lea
- ☐ Cream/sour cream
- ☐ Dressings e.g. Tartare, Mayonnaise, Thousand Island, Ranch
- ☐ Light dressings e.g. French and Italian dressing, Balsamic vinegar
- ☐ Yoghurt dressing
- ☐ Sauces e.g. Tomato, Barbeque, Sweet Chilli and Mint sauce
- ☐ Mustard
- ☐ Béchamel or white or cheese sauce
- ☐ Homemade gravy
- ☐ Premade gravy e.g. Maggi packet gravy
- ☐ Saturated fat oils e.g. Lard, Dripping, Coconut oil
- ☐ Monounsaturated fat oils e.g. Olive, Canola, Avocado, Soybean, Peanut, Rice Bran oil
- ☐ Polyunsaturated fat oil e.g. Sunflower, Corn, Safflower, Cottonseed, Sesame seed, Grape seed oil
- ☐ Don't know
- ☐ Other *(please state)* ____

Fresh Fruit

46. Do you eat fruit?
    - ☐ No
    - ☐ Yes

47. On average, how many servings of fruit (fresh, frozen or stewed) do you eat per ***day***?
    Do not include fruit juice or dried fruit. (*Please* ***choose one*** *only*)

(A ‘serving’ = 1 medium piece or 2 small pieces of fruit or ½ cup of stewed fruit)

E.g. 1 apple + 2 small apricots = 2 servings

Per Day

- ☐ Less than 1 serving
- ☐ 1 serving
- ☐ 2 servings
- ☐ 3 or more servings

48. How often do you usually eat these foods?

Fresh Fruit										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Apple	1 medium or ½ cup									
Pear	1 medium or ½ cup									
Banana	1 medium or ½ cup									
Orange, mandarin or tangelo	1 medium or 2 small									
Grapefruit	1 medium or ½ cup									
Peach, nectarine, plum or apricot	1 medium or ½ cup or 2 small									
Mango, paw-paw or persimmons	½ cup									

Fresh Fruit										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Pineapple	½ cup									
Grapes	½ cup (8-10 grapes)									
Strawberries and other berries or cherries	½ cup									
Melon (e.g. watermelon, rockmelon etc.)	½ cup									
Kiwifruit	1 medium or 2 small									
Feijoas	1 medium or 2 small									
Tamarillos	1 medium or ½ cup									

Preserved Fruit (dried, canned)

49. Do you eat preserved fruit?

- ☐ No
- ☐ Yes

50. On average, how many servings of preserved fruit (dried or canned) do you eat per ***day***? (*Please **choose one** only*)

(A 'serving' = 50g or ½ cup of dried fruit)

E.g. 4 prunes + ½ cup of raisins = 2 servings

Per Day

- ☐ Less than 1 serving
- ☐ 1 serving
- ☐ 2 servings
- ☐ 3 or more servings

51. How often do you usually eat these foods?

Preserved Fruit										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Sultanas, raisins or currants	1 small box									
Other dried fruit (e.g. apricots, prunes, dates)	4 pieces									
Preserved or canned fruit in syrup	½ cup									
Preserved or canned fruit in water or juice	½ cup									
Stewed dried fruit	½ cup									

Drinks

52. Do you have any other drinks other than milk or water?

- ☐ No
- ☐ Yes

53. On average, how many glasses of these drinks (other than milk or water) do you have per ***day***?

(A 'serving' = 250mL or one cup/glass)

Per Day

- ☐ Less than 1 serving
- ☐ 1-3 servings
- ☐ 4-6 servings
- ☐ 7 or more servings

54. How often do you usually have these drinks?

Drinks										
Please fill in one category for each drink	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Instant, packet or canned soup	250ml or 1 cup									
Fruit juice (e.g. Just Juice, Fresh-up, Charlie's or Rio Gold)	250ml or 1 cup/glass									

Drinks										
Please fill in one category for each drink	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Fruit drink (e.g. Choice, Rio Splice etc.)	250ml or 1 cup/glass									
Vegetable juice e.g. tomato juice, V8 juice	250ml or 1 cup/glass									
Cordial or Powdered drinks (e.g. Thriftee, Raro, Vita-fresh etc.)	250ml or 1 cup/glass									
Low-calorie cordial	250ml or 1 cup/glass									
Cordial	250ml or 1 cup/glass									
Energy drinks (e.g. V, Monster, Red Bull)	1 small can									
Sugar-free Energy drinks (e.g. sugar-free V, Monster, Red Bull)	1 small can									

Drinks										
Please fill in one category for each drink	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Diet soft/fizzy/carbonated drink (e.g. diet sprite)	250ml or 1 cup/glass									
Soft/fizzy/carbonated drinks (e.g. coke, lemonade etc.)	250ml or 1 cup/glass									
Sport's drinks (e.g. Gatorade, Powerade etc.)	1 cup or 1/3 bottle									
Flavoured water (e.g. Mizone, H2Go flavoured)	1 cup or 1/3 bottle									
Water (including unflavoured mineral water, soda water, tap water)	250ml or 1 cup/glass									
Coffee instant or brewed with or without milk (e.g. Nescafe, express)	1 cup									
Specialty coffees (e.g. flat white, cappuccino, lattes)	1 small cup									

Drinks										
Please fill in one category for each drink	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Coffee – decaffeinated or substitute (e.g. Inka)	1 cup									
Hot chocolate drinks (e.g. drinking chocolate, hot chocolate, Koko)	1 cup									
Tea (e.g. English breakfast tea, Earl Grey)	1 cup									
Herbal tea or Green tea	1 cup									
Soy drinks	1 cup									
Beer – low alcohol	1 can or bottle									
Beer – ordinary	1 can or bottle									
Red wine	1 small glass									

Drinks										
Please fill in one category for each drink	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
White wine or champagne / sparkling wine	1 small glass									
Wine cooler	1 small glass or bottle									
Sparkling grape juice	1 glass or cup									
Sherry or port	100ml									
Spirits, liqueurs	1 shot or 30ml									
RTD (e.g. KGB, Vodka Cruiser, Woodstock bourbon)	1 bottle or can									
Cider	1 glass or cup or bottle									

Drinks										
Please fill in one category for each drink	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Kava	1 glass or cup									

55. How often do you usually use these foods?

Dressings and Sauces										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Mayonnaise or creamy dressings (e.g. aioli, tartae sauce)	1 Tablespoon									

Dressings and Sauces										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Low fat/calorie dressing (reduced fat mayonnaise)	1 Tablespoon									
Salad dressing (e.g. French, Italian)	¼ cup									
Tomato sauce/ BBQ sauce/ sweet chilli/ mustard	1 Tablespoon									
Chutney or relish	1 Tablespoon									
Gravy homemade	¼ cup									
Instant Gravy (e.g. Maggi)	¼ cup									
White sauce/cheese sauce/ béarnaise	¼ cup									

Dressings and Sauces										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Coconut cream	¼ cup									
Coconut milk	¼ cup									
Lite coconut milk	¼ cup									
Pate	1 Tablespoon									
Hummus	1 Tablespoon									

Miscellaneous

56. Do you eat baked products e.g. cakes, puddings and muffins?

☐ No
☐ Yes

57. How often do you usually eat these foods?

Cakes, biscuits and puddings										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Cakes, loaves, sweet muffins	1 piece or 1 slice or 1 muffin									
Sweet pies or pastries, tarts, doughnuts	1 medium									
Other puddings or desserts (not including milk-based puddings) e.g. cheesecake, pavlova	½ cup									
Plain biscuits/ cookies (e.g. Round wine, ginger nut)	2 biscuits									
Fancy biscuits (e.g. chocolate, cream)	2 biscuits									

58. Do you bake cakes, biscuits or puddings?

- ☐ No
- ☐ Yes

59. If you **bake** these foods, do you use fat or oil?

- ☐ No
- ☐ Yes

What type(s) of fat or oil do you use most often?

(You can choose more than one, but please only choose the ones you usually have)

- ☐ Butter (all varieties)
- ☐ Monounsaturated fat margarine e.g. Olive, Rice Bran, Canola Oil Spreads
- ☐ Polyunsaturated fat margarine e.g. Sunflower Oil Spreads
- ☐ Light monounsaturated fat margarine e.g. Olivio Spread Light
- ☐ Light polyunsaturated fat margarine e.g. Flora Spread Light
- ☐ Plant sterol enriched margarine e.g. Pro Active, Logical Spreads
- ☐ Light plant sterol enriched margarine e.g. Pro Active Spread Light
- ☐ Butter and margarine blend e.g. Country Soft, Butter Lea
- ☐ Saturated fat oils e.g. Lard, Dripping, Coconut oil
- ☐ Monounsaturated fat oils e.g. Olive, Canola, Avocado, Soybean, Peanut, Rice Bran oil
- ☐ Polyunsaturated fat oil e.g. Sunflower, Corn, Safflower, Cottonseed, Sesame seed, Grape seed oil
- ☐ Don't know
- ☐ Other *(please state)* ____

60. How often do you usually eat these foods?

Miscellaneous Foods										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per mont h**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Jelly	½ cup									
Ice blocks	1 ice block									
Sugar added to food/drinks	1 teaspoon									
Jam, honey, marmalade or syrup	1 level teaspoon									
Vegemite or marmite	1 level teaspoon									
Peanut butter or other nut spreads	1 level teaspoon									

Miscellaneous Foods										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per mont h**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Brazil nuts or walnuts	2									
Other nuts e.g. peanuts, almonds, cashew, pistachio, macadamia	10									
Muesli bars	1 bar									
Chocolate (including chocolate bars e.g. Moro bars)	1 small bar									
Lollies	2 lollies									
Potato crisps, corn chips, Twisties etc.	½ cup									
Meat pie, sausage roll or other savouries	1 meat pie or 2 small sausage									

Miscellaneous Foods										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per mont h**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
	rolls/savou ries/									

61. On average, how often do you eat ‘takeaways’ ***per week***?

Per Week

- ☐ Never
- ☐ Less than 1 times
- ☐ 1-2 times
- ☐ 3-4 times
- ☐ 4-6 times
- ☐ More than 7 times

62. How often do you usually eat these takeaways?

Takeaway Foods										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Hot potato chips or kumara chips/French fries/wedges	½ cup									
Chinese	1 serve									
Indian	1 serve									
Thai	1 serve									
Pizza	1 medium slice									
Burgers	1 medium burger									
Battered fish	1 piece									
Fried chicken (e.g. KFC, Country fried chicken)	1 medium piece									

Takeaway Foods										
Please fill in one category for each food	**Quantity**	**Never**	**Less than once a month**	**1-3 times per month**	**Once per week**	**2-3 times per week**	**4-6 times per week**	**Once per day**	**2 to 3 times per day**	**4 plus times per day**
Bread based e.g. Kebab, sandwiches, wraps, Pita Pit, Subway	1 medium									
Other (*please state*):										

Appendix C. Standard Operating Procedure for the Weighed Four-day Food Record

- Show participants the 4-day food record and food portion booklet, and give them a brief run down on its purpose and how to fill it out.
- Set participants up to watch the DVD (which explains how to keep a food diary).
- On completion of watching the DVD, check whether the participant has any questions regarding the completion of the food diary.
- Emphasize the importance of being as honest and accurate as possible when filling out the food diary, as it will allow a more accurate assessment of their current diet.
- Assign participants dates that they need to complete the food diary
- Ask participants to return the food diary as soon as they have completed the last day of recording, via stamped addressed envelope.
- Provide participant with scales to weigh food if needed and a courier envelope to return the scales in.

Script: *I would like to make appointments now for your nutrition consultation and also the visit after that. Then I will show you the 3-day food diary we would like you to fill in.*

The purpose of the 3-day food diary is to allow us analyse the nutrient content of your current diet, so that a summary can be prepared for you, to discuss at your nutrition consultation. It is therefore important that you fill it out as accurately and honestly as possible.

(Show them the 2nd page) You need to record all the food and drink that you consume on 3 different days – 2 week days and 1 weekend day. Do you think that you will be able to do that, on the days that we have filled in for you?

In the back is a CD and it is important that you watch before you start and if you can get your partner to watch it with you. Do you have something to watch it on? The short CD gives more detailed instructions on how to fill in the 3-day diary and I will also give you this food portion booklet which will also help you, when it comes to estimating different portion sizes.

We then need you to get it returned to us, as soon as possible, in the stamped addressed envelope, so we can carry out the analysis before your next visit.

While you are having breakfast have a look through and if you have any questions just ask

Appendix D: Four-day Weighed Food Record

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

Women's EXPLORE Study

Weighed 4 Day Food Record

Thank you very much for taking part in the EXPLORE Study. We are extremely grateful for your time, effort and commitment!

If you have any questions, please contact EXPLORE staff on:
414 0800 (extn 41189) email: explore@massey.ac.nz or
Zara Houston 021 029 31620 AJ Hepburn 027 404 5351

All information in this diary will be treated with the strictest confidence. No one outside the study will have access to this.

We will arrange the return of your food diary and accelerometer (and may be in contact with you regarding the food diary).

What to do?

- Record all that you eat and drink on the following dates.

____

____

____

____

- If possible record food at the time of eating or just after – try to avoid doing it from memory at the end of the day.

- Include all meals, snacks, and drinks, even tap water.

- Include anything you have added to foods such as sauces, gravies, spreads, dressings, etc.

- Write down any information that might indicate **size or weight** of the food to identify the portion size eaten.

- Use a new line for each food and drink. You can use more than one line for a food or drink. See the examples given.

- Use as many pages of the booklet as you need.

Describing Food and Drink

- Provide as much detail as possible about the type of food eaten. For example **brand names and varieties / types** of food.

General description	**Food record description**
Breakfast example – cereal, milk, sugar	1 cup Sanitarium Natural Muesli 1 cup Pam's whole milk 1 tsp Chelsea white sugar
Coffee	1 tsp Gregg's instant coffee 1 x 200ml cup of water 2 Tbsp Meadow fresh light green milk
Pasta	1 cup San Remo whole grain pasta spirals (boiled)
Pie	Big Ben Classic Mince and Cheese Pie (170g)

- Give details of all the **cooking methods** used. For example, fried, grilled, baked, poached, boiled…

General description	Food record description
2 eggs	2 size 7 eggs fried in 2tsp canola oil 2 size 6 eggs (soft boiled)
Fish	100g salmon (no skin) poached in 1 cup of water for 10 minutes

- When using foods that are cooked (eg. pasta, rice, meat, vegetables, etc), please record the **cooked portion** of food.

General description	Food record description
Rice	1 cup cooked Jasmine rice (cooked on stove top)
Meat	90g lean T-bone steak (fat and bone removed)
Vegetables	½ cup cooked mixed vegetables (Wattie's peas, corn, carrots)

- Please specify the **actual amount of food eaten** (eg. for leftovers, foods where there is waste)

General description	Food record description
Apple	1 x 120g Granny Smith Apple (peeled, core not eaten – core equated to ¼ of the apple)
Fried chicken drumstick	100g chicken drumstick (100g includes skin and bone); fried in 3 Tbsp Fern leaf semi-soft butter

- **Record recipes** of home prepared dishes where possible and the proportion of the dish you ate. There are blank pages for you to add recipes or additional information.

Recording the amounts of food you eat

It is important to also record the quantity of each food and drink consumed. This can be done in several ways.

- By using household measures – for example, cups, teaspoons and tablespoons. Eg. 1 cup frozen peas, 1 heaped teaspoon of sugar.

- By weight marked on the packages – eg. a 425g tin of baked beans, a 32g cereal bar, 600ml Coke

- Weighing the food – this is an ideal way to get an accurate idea of the quantity of food eaten, in particular for foods such as meat, fruits, vegetables and cheese.

- For bread – describe the size of the slices of bread (eg. sandwich, medium, toast) – also include brand and variety.

- Using comparisons – eg. Meat equal to the size of a pack of cards, a scoop of ice cream equal to the size of a hen's egg.

- Use the food record instructions provided to help describe portion sizes.

General description	Food record description
Cheese	1 heaped tablespoon of grated cheese 1 slice cheese (8.5 x 2.5 x 2mm) 1 cube cheese, match box size Grated cheese, size 10B

- If you go out for meals, describe the food eaten in as much detail as possible.

- ***Please eat as normally as possible - don't adjust what you would normally eat just because you are keeping a diet record and be honest! Your food record will be identified with a number rather than your name.***

Example day

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed (units, measures, weight)
Example 7:55am	Sanitarium weetbix	2 weetbix
" "	Anchor Blue Top milk	150ml
" "	Chelsea white sugar	2 heaped teaspoons
" "	Orange juice (Citrus Tree with added calcium – nutrition label attached)	1 glass (275 ml)
10.00am	Raw Apple (gala)	Ate all of apple except the core, whole apple was 125g (core was ¼ of whole apple)
12.00pm	Home made pizza (recipe attached)	1 slice (similar size to 1 slice of sandwich bread, 2 Tbsp tomato paste, 4 olives, 2 rashers bacon (fat removed), 1 Tbsp chopped spring onion, 3 Tbsp mozzarella cheese)
1.00pm	Water	500ml plain tap water
3.00pm	Biscuits	6 x chocolate covered Girl Guide biscuits (standard size)
6.00pm	Lasagne	½ cup cooked mince, 1 cup cooked Budget lasagne shaped pasta , ½ cup Wattie's creamy mushroom and herb pasta sauce, ½ cup mixed vegetables (Pam's carrots, peas and corn), 4 Tbsp grated Edam cheese
6.30pm	Banana cake with chocolate icing (homemade, recipe attached)	1/8 of a cake (22cm diameter, 8 cm high), 2 Tbsp chocolate icing
" "	Tip Top Cookies and Cream ice cream	1 cup (250g)
7.30pm	Coffee	1 tsp Gregg's instant coffee 1 x 300ml cup of water 2 Tbsp Meadow fresh blue top milk 2 tsp sugar

Date________________________________ DAY 1

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Date________________________________ **DAY 1 continued**

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Recipes (Day 1)

Recipes (Day 2)

Date________________________________ DAY 2

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Date________________________________ DAY 2 continued

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Date__________________________________ DAY 3

Time food was eaten	**Complete description of food (food and beverage name, brand, variety, preparation method)**	**Amount consumed**

Date_________________________________ **DAY 3 continued**

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Recipes (Day 3)

Recipes (Day 4)

Date________________________________ **DAY 4**

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Date________________________________ **DAY 4 continued**

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Date________________________________ (spare pages)

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Date________________________________   **(spare pages)**

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed