Dietary intakes and body composition of Māori and Pacific women in the women's EXPLORE study

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Abstract

The most thorough record of dietary intake among New Zealand (NZ) Māori and Pacific women was undertaken in the 2008 NZ Adult Nutrition Survey, but it did not consider the relationship with body composition. The aim of this study was to investigate the relationship between dietary intake and body composition (particularly body mass index (BMI) and body fat (BF) percentage) of all Māori (n=79) and Pacific (n=75) women (16-45 years old) recruited in the women's EXPLORE study. Anthropometric data was measured using weight, height, and air displacement plethysmography (BodPod), while dietary data was assessed using a validated, 220-item, semi-quantitative food frequency questionnaire. On average, the BMI (28.2 kg/m^2) and BF (34.6%) of Māori women classified them as overweight, while the average BMI (31.9 kg/m^2) and BF (37.8%) of Pacific women classified them as obese. There were significant positive correlations between the BMI and BF percentage of Māori (r=0.86) and Pacific women (r=0.87), which suggests BMI is a good indicator of BF percentage in these populations. The percentage of Māori and Pacific women who exceeded their estimated energy requirement was similar and identical to the percentage of women found in the obese BF percentage groups, respectively. Dietary intake was compared with NZ guidelines, revealing that both groups of women consumed inadequate carbohydrate. In contrast, both groups consumed excess total and saturated fat, and sodium in excess of the upper level, mostly due to high intakes of takeaways. Takeaways were also the top contributor of total energy (13.4%), protein (13.4%) and fat (17.7%) in Pacific women. Obese Māori women consumed more takeaways (42.7%) than non-obese. Obese Pacific women consumed more discretionary breads, cereals and starchy foods (e.g. iced buns, croissants and paraoa parai (fry bread)) (210%) than non-obese. Recommendations include reducing takeaways, fats (e.g. butter), and sugar-sweetened beverages. Instead, opt for more complex carbohydrates and leafy green vegetables. Further research should investigate relationships between dietary intake and waist circumference, as well as other factors influencing body composition, such as physical activity and level of deprivation.

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Abbreviations

ADG	Australian Dietary Guidelines
ADP	Air displacement plethysmography
AI	Adequate Intake
AMDR	Acceptable Macronutrient Distribution Range
BF	Body fat
BIA	Bioelectrical impedance analysis
BMI	Body Mass Index
BMR	Basal Metabolic Rate
CHD	Coronary heart disease
CVD	Cardiovascular disease
DAS	Dietary assessment software
DF	Dietary fibre
DHHS	Diabetes, Heart and Health Study
DPRF	Dietary Patterns and Risk Factors study
DXA	Dual-energy X-ray absorptiometry
EAGNZA	Eating and Activity Guidelines for New Zealand Adults
EAR	Estimated Average Requirement
EE	Energy expenditure
EER	Estimated Energy Requirement
EI	Energy intake
EXPLORE	Examining the Predictors Linking Obesity Related Elements
FAVs	Fruit and vegetables
FFM	Fat free mass
FFQ	Food frequency questionnaire

MOH	Ministry of Health
MUFA	Monounsaturated fat
NHMRC	National Health and Medical Research Council
NRV	Nutrient reference value
NZ	New Zealand
NZANS	New Zealand Adult Nutrition Survey
NZHF	New Zealand Heart Foundation
NZHS	New Zealand Health Survey
PAL	Physical activity level
PUFA	Polyunsaturated fat
RCT	Randomised controlled trial
RDI	Recommended Dietary Intake
RMR	Resting metabolic rate
SD	Standard deviation
SDT	Suggested Dietary Target
SFA	Saturated fat
SSB	Sugar-sweetened beverages
SSE	Standard serving equivalents
TEE	Total energy expenditure
T2DM	Type two diabetes mellitus
UL	Upper Level of Intake
WC	Waist circumference
WHO	World Health Organization
WHR	Waist-hip ratio
WHtR	Waist-height ratio

1.0 Introduction

1.1 Background

Excess adiposity is associated with a number of chronic diseases including type two diabetes (T2DM), cardiovascular disease (CVD) and some cancers (Bray, 2004; Huxley, Mendis, Zheleznyakov, Reddy, & Chan, 2010; Kramer, Zinman, & Retnakaran, 2013; Lawrence, & Kopelman, 2004). The impact of excess adiposity is evident through rising rates of diabetes and associated metabolic syndrome, particularly among Māori and Pacific women in New Zealand (NZ) (Joshy, & Simmons, 2006; MOH, 2015a). At the time of the 2014/15 New Zealand Health Survey (NZHS), there were more obese Māori (47.6%) and Pacific women (69.5%) than obese NZ European/ others (30.6%) (MOH, 2015a). Furthermore, the life expectancy of Māori (77.1 years) and Pacific women (78.7 years), at birth, was at least 6.6% lower than non-Māori women (83.9 years) (SNZ, 2015).

There is growing interest in associations between dietary intake and body composition, particularly body fat (BF) percentage. Although Body Mass Index (BMI) is easier to measure than BF percentage, it does not always accurately diagnose obesity (Okorodudu et al., 2010; Romero-Corral et al., 2008). BMI cannot distinguish BF from muscle mass, and visceral from peripheral fat (Oliveros, Somers, Sochor, Goel, & Lopez-Jimenez, 2014). Therefore, BMI fails to consider the metabolic composition of body weight. Consequently, people with a 'normal' BMI (18.5–24.9 kg/m^2) may have excess BF and thus, an increased risk of metabolic syndrome, CVD and mortality (Coutinho et al., 2011; Oliveros et al., 2014; Romero-Corral et al., 2009). This concept of 'hidden' fat has been coined Normal Weight Obesity (NWO) (De Lorenzo, Martinoli, Vaia, & Di Renzo, 2006; Marques-Vidal et al., 2008; Oliveros et al., 2014; Romero-Corral et al., 2009).

Studies have proposed a range of BF percentage cut-offs to serve as markers of obesity among women. However, these range from 30% to 37%, with no agreement in the literature (Oliveros et al., 2014). Therefore, BMI ≥30 kg/m^2 continues to be the most widely accepted measure of obesity (Ortega, Sui, Lavie, & Blair, 2016; WHO, 2006). With an abundance of studies reporting BMI, it makes sense to measure BMI in consequent studies, alongside other measures such as BF percentage. The relationship between obesity and specific dietary intake could be investigated by comparing differences in food consumption between women in lower (non-obese) versus higher (obese) categories for both BMI and BF percentage.

A number of factors are associated with obesity including genetics, excess energy intake (EI) and inadequate physical activity. Diet plays a key role in the development, or prevention, of obesity (WHO, 2014). It is widely accepted that consumption of excess energy (in relation to energy expenditure) will cause weight gain (Branca, Nikogosian, & Lobstein, 2007; MOH, 2015b), yet there is controversy regarding which dietary components have the largest effect on BF deposition (Ebbeling, Swain, Feldman, Wong, Hachey, Garcia-Lago, & Ludwig, 2012; Goss, Goree, Ellis, Chandler-Laney, Casazza, Lockhart, & Gower, 2013; Gower, & Goss, 2015; Samaras & Campbell, 1997). Regularly consuming discretionary food results in excessive EI, consequent weight gain, and numerous nutrient deficiencies (Branca, Nikogosian, & Lobstein, 2007). Discretionary foods tend to be high in energy, fat, saturated fat (SFA), added sugar and sodium and include foods such as sugar-sweetened beverages (SSB) and most takeaways (Jaworowska, Blackham, Davies, & Stevenson, 2013).

Consumption of discretionary foods appears to be more common among Māori and Pacific women than women of other ethnicities in NZ (MOH, 2012b, 2012c). The 2008/09 New Zealand Adult Nutrition Survey (NZANS) found that the percentage of Māori (29.1%) and Pacific women (31.7%) who consumed SSB over three times per week was approximately double the percentage of NZ European/ Others (15.7%) (MOH, 2012a). Similarly, the percentage of Māori (11.2%) and Pacific women (13.2%) who ate takeaways more than three times per week was at least four times greater than the percentage of NZ European/ Others (2.6%) (MOH, 2012a). These may in part explain the higher levels of obesity in Māori and Pacific women in NZ.

Since the 2008/09 NZANS, the NZ food supply has been dramatically changing. With population growth, the demand for food is rising (FAO, 2009). It is expected that 9.15 billion people will be living on earth in 2050, requiring a ~70% increase in food production (Alexandratos & Bruinsma, 2012; FAO, 2009). With NZ being one of the main exporters of food, there is concern whether our national prices will compete with offers from overseas (Alexandratos & Bruinsma, 2012). Some areas in NZ are becoming more prosperous while others are continuing to suffer poverty and food insecurity (Rush & Rusk, 2009c; Salmond, Crampton, & Atkinson, 2007). One in five NZ people live with food insecurity and they are mostly females, of Māori and Pacific descent (Carter, Lanumata, Kruse, & Gorton, 2010; Dowding-Smith, 2015; Parnell, Reid, Wilson, McKenzie, & Russell, 2001; Rush, Puniani, Snowling, & Paterson, 2007; Rush & Rusk, 2009c). This is ironic because over 30% of the world's food is wasted (Godfray et al., 2010). This uneven distribution of food has an impact on health, the economy and environment. As the land is drained of natural resources, demand for whole, unprocessed foods will rise, thereby increasing the cost of natural food, and restricting access to wealthier populations. These un-processed foods are healthier than their processed equivalents because they tend to be richer in nutrients and lower in energy (Rush et al., 2007; Stevenson, 2012). Consequently, deprived populations may continue to consume energy-dense and nutrient-poor foods, causing an obesity endemic in the face of a global food shortage. It is therefore important to do a study on the current dietary intake of Māori and Pacific women in NZ, to find out if they are already being affected by this global change in food supply.

Air Displacement Plethysmography is the gold-standard measure for BF percentage. Although these machines are expensive, they provide more accurate and reproducible measurements than Bioelectrical Impedance Analysis (BIA) or skin fold measurements (Heyward & Wagner, 2004; Lee & Gallagher, 2008). Furthermore, Air displacement plethysmography machines are more accurate than Dual-energy X-ray absorptiometry (DXA) when measuring participants with extremely high BF (Bredella et al., 2010; Heyward & Wagner, 2004; Lee & Gallagher, 2008). Dietary intake can be measured in many ways. One of the most popular methods of dietary assessment is using a Food Frequency Questionnaire (FFQ). FFQs are inexpensive, easy to administer, and less of a burden to participants than methods such as weighed food records (Gibson, 2005). However, unlike weighed food records, FFQs are not suitable for measuring absolute intake of food and nutrients. Rather, they are best utilised to identify participants – according to high, moderate and low intakes.

1.2 Purpose of study

At present, in NZ, there have been three studies which analysed the dietary intakes and body composition of young Māori and Pacific women (Metcalf, Scragg, Schaaf, Dyall, Black, & Jackson, 2008; MOH, 2011a, 2015a). Of these studies, two explored the intakes of food, macro and micronutrients (Metcalf, et al., 2008; MOH, 2011a). The NZANS also investigated the percentage contribution of particular foods to macro and micronutrients (MOH, 2011a). However, the NZANS is at least seven years old and included participants who may have been post-menopausal, trying to lose or gain weight, and living with a chronic disease, such as diabetes or CVD. Additionally, these studies failed to analyse participant's intake of manganese and iodine, which are essential for bone health and regulation of metabolism, respectively (NHMRC, 2006). Finally, none of the studies compared the dietary intake of women in higher-versus-lower BF percentage and BMI groups. These limitations highlight the need for an up-to-date assessment of dietary intake and body composition of healthy, young, Māori and Pacific women living in NZ. More specifically, an investigation of dietary intake which may differ significantly among women in higher versus lower BF percentage/ BMI groups. Such a study may be useful to target dietary inadequacies and excess among Māori and Pacific women, allowing the development of population-specific health promotion programmes and strategies.

1.3 Aim

To assess the dietary intake and body composition of all the Māori and Pacific women recruited in the Women's EXPLORE (Examining the Predictors Linking Obesity Related Elements) study, and to investigate the relationship between dietary intake and body composition.

1.3.1 Objectives

- To investigate body composition, particularly BMI and BF percentage, of young Māori and Pacific women recruited in the women's EXPLORE study.
- To investigate dietary intakes (macronutrients, micronutrients, and food groups) of young Māori and Pacific women recruited in the women's EXPLORE study, and to compare these with NZ guidelines.
- To explore relationships between dietary intake and body fat percentage (high versus low groups [BF ≥35% / <35% respectively]).

1.4 Thesis structure

This thesis is presented in six chapters. Chapter one introduces the background and purpose of this study. Chapter two is a review of the literature that investigates the prevalence of obesity among Māori and Pacific women in NZ, their dietary intake and their determinants of obesity. It also compares different methods of measuring body composition and diet. Chapter three outlines and justifies the study design, procedures and resources required to measure and assess body composition and dietary intake of Māori and Pacific women in this study. Chapter four reports study results and is followed by chapter five, which discusses findings from this study and compares results with those in comparable surveys and studies. Finally, chapter six summarises the main points, provides advice to improve dietary intake of the Māori and Pacific women, highlights study strengths/ limitations, and suggests recommendations for future research.

1.5 Researchers' contributions

Table 1.1 Researchers' contributions to this study

Researchers	Contributions to thesis
Alexandra Lawn	Designed and led the study assessing dietary intakes and body composition of Māori and Pacific cohorts of women recruited in the women's EXPLORE study. Facilitated participant testing, organised blood samples for the lab, entered data from the FFQ, cleaned data, analysed data, statistically analysed data, and interpreted results e.g. Investigating the relationship between dietary intake and body fat.
Associate Professor Rozanne Kruger	Academic supervisor and guidance in study design, methods, protocols, statistical analysis, thesis editing and approval.
Dr Kathryn Beck	Academic supervisor and guidance in study design, methods, protocols, statistical analysis, thesis editing and approval.
Rozanne Kruger, Sarah Shultz, Sarah McNaughton, Aaron Russell, Ridvan Firestone, Lily George and Welma Stonehouse	Established protocol for the women's EXPLORE study.
Wendy O'Brien and Shakeela Jayasinghe	PhD students coordinated the women's EXPLORE study, from recruitment of participants to screening and testing.
Wendy O'Brien, Shakeela Jayasinghe, Zara Houston, Sarah Philipsen, Adrianna Hepburn, Rozanne Kruger	Involved in recruiting and screening participants across Auckland.
Wendy O'Brien, Shakeela Jayasinghe, Sarah Philipsen, Adrianna Hepburn, Rozanne Kruger, Kathryn Beck, Pamela Von Hurst, Cathryn Conlon, Zara Houston, Richard Swift, Owen Mugridge, PC Tong, Jenna Schrijvers, Maria Casale, Andrea Fenner and Alexandra Lawn.	Facilitated participant testing. There were eight different stations, measuring the following: - Blood pressure - Body weight - Height - BF percentage - Bone density - Taste perception - Dietary intake, using three questionnaires (one of these was the semi-quantitative FFQ)
Jenna Schrijvers, Maria Casale, Sarah Philipsen, Adrianna Hepburn, Chelsea Symons and Alexandra Lawn.	Data entry.
Harry Perkins	Provided technical advice towards organising and managing data.
PC Tong	Organised equipment for data collection.

2.0 Literature review

2.1 Obesity among Māori and Pacific women in New Zealand

Overweight and obesity have been described by the World Health Organisation (WHO) as an excessive accumulation of body fat (BF) and classified by a BMI at (or above) 25 kg/m^2 and 30 kg/m^2, respectively (WHO, 2006). NZ has the highest rate of obesity, when compared against adults (aged 15 years and over) in other OECD (The Organisation for Economic Co-operation and Development countries) countries (OECD, 2014). The Ministry of Health's (MOH's) 2014/15 annual update of the NZHS found 31% of adults to be obese (MOH, 2015a). This rate of obesity has increased by 4% since the 2006/07 NZHS update.

Prevalence of obesity in NZ is greatest among women of Māori and Pacific ethnicity. At the time of the 2014/15 NZHS*,* 47.6% of Māori women were obese and 69.5% of Pacific women were obese (MOH, 2015a). According to the NZANS, Māori and Pacific women were at least two times more likely to be obese compared to non-Māori and non-Pacific women (MOH, 2012b, 2012c). These ethnicities make up 14.9% and 7.4% of the total NZ population, respectively (Statistics New Zealand, 2013c).

Obesity is detrimental to both metabolic and psychological health (Djalalinia, Qorbani, Peykari, & Kelishadi, 2015). It can lead to other non-communicable diseases such as T2DM, CVD, musculoskeletal disorders, and some cancers (WHO, 2016b). If pregnant, the mother is at risk of gestational diabetes and preeclampsia, while the unborn child is at risk of developing foetal macrosomia and is likely to have health problems later in life (Leddy, Power, & Schulkin, 2008). There may also be increased emotional distress caused by discrimination and marginalisation of obese people (NZIER, 2015). Aside from health, overweight and obesity costs NZ between $722-$849 million a year (Lal, Moodie, Ashton, Siahpush, & Swinburn, 2012). This figure is likely to increase over time, with the rising rates of obesity, particularly among Māori and Pacific women (MOH, 2015a).

2.2 Assessment of body composition

Obesity is internationally classified using BMI because it is a quick, easy way of assessing body weight in relation to height (Gallagher et al., 1996; Huxley, Mendis, Zheleznyakov, Reddy, & Chan, 2010; WHO, 2006, 2011). Higher BMI values often correlate with higher percentages of BF percentage and adiposity biomarkers (McAdams, Van Dam, & Hu, 2007; Taylor et al., 2010), allowing application of percentage cut-offs to population data. However, BMI failed to recognise ~50 of participants with excess BF percentage in Okorodudu et al.'s (2010) meta-analysis. A more recent study found BMI and excess BF percentage to have significant agreement in women ≥24 kg/m^2 (Shah & Braverman, 2012). Nevertheless, BMI is a valid index and widely used in the clinical environment, by various health practitioners (Ortega, Sui, Lavie, & Blair, 2016). Percentage cut-offs are presented in Table 2.1 (WHO, 2016a).

Table 2.1 BMI classification

BMI	Nutritional status
Below 18.5	Underweight
18.5–24.9	Normal weight
25.0–29.9	Pre-obesity
30.0–34.9	Obesity class I
35.0–39.9	Obesity class II
Above 40	Obesity class III

BMI = Body mass index

Overweight and obesity BMI cut-offs were defined on the basis of European population data (Deurenberg, 2001; WHO, 2000, 2011). This created uncertainty using BMI for different ethnicities, such as Māori and Pacific women, whose body frames are traditionally larger than European and Asian ethnicities (Deurenberg, 2001; Huxley et al., 2010; MOH, 2009; Rush, Freitas, & Plank, 2009b; Swinburn, Caterson, Seidell, & James, 2004). However, a more recent study has found no need to discriminate between Māori , Pacific and European ethnicities when deciding on BMI cut-off points (Taylor et al., 2010). Area under the curve (AUC) for BMI, WC, and waist-to-height ratio (WHtR) were identical for the women, suggesting similar performance in these anthropometric measurements between ethnicities.

Similarly, a study on 104 children, aged 1-3 years, found no difference in BF between the European, Indian and Polynesian girls (Rush, Obolonkin, Battin, Wouldes, & Rowan, 2015). Again, this suggests BMI is applicable across various ethnicities, and any differences in body composition are likely due to environmental factors. Consequently, the NZ MOH use BMI across all ethnicities and both genders, to assess for risk of BMI-related health conditions, such as CVD (MOH, 2016b). BMI is only contraindicated for those under 18 years old, over 69 years old, pregnant, and/or extremely muscular (MOH, 2014a). In these instances, BMI is not representative of their risk of obesity-related disease because it fails to account for the percentage and distribution of total BF (Dulloo, Jacquet, Solinas, Montani, & Schutz, 2010). For example, BMI is likely to classify muscular rugby players as obese because of their high weight-to-height ratio, regardless of their low adiposity.

Excess adiposity is of importance because it has been related to a range of non-communicable diseases, such as T2DM, hypertension, CVD and even some cancers (Bray, 2004; Lawrence, & Kopelman, 2004). In particular, abdominal adiposity (visceral fat) has posed greater metabolic and cardiovascular risks in comparison with adiposity around the hip region (Cameron et al., 2009; Huxley et al., 2010; Kramer, Zinman, & Retnakaran, 2013; Martinez et al., 2008). Metabolic risk factors include strong, positive correlations with impaired glucose tolerance, hypertension, and hyperlipidaemia (Balkau et al., 2007; Rosito et al., 2008). However, the relationship between dietary intake and central adiposity remains unclear because of controversial results in the literature (Samaras & Campbell, 1997).

To minimise BMI limitations, it is better utilised in conjunction with other measures of body composition. Table 2.2 investigates different measures of body composition regarding the appropriate subjects, difficulty of assessment, skills required, level of participant involvement, time, and cost.

Table 2.2 Different measures of body composition

Assessment methods	Appropriate subjects	Assessment difficulty and skills needed	Participant involvement	Time required	Cost	Identifies body fat (BF)	Identifies fat-free mass (FFM)	Identifies distribution of BF and/or FFM	Strengths	Weaknesses
Waist circumference (WC) (Wells & Fewtrell, 2006; WHO, 2008)	Anybody	Easy	Low. One simple measurement is required	Low. Fastest measurement of all those listed in this table	Low	Indirectly	No	Yes. Waist adiposity	• Gender- and ethnic-specific cut-offs • Suitable for field testing • Non-invasive • Central adiposity is more predictive of health outcomes than total BF • Favoured over WHR and WHtR	• Cut-off points largely based European participants • Close associations between WC and abdominal fat
Waist-hip ratio (WHR) (Wells & Fewtrell, 2006; WHO, 2008)	Anybody	Easy	Low	Low	Low	Indirectly	No	Yes. Waist adiposity	• Gender-specific cut-offs • Suitable for field testing • Non-invasive	• Cut-off points largely based on European participants • Inconsistent associations (or none at all) between WHR and abdominal fat • WC favoured over WHR
Waist-height ratio (WHtR) (WHO, 2008)	Anybody	Easy	Low	Low	Low	Indirectly	No	Yes. Waist adiposity	• Gender-specific cut-offs • Suitable for field testing • Non-invasive	• Same cut-offs between ethnicities • WC favoured over WHtR

Assessment methods	Appropriate subjects	Assessment difficulty and skills needed	Participant involvement	Time required	Cost	Identifies body fat (BF)	Identifies fat-free mass (FFM)	Identifies distribution of BF and/or FFM	Strengths	Weaknesses
Body mass index (BMI) (Heyward & Wagner, 2004; WHO, 2008)	Anyone over 18 years	Easy	Low	Low	Low	Indirectly, using an equation	No	No	• Suitable for field testing • Non-invasive	• Same cut-offs between ethnicities
Skin folds (Heyward & Wagner, 2004)	Anybody	Difficult. Need training in skin fold assessment	Medium. Multiple measurement s need to be taken (two measurement s required with BMI and WHR)	Moderat e	Low	Indirectly	No	Yes. Standardised sites for skin fold measures	• Suitable for field testing • Equations can account for age, gender, race, Physical Activity Level (PAL), and BF • Non-invasive	• Accuracy affected by technician's level of skill
Bioelectrical impedance analysis (BIA) (Heyward & Wagner, 2004; Kyle et al., 2004; Lee, & Gallagher, 2008)	Anybody who can stand upright and is adequately hydrated	Easy. It does not require the level of training needed for measuring skin folds	Low	Low	Initial cost high	Indirectly	Yes	Limited to particular BIA machines	• Suitable for field testing • Equations can account for age, gender, race, PAL, and BF • Non-invasive	• Poor accuracy: Results can vary considerably, depending on factors such as participant hydration status and BIA model • Not as accurate as air displacement plethysmography (ADP)
Dual-energy X-ray absorptiometr	Anyone, depending on the type	Difficult. An experienced radiology	High. Participants must stay still	Moderat e (10-20 minutes	High	Yes	Yes	Yes	• More accurate, reliable and reproducible than BIA	• Less accurate than ADP for extremely high BF

Assessment methods	Appropriate subjects	Assessment difficulty and skills needed	Participant involvement	Time required	Cost	Identifies body fat (BF)	Identifies fat-free mass (FFM)	Identifies distribution of BF and/or FFM	Strengths	Weaknesses
y (DXA) (Bredella et al., 2010; Heyward & Wagner, 2004)	of model	technician must operate the machine	for long durations of time	for a whole body scan)					• Minimal radiation exposure compared with computed tomography scans and magnetic resonance imaging • Non-invasive	• Fails to distinguish visceral from subcutaneous fat tissue • Underestimates BF and overestimate muscle • Gender bias • Not suitable for field measurements, due to large size of machine
Air displacement plethysmo-graphy (ADP) e.g. BodPod (Heyward & Wagner, 2004; Lee & Gallagher, 2008)	Adults. A PEAPOD must be used for participants <6 months of age or <7 kg body weight	Moderate. T Only qualified technicians should operate the machine	High, especially if the participant has claustrophobia.	High (~30 minutes)	High	Yes	Yes	Yes	• High accuracy • More accurate, reliable and reproducible than BIA • Non-invasive	• Not suitable for field measurements, due to large size of machine • Assumptions made regarding tissue density
Abdominal ultrasono-graphy (Bazzocchi et al., 2013; Bazzocchi et	Adults	Difficult. Only qualified radiologists/ sonologists/ doctors should use	Low	Moderate. The scan itself is quick but interpretation can	High	Yes	Yes	Yes. Abdominal adiposity	• Accurate, precise, reliable and reproducible • Captures regional and segmental measures • Non-invasive • Small and portable,	• Subjective interpretation of results • Difficult to interpret results. Need a qualified radiologist, sonologist or doctor

Assessment methods	Appropriate subjects	Assessment difficulty and skills needed	Participant involvement	Time required	Cost	Identifies body fat (BF)	Identifies fat-free mass (FFM)	Identifies distribution of BF and/or FFM	Strengths	Weaknesses
al., 2011; Mani, 2012; Ribeiro et al., 2001; Wagner, 2013)		the machine, in the registered centre. Interpretation is also subjective		be challenging					allowing it to be used in the field • Non-invasive	• Procedures and techniques for measuring BF have not yet been standardised • Not suitable for field measurements due to large size of machine
Computed tomography (Baracos, 2009; Bredella et al., 2010; Topend Sports, n.d.a; Imaginis, 2016a)	Anybody, except pregnant women	Difficult. Only qualified technicians should operate the machine	High. Participants must remain still for up to 45 minutes and hold their breath on several occasions	High (10 - 45 minutes)	High. More expensive than using DXA	Yes	Yes	Yes. Especially for the ratio of intra-abdominal fat to extra-abdominal fat	• Gold standard for assessing body composition • Less sensitive to movement than magnetic resonance imaging • Non-invasive	• Radiation exposure • Not suitable for field measurements, due to large size of machine
Magnetic resonance imaging (Bredella et al., 2010; Imaginis, 2016b; Lee & Gallagher, 2008; Topend Sports, n.d.b; Wells &	Anybody, except women in their first trimester of pregnancy	Difficult. Only a qualified radiographer should operate the machine	High, especially if the participant has claustrophobia. Also, participants must remain still for up to 45 minutes and hold their breath on	High (about 30 minutes)	High	Yes	Yes	Yes	• High accuracy, precision and reproducibility • Measures whole body and/or regional distribution of BF and/or lean body mass • Gold standard for finding visceral BF • Non-invasive	• Low accuracy and specificity: Found to underestimate BF and overestimate lean body mass • Not suitable for field measurements, due to large size of machine

Assessment methods	Appropriate subjects	Assessment difficulty and skills needed	Participant involvement	Time required	Cost	Identifies body fat (BF)	Identifies fat-free mass (FFM)	Identifies distribution of BF and/or FFM	Strengths	Weaknesses
Fewtrell, 2006)			several occasions						• Safer than a computed tomography scan, which uses ionizing radiation	
Hydrostatic weighing (underwater weighing) (Duren et al., 2008; Dempster & Aitkens, 1995).	Adults who are able to safely hold their breath and completely submerge themselves under water	Difficult	High. Participants need to hold their breath and be completely submerged under water for multiple measurement s	High	High	Yes	Yes	No	• Non-invasive • Most commonly used body density test • Gold standard, against which other tests can be measured	• Not suitable for children, elderly, cardiac and obese participants • Not suitable for field measurements due to large equipment (tank) • Estimates lung air volume • Assumptions are made regarding tissue density: May under-estimate BF of athletes and over-estimate BF of elderly suffering from osteoporosis

ADP = Air displacement plethysmography; BF = Body fat; BIA = Bioelectrical impedance analysis; BMI = Body mass index; CT = Computed tomography; DXA = Dual-energy X-ray absorptiometry; FFM = Fat free mass; PAL = Physical activity level; WC = Waist circumference; WCRF = World Cancer Research fund; WHO = World Health Organization; WHR = Waist-hip ratio; WHtR = Waist-height ratio.

Appropriate body composition assessment methods are totally study-dependant. When deciding on the best method(s) to use for a study, many factors should be taken into consideration. Factors include (but are not limited to) the time constraints of a study, budget, type of participants, assessor abilities, measurement(s) required, and level of accuracy required (Beechy, Galpern, Petrone, & Das, 2012). Using multiple methods will help reduce error. However, this is often not feasible, due to financial-/time-restraints of studies.

Table 2.2 summarises multiple body composition assessment measures. In general, the cheaper assessment methods are easier to operate, faster to do, and more accessible. These include BMI, WHR, WHtR and WC, with the exception of skinfolds. Skinfold measurements require a significant amount of training and practice. Unfortunately, these cheaper methods tend to be less accurate than the more expensive, sophisticated measures such as Air displacement plethysmography (ADP) and Dual-energy X-ray absorptiometry (DXA).

Similar to BMI, the ADP, Bioelectrical impedance analysis (BIA) and DXA consider participant weight and height. However, they also have the advantage of measuring percentage BF and FFM. Furthermore, DXA can find the location of adiposity, which is further useful in determining the risk of metabolic and CVD (Cameron et al., 2009; Huxley et al., 2010; Kramer, Zinman, & Retnakaran, 2013; Martinez et al., 2008). Regardless, DXA is less accurate than ADP for extremely high BF because it was found to underestimate adiposity and overestimate lean body mass. This was also found with magnetic resonance imaging machines, which (along with computed tomography scans) cause more radiation exposure than DXA.

A limitation of these more sophisticated assessment methods is the large machine size. They are not transportable or easy to set up, thus are not suitable for field measurements. Furthermore, they are expensive to buy, expensive to run, and must be operated by trained professionals. In comparison, BIA machines can be used for field measurements because they are transportable, relatively inexpensive and simpler to run. However, they have poor accuracy in comparison with ADP and DXA machines. BF results from BIA can vary considerably, depending on factors such as participant hydration status and BIA model (Heyward & Wagner, 2004; Kyle et al., 2004; Lee & Gallagher, 2008).

Comparatively, one of the most accurate methods is hydrostatic weighing (underwater weighing), which remains the gold standard of body composition assessment. Calculating BF utilises Archimedes' principle of buoyancy, the participant’s weight on land, weight of water they displace, and density of the water in which they are submerged. However, there are many participants who find this procedure very taxing, such as children and the elderly, cardiac and obese. ADP uses the same displacement principle, except with air instead of water. Advantages of ADP over hydrostatic weighing include the time it takes to complete, as well as higher participant compliance.

2.3 Body composition of Māori and Pacific women in New Zealand

Rush et al (2009b) investigated the body size, body composition and fat distribution of European, Māori, Pacific Island and Asian Indian adults. Of the 479 participants aged 17–80 years, there were 90 Māori women and 97 Pacific women. In Māori women, abdominal fat increased with increasing age. Whereas total BF increased with age in both Māori and Pacific women (Rush et al., 2009b). The mean BMI of Māori and Pacific women was 30 kg/m^2 and 33.1 kg/m^2, even though they had similar age ranges (19-67 and 20-69 years), including an identical mean age of 42 years. Although Pacific women had a 3.1 kg/m^2 higher BMI than Māori women, adjustments in age, height and weight showed Pacific BF was lowest (25.8kg) (including abdominal adiposity (2.06kg)), and they had a greater fat-free mass (FFM) (46.4kg) than other populations in the study (Rush et al., 2009b). In comparison with Māori women, their total BF and abdominal adiposity were 1.8kg and 0.27kg lower, respectively (Rush et al., 2009b). With abdominal adiposity posing greater health risks than other regional adiposity (Cameron et al., 2009; Huxley et al., 2010; Kramer et al., 2013; Martinez et al., 2008) and FFM being beneficial to health (Kyle, Genton, Slosman, & Pichard, 2001; Rush, Plank, & Robinson, 1997; Stiegler & Cunliffe, 2006), the evidence suggests Pacific women have body compositions less metabolically detrimental than Māori women.

Similar to this study, the BF and FFM of 104 participants were measured at 1-3 years of age, using dual X-ray absorptiometry (DXA) (Rush et al., 2015). Participants included 17 Polynesian girls. During this early stage of life, the ethnic contribution of BF may be more apparent than in adults because there has been little time for the influence of environmental factors. Findings showed Polynesian girls weighed at least 1.8kg more at birth than the other ethnicities, but had the same percentage of BF (18.1%) (Rush et al., 2015). Adjustments in age, weight and height revealed Polynesian girls had the lowest total BF (2.27kg) and percentage BF (16.8%) of all the ethnicities by at least 141g and 1% respectively (Rush et al., 2015). Hence, Polynesian girls had the highest FFM (10.9kg) (Rush et al., 2015). With age, Polynesian BMIs tend to increase more than other ethnicities (MOH, 2012), so it is possible there is significant contribution to increasing BF from other factors, such as diet.

Howe, Ellison-Loschmann, Pearce, Douwes, Jeffreys, & Firestone's study (2015) also investigated ethnic differences in body weight of NZ infants: 493 were European, 21 Pacific, 94 Māori and 79 of other ethnicities. At the first week of life and at 3 months, Māori and Pacific infants had greater weights than the European infants (Howe et al., 2015). Howe's study is superior to the previous study because it also investigated BMI and dietary patterns of the infants' mothers. Māori and Pacific mothers were twice as likely to be obese (24%) compared with NZ European mothers (14%) (Howe et al., 2015). Table 2.3 shows Māori and Pacific mothers scoring highly for the 'Snacks' dietary pattern, yet scoring low for the 'Healthy' and 'Sweet' dietary patterns. The 'Snacks' dietary pattern was more commonly consumed by mothers whose infants had higher body weights, whereas the 'Healthy' and 'Sweet' dietary patterns appeared to be related to lower infant body weights (Howe et al., 2015). Differences in BMI and dietary pattern were not explained by maternal age, education, or area-based deprivation.

Table 2.3 Maternal dietary pattern during pregnancy, as a risk factor for obesity in New Zealand infants

Dietary pattern	High consumption of these foods	Infant body weight	Māori and Pacific score (n=64)
Snacks	Chocolate, sweets, fizzy drinks and crisps	High	High
Healthy	Stir-fried vegetables, fresh fruit, oats and pulses	Low	Very low
Sweet	Biscuits and cake	Low	Very low
Processed	Burgers, pizza, pies, chips and fried foods	NA	Moderate/Indifferent
Starchy	Rice and pasta	NA	Low

Table 2.4 investigates the BF percentage, weight and BMI of Māori and Pacific women in NZ studies. Almost all of the studies showed Māori and Pacific women to have an obese BMI (≥30 kg/m^2). None of these studies used air displacement plethysmography to assess body composition.

Table 2.4 Body composition of Māori and Pacific women in New Zealand

Study and participants	Mean BF (% / kg)		Mean weight (kg) and BMI (kg/m^2)		Obese BMI (≥30 kg/m^2)	Body composition assessment methods
	Māori	Pacific	Māori	Pacific	Yes/No	
Annual Update of Key Results 2014/15: New Zealand Health Survey (MOH, 2015a) 1913 Māori women and 518 Pacific women, aged ≥15 years			81.7 kg 30.7 kg/m^2	93.4 kg 34.8 kg/m^2	Yes	• Waist circumference (WC) • Body mass index (BMI)
Body mass index and waist circumference cutoffs to define obesity in indigenous New Zealanders (Taylor et al., 2010) 471 Māori women, with an average age of 43.4 years			86.6 kg 33.3 kg/m^2		Yes	• WC • BMI • Waist-to-height ratio (WHtR)
Obstructive Sleep Apnea in New Zealand Adults: Prevalence and Risk Factors Among Māori and Non-Māori (Mihaere et al., 2009) 1732 Māori women, aged 30-59 years			29.1 kg/m^2		No (overweight, see Table 2.1)	• BMI
Body size, body composition and fat distribution: comparative analysis of European, Māori, Pacific Island and Asian Indian adults (Rush, Freitas, & Plank, 2009b) 90 Māori women and 96 Pacific women, aged 17-80 years	38.1% 27.6 kg	35.7% 25.8 kg	72.5 kg 30.0 kg/m^2	72.2 kg 33.1 kg/m^2	Yes	• Dual-energy X-ray absorptiometry (DXA)
Optimal waist cutpoint for screening for dysglycaemia and metabolic risk: evidence from a Māori cohort (Rush, Crook, & Simmons, 2009a) 2472 Māori women, with a mean age of 47.1 years	42.4% 36.5 kg		86.2 kg 32.9 kg/m^2		Yes	• WC • Waist-to-hip ratio (WHR) • BMI • Bioelectrical impedance analysis

Study and participants	Mean BF (% / kg)		Mean weight (kg) and BMI (kg/m^2)		Obese BMI (≥30 kg/m^2)	Body composition assessment methods
	Māori	Pacific	Māori	Pacific	Yes/No	
						(BIA)
The 2008/09 New Zealand Adult Nutrition Survey (Gemming, Jiang, Swinburn, Utter, & Mhurchu, 2014; MOH, 2011a) 588 Māori women and 343 Pacific women, with a mean age of 37.8 and 37.9 years (respectively)			81.8 kg 30.7 kg/m^2	88.3 kg 33.0 kg/m^2	Yes	• WC • BMI
BMI, fat and muscle differences in urban women of five ethnicities from two countries (Rush, Goedecke, Jennings, Micklesfield, Dugas, Lambert, & Plank, 2007) 76 Māori women and 84 Pacific women, aged 18-60 years	37.4% 27 kg	34.8% 25 kg	72.1 kg 29.5 kg/m^2	71.9 kg 33.2 kg/m^2	Māori overweight and Pacific women obese	• DXA
Dietary patterns and risk factors for Type 2 diabetes mellitus in Fijian, Japanese and Vietnamese populations (Tomisaka, Lako, Maruyama, Nguyen, Do, Khoi, & Chuyen, 2002) 200 Fijian women, with a mean age of 35 years		44.7% 37.1 kg		83 kg 31.3 kg/m^2	Yes	• WHR • BMI • BIA
Frequency of eating occasions reported by young New Zealand Polynesian and European women (Amosa, Rush, & Plank, 2001) 39 Polynesian women, aged 18-27 years				30.7 kg/m^2	Yes	• BMI
Body size and composition in Polynesians (Swinburn, Ley, Carmichael, & Planck, 1999) 96 Māori women and 97 Samoan women, aged 20-70 years	40.2% 33.3 kg	40.8% 35.7 kg	80.4 kg 31.0 kg/m^2	85.7 kg 33.3 kg/m^2	Yes	• Skinfolds • BIA • DXA

Study and participants	Mean BF (% / kg)		Mean weight (kg) and BMI (kg/m^2)		Obese BMI ($\geq 30\ kg/m^2$)	Body composition assessment methods
	Māori	Pacific	Māori	Pacific	Yes/No	
Nutrition knowledge and practices of Samoans in Auckland (Bell, Amosa, & Swinburn, 1997) 280 Samoan women, with a mean age of 41 years				91.6 kg 35.2 kg/m^2	Yes (obesity class II, see Table 2.1)	• BMI • WHR
Effects of macronutrient composition of the diet on body fat in indigenous people at high risk of type 2 diabetes (Brooking, Williams, & Mann, 2012) 59 Māori women and 25 Māori menaged under 75 years, with an average age of 40.2 years	38.4% 38.5 kg (Men and women)		100.2kg 34.9 kg/m^2 (Men and women)		Yes	• WC • WHR • BMI • BIA
A comparison of the effects of indexation on standard echocardiographic measurements of the left heart in a healthy multi-racial population (Poppe, Doughty, Walsh, Triggs, & Whalley, 2014) 24 Māori and Pacific women, average age of 31 years	36% 27kg (Māori and Pacific women)		75 kg 27.2 kg/m^2 (Māori and Pacific women)		No (overweight, see Table 2.1)	• BMI • BIA
Energy expenditure of young Polynesian and European women in New Zealand and relations to body composition (Rush, Plank, & Coward, 1999) 40 Polynesian women (consisting of 22 Samoan, 12 Māori, 3 Tongan, 2 Niuean, and 1 Cook Islander) aged 18-27 years	40.6% 34.8 kg (Māori and Pacific women)		85.8 kg 31.2 kg/m^2 (Māori and Pacific women)		Yes	• Skinfolds • WC • Hip circumference • BMI

BF = Body fat; BMI = Body mass index; NZ = New Zealand

2.4 Determinants of obesity

The 'Obesity system map' (Figure 2.1) explains the complexity of obesity by displaying a myriad of interlinking factors, all contributing to the global epidemic. Leading academics in the field created this map through a multidisciplinary approach, so they could better understand the environmental and biological factors determining obesity (Foresight, 2012). These diverse, yet inter-related factors pose no obvious solutions. However, it draws attention to four key factors: psychological ambivalence, force of dietary habits, level of primary appetite control in the brain, and level of physical activity (Vandenbroeck et al., 2007).

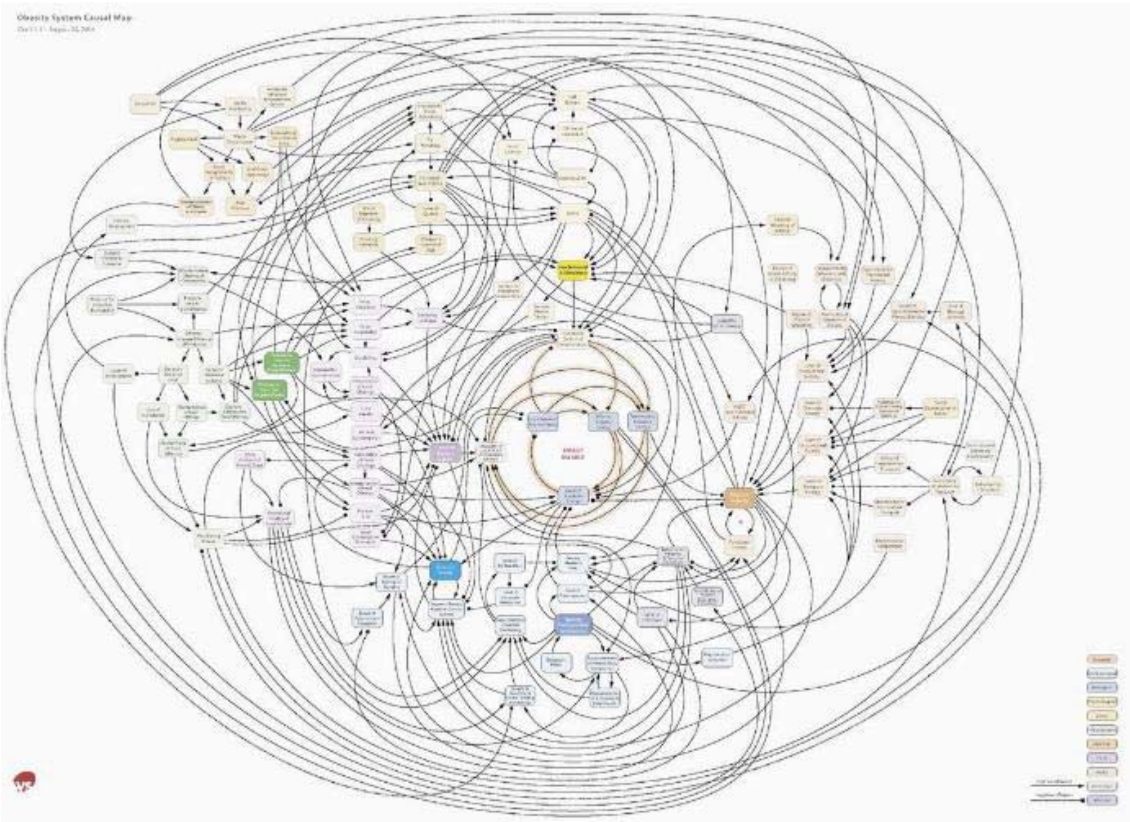

Figure 2.1 Vandenbroeck, Goossens, & Clemens, *Foresight obesity systems map demonstrating at its centre 'core' the imbalance between appetite regulation and sedentary existence…*, Cambridge University Press, (2007), retrieved from https://doi.org/10.1017/S0029665109991686

Psychological ambivalence is found in the 'psychology' area of the map (Figure 2.2) and refers to the consciousness of energy intake (EI) (Vandenbroeck et al., 2007). Awareness of eating patterns, and other lifestyle choices, such as level of physical activity, play a huge role in determining obesity. People who are more ambivalent are less likely to have control of their EI (Vandenbroeck et al., 2007) and are therefore susceptible to obesity. Perceived inconsistency surrounding nutritional science makes healthy decisions difficult, especially when the innate desire to eat sweet and fatty food often outweighs the desire to eat healthily (Drewnowski, 1997). Greater awareness of food intake may come from knowing the short-term and long-term health implications of different eating behaviours (Vandenbroeck et al., 2007). However, it has been challenging to reach people with little education, low income, and of Māori or Pacific ethnicity (Buchthal et al., 2011; Koloto, Duncan, de Raad, Wang, & Gray, 2007; Mallard & Houghton, 2012; Paterson, Tumama, Cowley, Percival, & Williams, 2004). Furthermore, nutritional knowledge is not necessarily reflective of healthy behaviours and actions (Bandura, 2004). Although it is difficult to change an individual's ambivalence, it is possible to reduce their exposure to high-risk foods, those which are energy-dense and nutrient-poor e.g. fizzy drinks. This may involve removing vending machines from particular areas, or creating policies which permit only a certain number of fast-food outlets per city, thus, impacting the food environment (Figure 2.2).

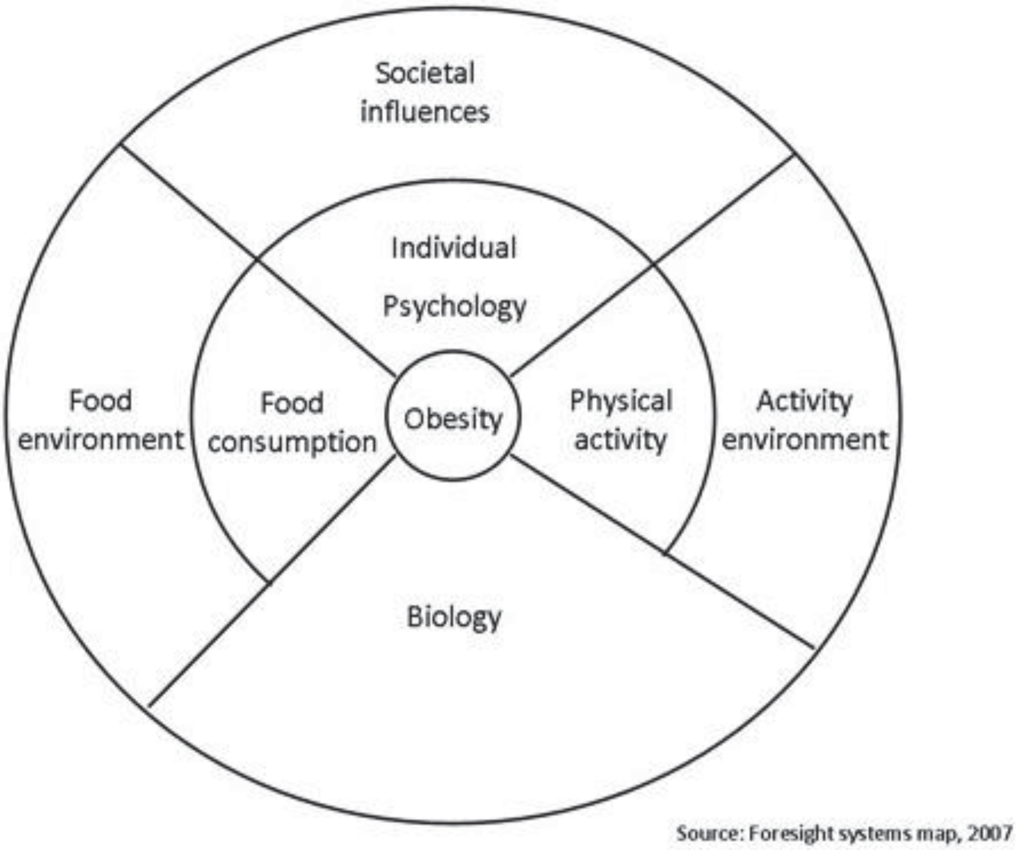

Figure 2.2 Vandenbroeck et al., *Foresight obesity systems map (simplified) demonstrating at its centre 'core' the imbalance between appetite regulation and sedentary existence…*, Cambridge University Press, (2007), retrieved from https://doi.org/10.1017/S0029665109991686

The ‘food environment’ area holds the ‘force of dietary habits’ factor (Vandenbroeck et al., 2007). As the force of dietary habits increases, the conscious control of eating and feelings of satiety will decrease. For example, 12pm may be the usual time for lunch, but if a person has eaten breakfast late, they will not necessarily be physically hungry for lunch. Regardless, eating lunch at 12pm has become a dietary habit, causing them to eat against feelings of satiety. Consequently, the extra energy intake is stored as fat, contributing to the development of obesity. A common ‘force of dietary habit’ in Māori and Pacific women is large portion-sizing (Metcalf et al., 2008; MOH, 2012a, 2012c). Reducing this ‘force of dietary habit’ would require a conscious reduction in portion size (Vandenbroeck et al., 2007) until it becomes habitual to the individual and an accepted social norm amongst their peers. Additionally, slower eating may help reduce the impact of this change in portion size, by allowing more time for feelings of satiety to kick-in (Andrade, Greene, & Melanson, 2008; Andrade, Kresge, Teixeira, Baptista, & Melanson, 2012) and possibly giving the illusion of a larger meal.

Satiety links to the ‘physiology’ area of the map, where there is a factor encompassing ‘level of primary appetite control in the brain’ (Vandenbroeck et al., 2007). Appetite is a physiological driver of food intake, which can vary greatly between individuals, even from birth (Carnell, Haworth, Plomin, & Wardle, 2008). Understanding the degree of influence from appetite is important when considering energy imbalance. Physical activity, different macronutrients, and the form of food are well known to affect appetite. However, the effect of physical activity varies greatly from person-to-person because it stimulates appetite in some and suppresses appetite in others (Blundell, Gibbons, Caudwell, Finlayson, & Hopkins, 2015; Martins, Morgan, & Truby, 2008; Prado et al., 2014). Of the three macronutrients, protein is the most satiating (Journel, Chaumontet, Darcel, Fromentin, & Tome, 2012; Poppitt, McCormack, & Buffenstein, 1998). Hence, isocaloric meals with greater protein will be more ‘filling’ than meals with less protein, resulting in a longer inter-meal period. Complex carbohydrates are satiating because they take longer to break down than simple (refined) carbohydrates, such as white bread and lollies. Complex carbohydrates could include the soluble dietary fibre (DF) found in oats, which is both satiating and has the added benefit of helping to lower blood cholesterol levels (Aller et al., 2004; James, Muir, Curtis, & Gibson, 2003; Lunn, & Buttriss, 2007; Threapleton, Greenwood, Burley, Aldwairji, & Cade, 2013).

On the other hand, meals high in simple sugars are poorly satiating (Malik, Popkin, Bray, Després, & Hu, 2010) and can also stimulate appetite, especially if they’re in liquid form (e.g. fizzy drinks) (DiMeglio & Mattes, 2000; Montmayeur & Le Coutre, 2009). Likewise, high-fat meals stimulate appetite (Prentice, 1998; Gaysinskaya, Karatayev, Chang, & Leibowitz, 2007) but are found to be more satiating than foods concentrated in sugar (Reid & Hammersley, 1999; Anderson, 1996). In this way, many Māori and Pacific women may be consuming excess calories through absent-minded consumption of fizzy drinks and high-fat foods, such as savoury pies.

To counterbalance an excessive energy intake (EI), there must be greater energy expenditure (EE). The 'level of physical activity' in the 'Obesity system map' (Figure 2.2) is a component of EE (Vandenbroeck et al., 2007). The more physical activity a person partakes in, the greater their EE, and they therefore have a larger allowance for EI. In the 2012/13 NZHS, 42.8% of Māori women and 38.3% of Pacific women were physically active (MOH, 2013). These statistics were based on previous guidelines, which suggested doing ≥30 minutes of exercise, five days per week (MOH, 2003). However, the most recent Eating and Activity Guidelines recommend >2.5 hours of moderate or 1.25 hours of vigorous physical activity throughout the week (MOH, 2015a). Even fewer Māori and Pacific women would meet these current guidelines, especially considering the downward trend in PALs (MOH, 2013). Compounding a decrease in physical activity is the increase in sedentary leisure activities, such as time spent watching television (SNZ, 2011).

Consequences of excessive sedentary behaviour have been demonstrated in multiple studies. These studies show negative correlations between physical activity and markers of obesity, such as WC and BMI (Dickerson, Smith, Benden, & Ory, 2011; Oliver, Schluter, Healy, Tautolo, Schofield, & Rush, 2013; Sternfeld et al., 2004). Health benefits from physical activity extend beyond decreasing WC and BMI, through helping prevent CVD, diabetes, hypertension, certain cancers, and depression (Hassmen, 2000; NICE, 2010; WHO, 2010). These benefits are amplified in conjunction with a healthy diet (NICE, 2010).

NZ's increasingly 'obesogenic' environment reflects an imbalance between energy intake and energy expenditure (MOH, 2014b; Pincock, 2011; Tukuitonga, 2013). There are poor opportunities for physical activity in these environments (MOH, 2014b; Tukuitonga, 2013) and they support high consumption of food and drinks, especially those which are energy-dense and nutrient-poor (Lake, Townshend, & Alvanides, 2010; Tukuitonga, 2013). The exact process of these 'obesogenic environments' is complex because of its influence from the macro- and micro-level, correlating with urbanisation, globalisation, and advances in technology (Lake, Townshend, & Alvanides, 2010).

NZ tends to have higher rates of obesity in neighbourhoods where economic resources are scarce (SNZ & MPIA, 2011). The chance of obesity is 1.7 times higher in more deprived areas compared to the least deprived areas (MOH, 2015a). Deprivation scores are based on a web of factors, including quality of housing, income, employment, access to internet and access to a car (Salmond, Crampton, Sutton, Atkinson, 2013). These factors can all create barriers to accessing or purchasing healthy food. Consequently, people with lower incomes have shown more adverse dietary intake patterns, evidenced by lower consumption of DF, milk, vegetables and fruit (P. A. Metcalf, Scragg, & Jackson, 2014). This is significant to NZ Māori and Pacific women because a large proportion live in low socio-economic areas, with little income or unemployment (Milne, Byun, & Lee, 2013; SNZ & MPIA, 2011). Their over-representation in these areas may explain why the prevalence of obesity in NZ is greatest among women of Māori and Pacific ethnicity (SNZ & MPIA, 2011; White, Salmond, Atkinson, & Crampton, 2008).

Although food choices are influenced by many factors (including culture, family, habits, and personal preference), affordability is arguably one of the most influential (Metcalf, Scragg, & Davis, 2006; Metcalf et al., 2014; SNZ & MPIA, 2011), especially for Pacific women (Metcalf et al., 2006; Metcalf et al., 2014; SNZ & MPIA, 2011). In 2011, Pacific people were more likely to report sometimes running out of food due to financial restraints (SNZ & MPIA, 2011). Their financial hardships are also evident in the 2013 Census where the median personal income for Pacific people was lower than all other ethnic groups, at $19,700 per annum (SNZ, 2013c). This is $2,800 less than the median personal income for Māori , and $8,800 less than the national median income (SNZ, 2013b). Lower incomes could partially be explained by age because Māori and Pacific are the youngest of all ethnic groups in NZ. People in NZ who received the highest personal income were within the age bracket of 35-54 years old, which was older than the median age for Māori and Pacific (SNZ, 2013b).

Lower income will affect the food choices of Māori and Pacific women because healthier food choices tend to be more expensive than those which are energy-dense and nutrient-poor (Robinson, 2011). For example, wholemeal bread is more expensive than white bread (Countdown, 2016), which lacks the DF and B vitamins that wholemeal bread provides. Unfortunately, these are the types of food more prevalent in lower socioeconomic areas: there is less access to supermarkets and greater access to convenience stores, such as dairies and takeaway outlets (Robinson, 2011). Convenience stores are unlikely to sell healthful products, such as wholemeal bread and fresh vegetables. On the rare occasion they do stock such items, prices are usually higher than standard versions of the same food (Robinson, 2011). This makes it harder for Māori and Pacific to purchase food beneficial to health and therefore prevent obesity.

2.4.1 Dietary determinants of obesity

Regular intake of foods which are energy-dense and nutrient-poor have led to the accumulation of excess BF percentage (Peters, Wyatt, Donahoo, & Hill, 2002; Vadiveloo, Dixon, Mijanovich, Elbel, & Parekh, 2015). These foods include biscuits, chips, fizzy drinks, cakes and alcohol (MOH, 2003). The chance of becoming overweight increases when regular consumption of these energy-dense foods is combined with inactivity. The excess energy is stored as fat, triacylglycerols within white adipocytes (Rodriguez, Ezquerro, Mendez-Gimenez, Becerril, & Fruehbeck, 2015).

Māori and Pacific women are more likely to consume these high-risk foods (e.g. takeaways and fizzy drinks) than women of other ethnicities (MOH, 2012b, 2012c). The NZANS found 11.2% of Māori women and 13.2% of Pacific women eat takeaways over three times per week, compared with only 2.6% of NZ European and Others (MOH, 2012a). Similarly, the number of Māori and Pacific women (29.1% and 31.7%) consuming soft drinks and energy drinks over three times per week was double the number of NZ European and Others (15.7%) (MOH, 2012a). These foods put them at increased risk of obesity and/or exacerbate pre-existing metabolic conditions.

Furthermore, a couple of studies found Māori and Pacific ethnicities have greater portion sizing and frequency of certain foods than European (Metcalf, Scragg, Tukuitonga, & Dryson, 1998; Metcalf et al., 2008). Portions of chicken, fish, red meat, taro, kumara and potato were larger than standard size for more Māori and Pacific women compared with the European and Asian groups (Metcalf et al., 2008). Portion-sizing differences between Māori and Pacific women were found with vegetables and cake/dessert. Māori women were more likely to have a larger portion size of cake/dessert, whereas Pacific women would have a larger portion size of vegetables (Metcalf et al., 2008). In general, excessive portion sizes are likely to cause excessive energy intake and consequently fat deposition. However, vegetables (non-starchy) are lower in energy and more nutrient-dense than cakes and desserts, which are generally energy-dense and nutrient-poor. Therefore, an excessive portion size of vegetables would not be as detrimental to health as an excessive portion of cake or dessert.

A multitude of research relates particular dietary intake to changes in body weight and obesity, as summarised in Table 2.5. Topics include consumption of sugar (Te Morenga, Mallard, &

Mann, 2013), dairy (Chen, Pan, Malik, & Hu, 2012), and fat (Astrup, Grunwald, Melanson, Saris, & Hill, 2000). However, most of these studies lack focus on ethnic-specific responses to different dietary components, and only a few of them address the connection between diet and BF percentage/distribution. These measures are arguably more important and relevant than using BMI in isolation.

Table 2.5 investigated various trials, studies and meta-analyses to find possible relationships between diet (macronutrients, food groups, and dietary patterns) and obesity. These all had to include women as the participants, be a recent publication (≥year 2000), and consider the link between dietary intake and body fat (with the exception of four studies, which investigated BMI instead of BF). Recent studies are likely to consider the newer technology and more up-to-date techniques for assessing body composition and diet (such as DXA scans and online semi-quantitative FFQs, respectively). Additionally, the type of food and availability is likely to be more reflective of modern dietary patterns and habits.

Table 2.5 Investigating the relationship between diet and obesity, particularly body fat

Study	Design and participants (ppts)	Body fat assessment method(s) used	Dietary intake assessment used	Findings	Strengths	Weaknesses
Randomised controlled trials (RCT)						
Does the Mediterranean diet counteract the adverse effects of abdominal adiposity? (Eguaras et al., 2015) Spain	• Randomized primary prevention trial • 7447 ppts, 55–80 years • 57% women • At high cardiovascular risk but free of CVD at enrolment	• BMI • WC • WHtR	• Semi-quantitative 137-item FFQ	• Mediterranean diets counteracted harmful effects of increased adiposity	• Recent study • Large number of ppts • Investigates the relationship between dietary intake and BF	• WHtR not as accurate as DXA in measuring abdominal adiposity • Ppts are at high risk of CVD • Unknown ethnicity
Effects of macronutrient composition of the diet on body fat in indigenous people at high risk of type 2 diabetes (Brooking et al., 2012) New Zealand	• Intervention • 84 ppts, <75 years • 59 Māori women • Ppts had impaired glucose tolerance and at least one first-degree relative with T2DM • Involved three 8-week phases, with measurements after each phase	• BIA	• Ppts randomly prescribed one of three diets: ○ High protein (HP) ○ High carbohydrate, high DF diet (HCHF) ○ Control • 3-day diet records	• Weight loss with HP and HCHF diets (more significant with HP). • Māori are more likely to maintain a HP diet, even after intensive nutrition support was withdrawn	Investigates the relationship between dietary intake and BF	• Little compliance to prescribed dietary advice • Ppts had T2DM
Determining optimal approaches for weight maintenance: a randomized controlled trial (Dale et al., 2009)	• RCT, intervention • 200 women, 25–70 years • 30 Māori women • Healthy • Ppts had intentionally lost ≥5% of their initial	• BMI • BIA	• Assigned to one of four diets: ○ High monounsaturated (MUFA) fat diet + intensive support	• Both diets reduced body weight, BMI, WC, and BF percentage, with no significant difference between diets • For both groups, EI	• Investigates the relationship between dietary intake and BF • High retention rate of ppts • The 2 support programs and 2	• Increasing MUFA led to a parallel increase in SFA • Motivated ppts (lost weight prior to study)

Study	Design and participants (ppts)	Body fat assessment method(s) used	Dietary intake assessment used	Findings	Strengths	Weaknesses
New Zealand	body weight in the last 6 months, or had a BMI ≥27 kg/m^2		○ High carbohydrate (CHO) diet + intensive support ○ High MUFA fat diet + nurse support ○ High CHO diet + nurse support • 3-day diet records	reduced after the first and second years of the study • Intake of protein, total fat, SFA, MUFA, and PUFA were higher for those on the high CHO diet • Compared with those on the high CHO diet, ppts on the high MUFA diet had lower intakes of energy, CHO, and DF during the follow-up period	dietary interventions were effectively assessed through the 2 × 2 factorial design • Ppts in the nurse-support programme were weighed every fortnight	
Cross-sectional studies						
Dietary Variety Is Inversely Associated with Body Adiposity among US Adults Using a Novel Food Diversity Index (Vadiveloo et al., 2015) United States of America (USA)	• Cross-sectional study • 7470 ppts, ≥20 years • 3684 non-pregnant, non-lactating • Ethnicities: Hispanic, non-Hispanic black, non-Hispanic white, Other	• BMI • WHtR • DXA • Fat mass index	• Two multiple-pass, 24-hour dietary recalls, on non-consecutive days: one weekday and one weekend day • Investigated associations between excess adiposity and dietary variety	A large variety of healthful food (quantified using the US Healthy Food Diversity index) was inversely associated with most adiposity indicators	• Large number of ppts • Investigates the relationship between dietary intake and BF	• 24-hour recalls may not be representative of usual dietary intake, which can vary considerably from day-to-day, especially on weekends
Major dietary patterns in relation to general obesity and central adiposity	• Cross-sectional study • 486 women, 40-60 years • Tehrani teachers	• BMI • WC	• Validated, semi-quantitative Willett-format, 168-item FFQ	3 major dietary patterns extracted: ○ Iranian - likely to be centrally obese	• The 'healthy' and 'western' dietary patterns are very similar to those in	Limited adiposity measures make it hard to compare findings with other studies

Study	Design and participants (ppts)	Body fat assessment method(s) used	Dietary intake assessment used	Findings	Strengths	Weaknesses
among Iranian women (Esmaillzadeh & Azadbakht, 2008) Iran			• FFQ administered by a trained Dietitian	○ Western - likely to be generally and centrally obese. ○ Healthy - less likely to be generally and centrally obese	other renowned studies	
Central obesity and dietary intake in HIV/AIDS patient (Jaime, Florindo, Latorre, & Segurado, 2006) Brazil	• Cross-sectional study • 223 patients, 20-59 years • 171 males • 52 women • Patients had HIV/AIDS and were using highly active antiretroviral therapy with protease inhibitors ≥3 years	• BMI • WC • WHR • Skinfolds	• Two consecutive, 24-hour dietary recalls, excluding one weekend day • A trained nutritionist instructed ppts on how to describe their dietary intake	Greater consumption of fat was associated with an increase in central obesity, whereas carbohydrate intake was negatively associated with central obesity	• Investigates the relationship between dietary intake and central obesity	• Ppts not healthy, as they all had HIV/AIDS • Similar studies did not find the same associations between macro-nutrients and fat distribution
Dietary patterns and risk factors for Type 2 diabetes mellitus in Fijian, Japanese and Vietnamese populations (Tomisaka et al., 2002) Asia	• 552 women, 30-39 years • 200 Fijian women	• BMI • WHR • BIA	• 3-day, 24-hour dietary recalls (Fiji and Vietnam) • 3-day dietary recalls (Japan) • Food models used to aid recall • Trained interviewers	• Fijians had the highest total energy, fat and protein intake, with >30% energy from fat • BMI, BF percentage and WHR significantly higher amongst the Fijian women. WHR was only slightly higher	The narrow age bracket of 30-39 years reduces the chance of age-related influences on BF	• PALs were not controlled • Glycosuria testing was positive for many of the Fijian women. Diabetes could influence BF, which would compound dietary influences on BF
Dietary patterns are associated with body mass index in multi-ethnic women (Maskarinec,	• Cross-sectional study • 514 women • 28 premenopausal, native Hawaiian women, with an average age of	• BMI	• Validated, semi-quantitative, self-administered, multi-ethnic, ~200-item FFQ	• 'Meat' was the most common dietary pattern • The 'Meat' dietary pattern was positively	• Factor analysis identified ethnic-specific dietary patterns	• Small sample of Pacific (Hawaiian) women • A large number of indicator variables

Study	Design and participants (ppts)	Body fat assessment method(s) used	Dietary intake assessment used	Findings	Strengths	Weaknesses
Novotny, & Tasaki, 2000) Hawaii	52.7 years		• Photographs aided portion size selections in the FFQ	associated with BMI, whereas the other patterns had inverse relationships with BMI		(food items) • Large residuals
Longitudinal studies						
Dietary patterns and changes in body weight in women (Schulze, Fung, Manson, Willett, & Hu, 2006) USA	• Longitudinal cohort study • 51,670 women nurses, 24 – 44 years	• Weight • BMI	• Self-administered, 133-item FFQ	• The western dietary pattern resulted in greater weight-gain than the prudent pattern, which may facilitate weight maintenance	• Mean weight changes were calculated after adjusting for baseline physical activity, BMI, age, smoking, alcohol intake, oral contraceptive use, postmenopausal hormone use, cereal DF intake, and total fat intake • Adjustments were made for changes in some of these confounders	• May be error in self-reporting of body weight • Other dietary and lifestyle factors may be confounding
Food patterns measured by factor analysis and anthropometric changes in adults (Newby, Muller, Hallfrisch, Andres, & Tucker, 2004) USA	• Longitudinal study • Ppts entered the study on or after 1980, with yearly measurements thereafter • 449 healthy ppts, from the Baltimore Longitudinal Study of Aging • 219 disease-free	• BMI • WC	• 7-day dietary records • Food models and pictures aided portion size estimation. Later, a set of scales provided accurate calculation of portion sizes	• Six food patterns were identified: ○ Reduced-fat dairy products, fruit, and DF ○ Protein and alcohol ○ Sweets ○ Vegetable fats and vegetables ○ Fatty meats ○ Eggs, bread and soup	• Investigates the relationship between dietary intake and WC (measured over time). • Assessing dietary patterns is more representative of natural eating behaviour than assessing foods in isolation	• Subjective decisions regarding the treatment of dietary data e.g. deciding which variables should be adjusted for • The investigator pre-specified the number of factors

Study	Design and participants (ppts)	Body fat assessment method(s) used	Dietary intake assessment used	Findings	Strengths	Weaknesses
	women between 30 - 80 years		• Dietitians (initially) aided ppts with completing dietary records	• Dietary patterns rich in high-DF foods and low-fat dairy products led to smaller gains in BMI and WC	• Standardised anthropometric procedures used	
Dietary patterns and changes in body mass index and waist circumference in adults (Newby, Muller, Hallfrisch, Qiao, Andres, & Tucker, 2003) USA	• Longitudinal study • Ppts entered the study on or after 1980, with yearly measurements thereafter • 449 healthy ppts from the Baltimore Longitudinal Study of Aging • 219 disease-free women between 30-80 years	• BMI • WC	• 7-day dietary records • Food models and pictures aided portion size estimation. Later, a set of scales provided accurate calculation of portion sizes • Dietitians (initially) aided ppts with completing dietary records	• Ppts in the meat-and-potatoes cluster had an annual increase in BMI (6 times greater than those in the healthy cluster) • Mean annual increase in WC was >3 times greater in the white-bread cluster than the healthy cluster	• Investigates the relationship between dietary intake and WC (measured over time) • Assessing dietary patterns is more representative of natural eating behaviour than assessing foods in isolation • Standardised anthropometric procedures used	• Subjective decisions regarding the treatment of dietary data e.g. deciding which variables should be adjusted for • The investigator pre-specified the number of factors
Food groups as predictors for short-term weight changes in men and women of the EPIC-Potsdam cohort (Schulz, Kroke, Liese, Hoffmann, Bergmann, & Boeing, 2002) Germany	• Longitudinal cohort study • 17,369 non-smoking ppts from the European Prospective Investigation into Cancer and Nutrition (EPIC) -Potsdam cohort • 11,005 women, 19–70 years	• Weight ○ Baseline weight measured by a trained technician ○ Follow-up weight was self-reported	• Validated, quantitative, self-administered, 148-item FFQ	• High energy and high fat food groups (e.g. fats, sauces, meat) resulted in significantly large weight gain, whereas cereal consumption resulted in large weight loss	• Controlled for many potential confounding factors e.g. behavioural and lifestyle factors, BMI, age, previous changes in weight • Applied a polytomous logistic regression analysis allowed weight gain/loss to be analysed separately,	• Only used weight in analysis, excluding other useful anthropo-metric measures, such as BMI • There may be error in self-reporting of body weight

Study	Design and participants (ppts)	Body fat assessment method(s) used	Dietary intake assessment used	Findings	Strengths	Weaknesses
					increasing statistical power	
Meta-analysis						
Dietary sugars and body weight: systematic review and meta-analyses of randomised controlled trials and cohort studies (Te Morenga et al., 2013)	• 30 RCTs (at least 2 weeks long) and 37 prospective cohort studies (at least 1 year). The 30 RCTs were separated into ad-libitum (n=19) and isoenergetic (n=11) studies • Free-living adults	• Measures included: ○ Change in weight ○ Change in BMI or BMI Z-score ○ WC ○ BF (%) ○ FM (%) ○ Trunk fat (%)	• Intake of total sugars, a component of total sugars, or sugar-containing foods and beverages • Measured using various techniques e.g. analysis of FFQ	• Intake of SSB or free sugars are determinants of body weight in free-living people, on ad libitum diets • No change in weight when exchanging free sugars with other carbohydrates, in an isoenergetic diet	• A large, in-depth review of literature • GRADE and the World Cancer Research Fund criteria were used for evaluating strength of evidence for association • Trends remained consistent, even after excluding biased studies	• Most literature was based on SSB and body composition, with fewer studies on sugar or sugars
Effects of dairy intake on body weight and fat: a meta-analysis of randomized controlled trials (Chen et al., 2012)	• 29 RCTs • 2060 adult ppts	• Weight (29 studies) • BF (22 studies) • BMI	• Serves of dairy per day, for 1-24 months (median duration of 4 months) • Soy milk excluded	• Dairy may have a modest effect on facilitating weight loss in energy-restricted or short-term RCTs (less than 1 year) • Dairy may facilitate weight gain in ad libitum interventions and long-term trials (over 1 year)	• Recent study • Large number of ppts • Ppts were instructed to keep a constant level of physical activity for 27 of the 29 trials	• Of the 29 RCTs, 10 were classified as low quality, using the JADAD score • Many differences in study design, population, duration, and intervention • Most studies were not double-blinded • Energy-restricted trials were relatively small and of short duration

Study	Design and participants (ppts)	Body fat assessment method(s) used	Dietary intake assessment used	Findings	Strengths	Weaknesses
The role of low-fat diets in body weight control: a meta-analysis of ad libitum dietary intervention studies (Astrup et al., 2000)	• 16 controlled trials (14 RCTs), of 2-12 months • 62% of the 1910 ppts were women • Low-fat ad libitum trials on weight change	• Weight (pre- and post-treatment)	• Dietary fat intake as a percentage of total EI • Recorded pre- and post-treatment dietary fat intake	• Dietary fat reduction, without intentional energy restriction, was associated with weight loss • Weight loss greatest in ppts who were heavier at baseline	• The purpose of the trials was recorded e.g. blood lipids, body composition, breast cancer prevention	• Only body weight was extracted because BMI was not reported in all studies • Included fewer studies than other meta-analyses regarding dietary fat reduction and body weight • The studies were not blinded to ppts • In the weight-loss studies, ppts may subconsciously reduce their total EI by other means than reducing fat, in an effort to achieve further weight loss • Dietary intake was self-reported

BF = Body fat; BIA = Bioelectrical impedance analysis; BMI = Body mass index; CHO = Carbohydrate; CVD = Cardiovascular disease; DF = Dietary fibre; DXA = Dual-energy X-ray absorptiometry; EI = Energy intake; FFM = Fat free mass; FFQ = Food frequency questionnaire; MUFA = Monounsaturated fat; PAL = Physical activity level; Ppts = Participants; PUFA = Polyunsaturated fat; RCT = Randomised controlled trial; SFA = Saturated fat; SSB = Sugar-sweetened beverages; T2DM = Type two diabetes mellitus; WC = Waist circumference; WCRF = World Cancer Research fund; WHR = Waist-hip ratio; WHtR = Waist-height ratio

Literature in Table 2.5 has outlined particular macronutrients, foods and dietary patterns that may have effects on adiposity markers such as weight, WC, BMI, and BF percentage.

Carbohydrates were negatively associated with adiposity in multiple studies (Brooking et al., 2012; Dale et al., 2009; Jaime et al., 2006; Tomisaka et al., 2002). However, these carbohydrates were generally complex carbohydrates, which are likely to have a higher satiating effect than simple carbohydrates/sugars found in food such as white bread and SSB. Therefore, in ad libitum trials (or free-living situations), participants are less likely to consume as much food, and subsequently have lower EIs.

Protein was also found to be negatively associated with adiposity in Brooking et al.'s (2012) RCT. Participants on the high protein (HP) diet consumed 30% energy from protein, which is 5% above the Acceptable Macronutrient Distribution Range (AMDR) (NHMRC, 2006). Protein is the most satiating macronutrient (Journel, Chaumontet, Darcel, Fromentin, & Tome, 2012; Poppitt et al., 1998). Hence, isocaloric meals with greater protein will be more 'filling' than meals with less protein, resulting in a longer inter-meal period. However, Brooking et al.'s (2012) trial prescribed specific EI, depending on the individual's energy requirements. Furthermore, the trial included Māori women with T2DM and a first-degree relative with T2DM (Brooking et al., 2012). T2DM could influence BF percentage, which would compound dietary influences on BF percentage. It would therefore be prudent to compare Brooking et al.'s (2012) study with those who have also recruited diabetic Māori women.

Like carbohydrates and protein, fat also had a negative effect on adiposity markers in Dale et al.'s study (2009). Yet it had a positive effect on adiposity for Jaime et al. (2006). The prior is a RCT whereas the latter is a cross-sectional observational study. Observational studies only show a specific point in time, rather than the long-term effects of particular dietary intakes. Additionally, it is difficult to ascertain which variable(s) are more influential on the outcome because there is no control group, as with RCTs. Nonetheless, Dale et al.'s study (2009) recruited participants who had intentionally lost ≥5% of their initial body weight prior to the study. This suggests they were motivated to lose weight during the trial and weight loss was therefore not solely influenced by fat intake. Jaime et al. (2006) had recruited participants with HIV/AIDS who had been using protease inhibitors for over three years, both of which have demonstrated redistribution of BF (Batterham, Garsia, & Greenop, 2000; Carr, Samaras, Thorisdottir, Kaufmann, Chisholm, & Cooper, 1999).

Furthermore, Dale et al.'s (2009) participants were prescribed one of four diets, while Jaime et al. (2006) recorded his participants' actual dietary intake using two consecutive, 24-hour dietary recalls. In Dale et al.'s study (2009) 35% of EI was from fat. Of the total fat, 21% was from monounsaturated fat (MUFA), 8% from SFA, and 6% from polyunsaturated fat (PUFA). The types of fat in Jaime et al.'s (2006) study were not mentioned but, overall, ~30% of EI was from fat. This is 5% lower than Dale et al. (2009). Although fat may be highest in calories-per-gram than the other macronutrients, it is relatively satiating in comparison with foods concentrated in sugar, such as fizzy drinks (Reid & Hammersley, 1999; Anderson, 1996). Moreover, Dale et al.'s (2009) participants were encouraged to eat plenty of fruit and vegetables, moderate amounts of nuts, olive oil, canola oil, avocados, low-fat dairy, lean meat and some carbohydrate-containing foods - all of which are part of a healthy, balanced diet, as recommended in the Eating and Activity Guidelines for New Zealand Adults (EAGNZA) (MOH, 2015b). Within Dale et al.'s (2009) trial, participants on the high monounsaturated (MUFA) fat diet had obesity markers similar to participants on the high-carbohydrate diet, even though their EI was lower (Dale et al., 2009). Hence, fat intake may be more conducive to obesity than a simple imbalance in EI.

Regarding food, there are multiple ad libitum RCTs on SSB, free sugars and dairy, showing association with weight gain (Chen et al., 2012; Te Morenga et al., 2013). Yet in short-term RCTs, dairy may facilitate weight loss. Mechanisms facilitating weight loss may include the lower-energy-content of low-fat dairy (Te Morenga et al., 2013), the satiating effect of protein (Journel et al., 2012; Poppitt et al., 1998), and bioactive compounds such as calcium (Chen et al., 2012; Christensen et al., 2009; Zemel, 2005). Calcium could help to increase lipolysis or reduce fat absorption (Christensen et al., 2009; Zemel, 2005). However, dairy may also have a modest effect in facilitating weight loss in energy-restricted trials (Chen et al., 2012), and there was no change in weight when exchanging free sugars with other carbohydrates in an isoenergetic diet (Te Morenga et al., 2013). These findings suggest that changes in BW are likely related to changes in EI rather than in the foods themselves.

The majority of studies in Table 2.6 relate to 'Western' versus 'Healthy' dietary patterns, especially among the cross-sectional studies. These 'Western' versus 'Healthy' dietary patterns are often referred to in literature, with similar food components but sometimes different names e.g. a 'Healthy' dietary pattern may be called 'Prudent' (Schulze et al., 2006). There is a trend towards investigating overall dietary patterns rather than specific foods and/or nutrients, because patterns are more reflective of usual intake. Table 2.6 outlines the foods commonly consumed for that pattern and summarises findings related to obesity. The ‘Western’ dietary pattern often consists of regular intake of foods including refined grains, red meat, processed meat, sweets, desserts, fizzy drinks, fast foods, potatoes, high-fat dairy, and condiments, whereas the ‘Healthy’/‘Prudent’ dietary patterns are usually reflective of high intakes of fruits, vegetables, whole grains, cereals, fish and low-fat dairy. Findings are consistent in showing ‘Western’ dietary patterns positively correlating with obesity (Esmaillzadeh & Azadbakht, 2008; Maskarinec et al., 2000; Newby, Muller, Hallfrisch, Andres, & Tucker, 2004; Newby, Muller, Hallfrisch, Qiao, Andres, & Tucker, 2003; Schulz et al., 2002; Schulze et al., 2006). In comparison, the ‘Healthy’ dietary patterns are normally inversely related to obesity (Esmaillzadeh & Azadbakht, 2008; Maskarinec et al., 2000; Schulz et al., 2002).

Table 2.6 highlights findings from literature that investigated ‘Western’ and ‘Healthy’ dietary patterns. Some of the studies have been extracted from Table 2.5, above.

Table 2.6 Investigating the relationship between diet and obesity – 'Western' versus 'Healthy' dietary patterns

Study	'Western' dietary pattern	'Healthy' dietary pattern	Findings
Major dietary patterns in relation to general obesity and central adiposity among Iranian women (Esmaillzadeh & Azadbakht, 2008) Iran	"High in refined grains, red meat, butter, processed meat, high-fat dairy products, sweets and desserts, pizza, potatoes, eggs, hydrogenated fats and soft drinks, and low in other vegetables and low-fat dairy products".	"High in fruits, other vegetables, tomatoes, poultry, legumes, cruciferous and green leafy vegetables, tea, fruit juices, and whole grains".	The western pattern was positively associated with general and central obesity, whereas the healthy pattern was inversely associated.
Dietary patterns and changes in body weight in women (Schulze et al., 2006) USA	"High intakes of red and processed meats, refined grains, sweets and desserts, French fries and potatoes."	"High intakes of fruits, vegetables, whole grains, fish, poultry, legumes, oil and vinegar salad dressing."	The western dietary pattern resulted in a larger weight gain than the healthy patterns, which may facilitate weight maintenance.
Dietary patterns and changes in body mass index and waist circumference in adults (Newby et al., 2003) USA	High in meat, potatoes, fast food and soda.	"High in fruit, vegetables, reduced-fat dairy and whole grains."	The western dietary pattern was associated with larger increases in BMI and WC.
Food groups as predictors for short-term weight changes in men and women of the EPIC-Potsdam cohort (Schulz et al., 2002) Germany	High energy and high fat food groups (e.g. fats, sauces, meat): ○ Fats = Butter, margarine, oil ○ Sauces = Brown and white sauces (gravy), ketchup, mayonnaise, salad dressing, sauce for vegetables Meat = Poultry, pork, beef, hamburger, minced meat, liver, lamb, roast hare	Cereals = Pasta, cereals, rice, cornflakes, crisps, muesli	High energy and high fat food groups (e.g. fats, sauces, meat) significantly resulted in large weight gain, whereas cereal consumption resulted in large weight loss.
Dietary patterns are associated with body mass index in multi-ethnic women (Maskarinec et al., 2000) Hawaii	"High intake of processed and red meats, fish, poultry, eggs, fats and oils, and condiments."	High in vegetables, legumes, tofu, soy protein, fruit, fruit juice and cold breakfast cereals	The western dietary pattern was positively associated with BMI, whereas the healthy pattern had an inverse relationship with BMI.

BMI = Body mass index; WC = Waist circumference

In two longitudinal studies, ‘Healthy’ patterns have also shown a neutral (Schulze et al., 2006) or lesser effect on markers of obesity e.g. causing a smaller increase in BMI/WC than the ‘Western’ diet (Newby et al., 2003). In the prior study, because women did not have their EI controlled, any change in weight could be due to an imbalance in EI rather than in the foods themselves. In the latter study, the average age of women was ~57 years, which is ~13 years older than the age range of 24–44 years in Schulze et al.’s study (2006). Age is of significance because there are age-related changes in body composition, such as increases in FM and declines in muscle mass (Evans & Campbell, 1993; Lamberts, Van den Beld, & van der Lely, 1997; Willett et al., 1995). Since FM requires less energy than muscle mass, the need for energy decreases and is further impacted by the trend of lowering energy expenditure with age (Caspersen, Merritt, & Stephens,1994; President's Council on Physical Fitness, & Sports (US), 1996)). However, this trend is not seen among NZ women in the 2014/15 NZHS, suggesting that other factors (such as diet) may have more of an impact on adiposity than declining levels of exercise (MOH, 2015a).

The NZANS fails to investigate the relationship between dietary intake and BF percentage. Instead, it provides a general overview of the nutritional status of New Zealanders and the prevalence of overweight and obesity based on WHO BMI cut-off points (see Table 2.1). Similarly, the 2008 Diabetes, Heart and Health Study (DHHS) examined dietary intakes of Māori and Pacific women in NZ (Metcalf et al., 2008). Yet there is no evidence of body composition analysis to accompany and compare against the dietary intake variable.

In comparison, Tomisaka et al.’s study explores intake of energy, protein, fat and carbohydrate per kg of body weight (BW) (Tomisaka et al., 2002). In doing so, a link was made between dietary intake and BW, even though BW is not a good indicator of health compared with BF percentage. Calculating intake relative to body size may allow for better assessment of nutrient adequacy between individuals because larger people generally have higher requirements e.g. the Nutrient Reference Values (NRVs) for Australia and New Zealand recommend NZ women consume ~0.75g protein per kilogram of body weight (NHMRC, 2006). The NRVs also provide a modified Schofield equation to find energy requirements based on age, weight, height, PAL and gender (NHMRC, 2006). If participants report consuming excess energy, it is likely they will put on excess weight. However, this method will not work if there are significant outliers because they will skew the average population weight. Additionally, some recommendations per kg BW are not applicable when participants are heavier than they should be e.g. due to excess adiposity. Instead, percentage contributions to EI may be more applicable and can be compared with the AMDR. Protein (15-25% of EI), fat (20-35% of EI) and carbohydrate (45-65% of EI) have AMDRs, which are set to ensure adequate micronutrient status and reduce the risk of chronic disease (NHMRC, 2006). After finding the percentage of participants who have intakes above or below their requirements, these values can be compared with other populations.

Although these studies may shed light on dietary determinants of weight and adiposity, none directly investigate the effect on young Māori and Pacific women in NZ.

2.5 Assessment of diet

The strengths and weaknesses of common dietary assessment methods are outlined in Table 2.7, compiled from Cade, Thompson, Burley, and Warm, (2002), Gemming, Jiang, Swinburn, Utter, and Mhurchu (2014), Gibson (2005) and Wrieden et al. (2003).

Table 2.7 Dietary assessment methods

Dietary assessment methods	Appropriate subjects	Actual or usual intake	Literacy and numeracy required	Personal time required	Finances required	Strengths	Weaknesses
24-hour recall	• Groups • Populations	Usual	No	Low	Low	• Low respondent burden, so compliance is high • Researcher can question ppts over the telephone • Primary dietary assessment tool • Does not affect eating behaviour because ppts aren't recording intake themselves • Intake quantifiable • Can be a valid measure of intake if multiple single-day recalls are done on individuals in a group or population • Low non-response bias from having an interviewer	• A single 24-hour recall is not representative of usual intake unless done on the same participant over several days (including weekends) • Memory dependant, so unsuitable for young children and some elderly • Estimation of food portions • Potential bias in reporting "good/bad" food • Answers may be dependent on the day of the week • Under-reporting of EI in large dietary studies
Multiple-pass 24-hour recalls	• Groups • Populations	Usual	No	Medium	Low	• The four-stage, multiple-pass technique is usually used. It has more accuracy than a single 24-hour recall by including questions such as food brand, cooking technique, vitamin and mineral supplements etc. • Low respondent burden, so compliance is high • Can query over the telephone • Primary dietary assessment tool • Does not affect eating behaviour because ppts aren't recording intake themselves • Intake quantifiable	• Memory dependant, so unsuitable for young children and some elderly • Estimation of food portions • Potential bias in reporting "good/bad" food • More participant burden than for a single 24-hour recall

Dietary assessment methods	Appropriate subjects	Actual or usual intake	Literacy and numeracy required	Personal time required	Finances required	Strengths	Weaknesses
						• Can be a valid measure of intake if multiple single-day recalls are done on individuals in a group or population • Low non-response bias from having an interviewer	
Repeated 24-hour recalls	• Individuals	Usual	No	Medium	Low	• Primary dietary assessment tool (Willett et al.,1985) • Takes seasonal variation into account • Repeated 24-hour recalls can be carried out on a subset of the population and extrapolated • Low respondent burden, so compliance is high • Can query over the telephone • Does not affect eating behaviour because ppts aren't recording intake themselves • Intake quantifiable • Can be a valid measure of intake if multiple single-day recalls are done on individuals in a group or population • Low non-response bias from having an interviewer	• Memory dependant, so unsuitable for young children and some elderly • Estimation of food portions • Potential bias in reporting "good/bad" food • Repetitions over the year are used to estimate usual food intake, rather than their actual intake • Within-subject variation will determine the number of 24-hour recalls required. A high within-subject variation would require more recalls because their day-to-day variation in food intake is high
Estimated food record	• Individuals • Groups • Populations	Actual or usual (depending on the number of assessment days)	Yes	High	Low	• Commonly used • Lower participant burden than weighed food records • Not reliant on memory • Intake quantifiable • Self-monitoring intake may encourage	• Potential bias in reporting "good/bad" food • More participant burden than any type of 24-hour recall • Dietary reporting is dependent on participant motivation, whereas trained nutritionists record dietary intake in 24-hour recalls

Dietary assessment methods	Appropriate subjects	Actual or usual intake	Literacy and numeracy required	Personal time required	Finances required	Strengths	Weaknesses
						healthful behaviour change	• Potential error in quantifying portion sizes e.g. inaccurate conversion from volume to weight • With individuals, the number of days depends on the individual's day-to-day variation in food intake
Weighed food record	• Individuals • Groups	Actual or usual (depending on the number of assessment days)	Yes	Highest	High	• Most accurate method • Higher reproducibility than the estimated food record because foods are weighed and drinks are measured • Not reliant on memory • Intake quantifiable • Self-monitoring intake may encourage healthful behaviour change • Commonly used as a reference for validation studies	• Potential bias in reporting "good/bad" food • Participants may change their eating pattern to simplify the weighing/measuring process • Participants may underreport because of the effort required to record snacks around main meals. • Highest participant burden • High researcher burden • Dietary reporting is dependent on participant motivation • Potential error in scales or weighing technique • Number of days depends on the individual's day-to day variation in food intake
Diet history	• Individuals	Usual	No	Medium	Low	• As well as estimating food intake, it estimates meal patterns • Does not affect eating behaviour because ppts aren't recording intake themselves • May be more representative of usual dietary intake than a 7-day weighed food record. Participants are likely to	• Usually about one month long, but smaller time periods have demonstrated higher reproducibility and validity • Interviews may take up to two hours per participant • Can overestimate actual intake in comparison to weighed records • Researcher burden high

Dietary assessment methods	Appropriate subjects	Actual or usual intake	Literacy and numeracy required	Personal time required	Finances required	Strengths	Weaknesses
						change their intake in weighed records, to simplify the burden of recording food intake	• Results are dependent on interviewer skill • Memory dependant • Misreporting common
Food frequency questionnaire (FFQ)	• Individuals • Groups	Usual	No	Low	Low	• Daily, weekly, monthly or yearly response categories can be chosen, depending on study objectives • Usually takes 15-30 minutes to complete, which is much less than most of the other dietary assessment methods • Low researcher burden because the results are easy to collect and process • Low participant burden • Suitable for large groups • Can be self-administered • Does not affect eating behaviour because ppts aren't recording intake themselves • As well as estimating food intake, it estimates meal patterns	• Validity has not been clearly established • Lower accuracy than other methods • Estimation of food portions • Low cost and time to administer but developing the FFQ is costly and time-consuming • No gold standard for assessing FFQ validity • When foods are reported as combined, alone and in mixed dishes, it can be cognitively challenging and difficult for participants who do not take part in cooking or preparing meals • Overestimation and double-counting can occur when foods are reported separately, alone and as mixed dishes
Semi-quantitative FFQ	• Individuals	Usual	No	Low	Low	• Portion size estimates allow derivation of energy and nutrient intake • Widely used • Daily, weekly, monthly or yearly response categories can be chosen, depending on study objectives • Takes 15-30 minutes to complete (much less than most of the other dietary assessment methods)	• Validity has not been clearly established • Low cost and time to administer but developing the FFQ is costly and time-consuming • No gold standard for assessing FFQ validity • When foods are reported as being combined, alone and in mixed dishes, it can be cognitively challenging and difficult for participants who do not take part in

Dietary assessment methods	Appropriate subjects	Actual or usual intake	Literacy and numeracy required	Personal time required	Finances required	Strengths	Weaknesses
						• Suitable for large groups • Can be self-administered • Does not affect eating behaviour because ppts aren't recording intake themselves • Low researcher burden because the results are easy to collect and process • Low participant burden • Estimates food intake and meal patterns	cooking or preparing meals • Overestimation and double-counting can occur when foods are reported separately, alone and as mixed dishes

EI = Energy intake; FFQ = Food frequency questionnaire; Ppts = Participants

Historical assessment methods (see Table 2.7) are becoming more accurate and less time-consuming with emerging technologies, such as mobile phone applications, website tools, bar code scanners, camera and photographic devices (Gemming et al., 2015; Gibson, 2005; Gemming, Utter, & Mhurchu, 2015). However, validation for these technologies is limited, they can often be expensive in studies with large population groups, and there may still be errors in measurement (Gibson, 2005; Illner, Freisling, Boeing, Huybrechts, Crispim, & Slimani, 2012). Instead, commonly used and tested dietary assessment methods are therefore listed in the Table 2.7, above.

Semi-quantitative FFQs are widely used in dietary assessment, especially with epidemiologic research (Gibson, 2005; Michels & Willett, 2009). Although it can be expensive and time-consuming to develop a FFQ, they are cheap and easy to administer (Gibson, 2005). However, these types of dietary assessment methods are generally not as accurate as those requiring some finances, a skilled assessor and memory e.g. weighed food records. Regardless, FFQs are advantageous over weighed -food-records and estimated-food-records because they are quicker to complete and are less of a burden to the participant (Gibson, 2005; Wrieden et al., 2003). This is ideal for time-restricted studies, those with a focus aside from food quantities, and participants with busy lifestyles. Since FFQs are retrospective and relatively long-term, they can be more beneficial for investigating extremely high or low intakes, the variety of foods consumed and consequently, identifying particular dietary patterns (Gibson, 2005; Houston, 2014). Furthermore, semi-quantitative FFQs consider the serves of particular foods/drinks, allowing the investigator to estimate a participant's usual intake in both a qualitative and quantitative manner (Gibson, 2005; Wrieden et al., 2003). Semi-quantitative FFQs are therefore suitable for assessing food and nutrient intake in relation to specific health outcomes (Gibson, 2005; Ibiebele, Parekh, Mallitt, Hughes, O'Rourke, & Webb, 2009; Rodriguez, Mendez, Torun, Schroeder, & Stein, 2002).

Diet histories are similar to FFQs because they are retrospective, obtaining dietary information from about one month of intake (Gibson, 2005). Yet they are more time-consuming and require the assessor to have considerable literacy and numeracy skills, in order to record the type and amount of food consumed by the participant(s). Rather than being assessor-dependent, weighed -food-records and estimated-food-records are participant-dependent. They have a high participant burden, especially the weighed-food-records (Gibson, 2005; Wrieden et al., 2003). Instead of having to estimate portion size, individual components of food must be weighed, allowing documentation of precise measurements, e.g. kitchen scales are used to weigh an apple and then calculations are made to minus the weight of the uneaten core. Although this provides high accuracy, participants may simplify their usual intake of food in order to reduce the amount of measurements and documentation required (Gibson, 2005). Regardless, participants do not have to rely on their memory of food intake, thereby minimising the risk of misreporting.

Comparatively, 24-hour recalls and diet histories are highly reliant on the assessor’s knowledge of portions, serving size, and non-probing interview skills (Gibson, 2005; Wrieden et al., 2003). With assessment playing a large role, it takes considerable stress off the participant, even though they are still required to remember their intake from the previous day (with 24-hour recalls) or previous month (with diet histories). Nevertheless, 24-hour recalls provide only a snapshot of the participant’s dietary intake. This 24-hour window of consumption may not be reflective of their usual diet, which could vary considerably from day-to-day, especially when comparing weekday versus weekend intake (An, 2016; Gibson, 2005; Yang, Black, Barr, & Vatanparast, 2014). In comparison, diet histories provide a better overall trend of intake, but are more reliant on memory than a 24-hour recall and misreporting is common (Gibson, 2005). Repeated 24-hour recalls can overcome some of the error inherent/incurred in single, 24-hour recalls, particularly when all days of the week and seasons are equally represented. Alternatively, multiple single-day recalls can be carried out on individuals in a group or population, for a valid measure of intake (Gibson, 2005).

Although multiple-pass-recalls, weighed-food-records and estimated-food-records take longer to administer, they are more accurate in reporting a participant’s dietary intake than methods such as FFQs and diet histories. This is valuable in a study where the focus is to investigate the effect of nutrients on particular health outcomes. Unfortunately, when participants are required to record their food intake, it has the potential to affect eating behaviour (Block, 1982; Gibson, 2005) e.g. participants doing weighed-food-records may consciously decide to avoid eating their usual snacks because of the effort it takes to weigh and document the food (Gibson, 2005). Therefore, methods such as the 24-hour recall and FFQs are beneficial because they are a low burden to the participant(s) and thus, there is a higher compliance rate. Furthermore, a couple of studies suggested that repeated 24-hour recalls and FFQs have similar validity (Kabagambe, Baylin, Allan, Siles, Spiegelman, & Campos, 2001; Shai et al., 2005).

The cost, difficulty, time required, skills, and participant burden affect the quality of the dietary data collected. Choosing a dietary assessment method further depends on the study objective(s), type of participants and depth of information required. To minimise the downfalls of one dietary assessment method, it can be beneficial to use it in conjunction with another. Additionally, a simple way of validating answers is to include cross-checking questions (Gibson, 2005). These are especially useful for questions which may not be answered honestly, such as the number of fruit and vegetables eaten per day.

2.6 Capturing food and nutrient intake data

2.6.1 Dietary assessment software

Raw dietary data is usually entered into a computer program containing a database of food

Raw dietary data is usually entered into a computer program containing a database of food
composition tables. The dietary assessment software (DAS) aligns its database of foods with participant dietary input, consequently providing a breakdown of the energy content and nutrients. Researchers can then compare the EI to participant requirements, and the macro-/micro-nutrients against dietary guidelines. This allows identification of potential mis-reporters, over-reporters, and under-reporters.

Literature reviews on DAS have shown that one size does not fit all (Pennington et al., 2007; Probst & Tapsell, 2005; Stumbo, 2008). Participant demographics, study objective, budget, and researcher skills should all be considered when deciding on the most ideal DAS (Kim, 2015; Pennington et al., 2007).

For example, the Kai-culator (version 0.85) is a web-based DAS tool which has been developed by The Department of Human Nutrition, at the University of Otago, in Dunedin, NZ (Department of Human Nutrition: University of Otago, 2013). It determines the nutrients from individual and group dietary intakes through sourcing NZ FOODfiles, from the NZ food composition database (New Zealand Institute for Crop & Food Research, 2010). Although data entry is fast and the Kai-culator contains a breadth of NZ-specific foods, it fails to compare nutrient analyses with NRVs (Kim, 2015). However, sophisticated DAS like FoodWorks 8 (Xyris Software (Australia) Pty Ltd, Queensland, Australia) is able to do this. NRVs include Estimated Energy Requirements (EERs), Estimated Average Requirements (EARs), Adequate Intakes (AIs), Upper Levels of Intake (UL) and Recommended Dietary Intake (RDI) (FoodWorks Professional, 2016; NHMRC, 2006).

FoodWorks 8, like the Kai-culator (version 0.85), is also used to enter participants' dietary records and analyse nutrient profiles, through FOODfiles (2014) food composition database (FoodWorks Professional, 2016). FOODfiles (2014) was developed by the NZ Institute for Plant

& Food Research Limited and the MOH, and holds nutrient values for over 2700 frequently-consumed foods (FoodWorks Professional, 2016). Additionally, FoodWorks 8 utilises many other nutrient databases, including AusBrands, AusFoods, NUTTAB 2010, and USDA National Nutrient Database for Standard Reference (Release 24) (FoodWorks Professional, 2016). Having additional databases and the ability to compare with NRVs contributes towards making FoodWorks 8 (Xyris Software (Australia) the most popular DAS among NZ Dietitians (Kim, 2015).

Table 2.8 summarises study cut-off points and exclusion criteria for participants who may have over-/under-/mis-reported.

Table 2.8 Data processing

Study	Dietary assessment method	Study design and participants	Participant exclusion criteria	Other considerations
Dietary Variety Is Inversely Associated with Body Adiposity among US Adults Using a Novel Food Diversity Index (Vadiveloo et al., 2015) USA	• Multiple-pass 24-hour diet recall, on two non-consecutive days (including one weekday and one weekend day)	• Cross-sectional study • 7470 participants, ≥20 years • 3684 non-pregnant, non-lactating women • Ethnicities include: Hispanic, non-Hispanic black, non-Hispanic white, other	• EI <400 kcal/day or >7000 kcal/day	
2008/09 Adult Nutrition Survey NZ. Methodology Report for the 2008/09 New Zealand Adult Nutrition Survey (Gemming, Jiang, Swinburn, Utter, & Mhurchu, 2014; MOH, 2011a, 2011b) New Zealand	• Multiple-pass 24-hour diet recall	• Cross-sectional study • 4721 participants, >15 years • 588 Māori women • 343 Pacific women	• All women included, regardless of EI value: ○ EI for Māori women ranged between 1294 KJ per day to 27,524 KJ per day ○ EI for Pacific women ranged between 864 KJ per day to 42,730 KJ per day • However, participants were asked to clarify their intake when it revealed: ○ >5 litres of milk ○ <1000 kcal EI	• Rates of under-reporting were highest in Pacific (34.3%) and Māori (31.8%) women, especially if they were overweight or obese (Gemming et al., 2014). Overweight and obese women under-reported by 27.3% and 32.5%, respectively, in comparison to 17.9% of normal weight women • Under-reporting may be more common in foods which are perceived to be unhealthy, such as biscuits, fats, cakes and desserts • Over-reporting may be more common in foods perceived to be healthy (“social desirability bias”)
Development and validation of a semi-quantitative food frequency questionnaire to assess dietary intake of adult women living in New Zealand (Houston, 2014)	• Semi-quantitative FFQ • 4-day weighed food record	• Dietary assessment tool validation study • 110 participants, 16 - 45 years • 13 Māori women • 8 Pacific women	After four days of dietary intake, under-reporters can be found using the Goldberg cut-off method, when EI:BMR ratio is below 1.49 (Goldberg et al., 1991)	• Māori and Pacific populations had higher rates of under-reporting than NZ European, in the 2008/09 NZANS • Fruit and vegetables are more likely to be over-estimated • Overweight and obese populations have shown more under-reporting than healthy weight populations, especially those with a BMI >25

Study	Dietary assessment method	Study design and participants	Participant exclusion criteria	Other considerations
New Zealand				kg/m^2
Effects of dairy intake on body weight and fat: a meta-analysis of randomized controlled trials (Chen, Pan, Malik, & Hu, 2012)	• Dairy group and number of servings per day, at baseline and intervention stages	• Meta-analysis of RCTs	One study were participants reduced 1673 kcal/day from their pre-intervention energy amounts. This diet was considered severely energy-deficient	
Reproducibility of food and nutrient intake estimates using a semi-quantitative FFQ in Australian adults (Ibiebele et al., 2009) Australia	• 135-item self-administered semi-quantitative FFQ	• 100 Australian participants, 22 - 79 years	• EI <500 or >3500 kcal/day • Left out answers to >10% of questions	EI cut-offs may be ethnicity specific
Self-administered semi-quantitative food frequency questionnaires: patterns, predictors, and interpretation of omitted items (Michels & Willett, 2009) USA	• 147-item self-administered semi-quantitative FFQ	• Nurses' Health Study II • 87,676 women, 25-42 years • Mostly of Caucasian ethnicity • From 14 US states	• Omitted >70 food or beverage items • EI <600 or >3500 kcal/day	• Self-administered FFQ items may be omitted because the participant had difficulty remembering the amount or frequency of consumption, the food was not consumed, or due to a blunder • When macronutrients were calculated as a percentage of EI, missing food items did not have a considerable effect • Only 4% of the 87,676 participants completed the entire FFQ, whereas 66% omitted at least one food item • <u>Higher likelihood of missing data with these participants:</u> ○ Older women ○ Higher physical activity ○ More children

Study	Dietary assessment method	Study design and participants	Participant exclusion criteria	Other considerations
				• <u>Dealing with missing data in the semi-quantitative FFQ:</u> ○ It is reasonable to assume zero intake, but this is generally not the case if the food is commonly eaten by the rest of the population ○ True intake of an omitted food was best estimated as 0.82 times the population average
Major dietary patterns in relation to general obesity and central adiposity among Iranian women (Esmaillzadeh & Azadbakht, 2008) Iran	• 168-item dietitian-administered semi-quantitative FFQ (Willett format)	• Cross-sectional study • 486 Iranian women, 40-60 years	• Omitted >70 items on the FFQ • EI outside 800–4200 kcal/day	
Dietary intakes of European, Māori, Pacific and Asian adults living in Auckland: the Diabetes, Heart and Health Study, 2008 (Metcalf et al., 2008) New Zealand	• 142-item self-administered FFQ	• Cross-sectional study • 4007 adults, 35-74 years • 562 Māori women • 508 Pacific women	• Those who failed to complete the FFQ • Under-reporting food intake was defined by the Goldberg cut-off method, when EI (in MJ) to Resting Metabolic Rate (RMR) was below 1.38	• It was least likely for Pacific women to underestimate dietary intake
A Large Randomized Individual and Group Intervention Conducted by Registered Dietitians Increased Adherence to Mediterranean-Type	• FFQ • A registered dietitian assessed the participants at baseline and after the trial. Assessment	• RCT • 1551 participants, 55-80 years • 828 Spanish women, 60-80 years, who were free of coronary heart disease but had at least one risk factor	• EI <500 kcal/day or >3,500 kcal/day	

Study	Dietary assessment method	Study design and participants	Participant exclusion criteria	Other considerations
Diets: The PREDIMED Study (Zazpe et al., 2008) Spain	included a 14-item questionnaire on adherence to the prescribed diet, and a 137-item semi-quantitative FFQ assessing dietary habits over the previous year			
Dietary patterns and changes in body weight in women (Schulze et al., 2006) USA	• 133-item self-administered semi-quantitative FFQ	• Nurses' Health Study II • 51,670 women, 26-46 years • Mostly of Caucasian ethnicity	• Failed to complete the dietary questionnaires • Omitted >9 food items • EI <500 or >3500 kcal/day • Failed to report body weight	
Food-frequency questionnaires: a review of their design, validation and utilisation (Cade, Burley, Warm, Thompson, & Margetts, 2004) 5 NZ studies included in the literature review	A variety of FFQs	NA	NA	• Using correlation coefficients, the strength of relationship between calcium and fat intake was the strongest, whereas the relationship between vitamin A and vegetables was the lowest
Food patterns measured by factor analysis and anthropometric changes in adults (Newby et al., 2004) USA	• Dietitian-instructed, weighed 7-d food records in 1994	• 459 healthy participants • Baltimore Longitudinal Study of Aging	• Failure to complete ≥ 4 days of dietary records • Improbable food group intake, defined by over 6 standard deviations from the mean for each food group • Measures of weight or height	

Study	Dietary assessment method	Study design and participants	Participant exclusion criteria	Other considerations
			were absent at baseline and follow-up	

Accuracy of dietary energy reporting in young New Zealand men and women: relationships to body composition, physical activity level and ethnicity (Rush, Plank, Laulu, Mitchelson, & Coward, 2004)
 	
New Zealand
	• Self-reported 7-day diet diaries	• 107 participants, 18-27 years
		• 12 Māori women
		• 27 Pacific women
		• Measuring TEE:
		  ○ Doubly-labelled water
		• Measuring RMR:
		  ○ Indirect calorimetry
		• Calculating BF percentage from total body water:
		  ○ ^{18}O dilution space, to find total body water
			• Average EI was reported as 77% of total energy intake, with no differences in gender, ethnicity, or obesity (except in obese European women)	• Participants underreported by 23%
				• PAL and BF percentage were negatively correlated in Māori women but not Pacific women. Hence, Māori women with higher activity levels were likely to under-report EI
				• Younger Māori and Pacific adults were more likely to under-report EI than older Māori and Pacific adults

Markers of the validity of reported energy intake (Livingstone & Black, 2003) America	A variety of dietary assessment methods were used to compare with EE measured by doubly labelled water: • Oxford FFQ • 24-hour recall • Block FFQ • Willett FFQ	-	• Values below the 95% cut-off limit of EI/BMR may be excluded. Goldberg et al. created a formula (the Goldberg cut-off) for finding the lower 95% confidence limit. Numerous studies have used it to find under-reporters. • EI and EE gap was > 3 SD (standard deviations). This study later found portion sizes were inappropriate, and the FFQ was unsuitable for the participants who completed it • EI/BMR < 1.14. Yet this resulted in over-estimates of participants with nutrient deficiencies	• Under-reporting EI usually indicates there's under-reporting of other nutrients • Under-reporting is more common in women, especially those with a high BMI • Under-reporting may be greater in those with high EE because they are likely to eat more (larger portion sizes, frequent meals, more food items). Thus, increasing the burden to record EI • It is more accurate to distinguish under-reporters among individual participants than across groups of participants. The Goldberg cut-off was devised to assess under-reporting at the group level, while Black et al. found that commonly used PAL of 1.55 only identifies ~50% of under-reporters (Black, 2000a) • Some studies included all data and instead

Study	Dietary assessment method	Study design and participants	Participant exclusion criteria	Other considerations
			• EI/BMR < 1.2. They later concluded it was preferable to adjust the EI values of the low energy reporters	adjusted EI values of the low energy reporters • Coefficient of variation for within-individual differences was 28.5% for FFQs, compared with 18.6% for diet histories and 16.5% for 3-day food records. Large random errors in dietary assessment are likely to have caused such poor precision with FFQ data • Precision of individual dietary assessment was poor, even when repeated measures showed significant correlation
Using intake biomarkers to evaluate the extent of dietary misreporting in a large sample of adults: The OPEN Study (Subar et al., 2003) USA	• 124-item, diet history, self-administered, semi-quantitative, FFQ • 5-pass, 24-hour recall	• 484 participants, 40-69 years • 223 women • 77.6% non-Hispanic white ethnicity • 61% of women were overweight or obese • Biomarkers for energy and protein assessed error in a FFQ and 24-hour recall	• Over- and under-reporters were defined by values above and below the 95% confidence interval of the log ratio of reported intakes to biomarker measurements, respectively	• Participants tend to underreport fat, CHO and alcohol, but not protein • Women underreported EI by 34–38% and protein intake by 27–32% on the FFQs • Participants with a higher intake and/or increased BMI tended to underreport more than those with lower intakes and/or lower BMI
Development, validation and utilisation of food-frequency questionnaires - a review (Cade, Thompson, Burley, & Warm, 2002) United Kingdom			• Papers combining FFQ results with other dietary assessment techniques; the focus of this review was on FFQs only • FFQs with a large percentage of incomplete questions. The particular percentage cut-off should be decided a priori and is determined by the strength of accuracy required • Schofield equations for EE did not match well with participant EI. Those with unfeasibly low EIs	• Correlation coefficients of 0.5 to 0.7 were common • Over-reporting was common with fruit and vegetables, especially if they were presented in a long list • Dealing with missing data in FFQs: ○ Exclude FFQs with a large percentage of incomplete questions. The particular percentage cut-off should be decided a priori and is determined by the strength of accuracy required ○ Where questionnaires do not exceed the cut-off for incompleteness, a zero value

Study	Dietary assessment method	Study design and participants	Participant exclusion criteria	Other considerations
			could be excluded	(food not eaten) may be used, or the population average substituted • Possible causes of under-reporting: ○ Grouping items • The expert consensus group agreed single items, rather than grouped items, were generally better because they helped distinguish similar food items from each other e.g. full cream milk versus trim milk. Furthermore, single items can later be grouped but grouped items cannot be separated • Possible causes of over-reporting: ○ Long lists of vegetables ○ Numerous food items in the FFQ ○ Options for consuming the food item more than once a day • Correcting for over-/under-reporting: ○ Cross-check questions – however these were most effective with fruit and vegetables ○ Weighting factors can correct for over-reporting and were applied to individual participants. However, using weighting factors makes the assumption that all food items have the same level of misreporting
Evaluation of under- and over-reporting of energy intake in the 24-hour diet recalls in the European Prospective Investigation into Cancer and Nutrition	• 24-hour dietary recall	• Cross-sectional analysis • 35,955 participants, 35-74 years • 22,924 women	• Extreme under-reporters and over-reporters had EI/BMR values of <0.88 and >2.72 respectively • The EI/BMR values were derived from Goldberg's study and included an aggregate PAL value	• Participants with a higher BMI tended to under-report more than those with a lower BMI • Women tend to under-report more than men • Older adults tend to under-report more than younger adults

Study	Dietary assessment method	Study design and participants	Participant exclusion criteria	Other considerations
(EPIC) (Ferrari et al., 2002) Europe			of 1.55 (Black, 2000a, 2000b; Goldberg et al., 1991)	
The role of low-fat diets in body weight control: a meta-analysis of ad libitum dietary intervention studies (Astrup, Grunwald, Melanson, Saris, & Hill, 2000)	• Self-reported dietary records (type not specified)	• 14 RCTs and 2 trials, both types >2 months • 1910 participants • 1247 women • Ad libitum low-fat diets compared with groups consuming their habitual diet or a medium-fat diet ad libitum diet	• Interventions <2 months • Iso-caloric diets • Restriction of total EI • Other interventions affecting weight loss • Participants taking weight-loss drugs and those with T2DM • No appropriate control group • Missing values for body weight and final dietary fat intake	• 11 of the 19 studies were not related to weight loss, regarding weight loss as an undesirable effect. This is likely to outweigh the number of participants who intentionally restricted EI to lose weight
Critical evaluation of energy intake using the Goldberg cut-off for energy intake : basal metabolic rate. A practical guide to its calculation, use and limitations (Black, 2000a) United Kingdom	• Not specified	• A variety of studies with a mix of gender and age groups	• Under-reporters have been found using the EI/EE ratio (EI to EE ratio) below 1.55 but this is best used for groups, not individuals • Rather than using a single cut-off point for groups, applying the EI/(BMR x PAL) ratio to individual participants determines whether their reported EI is appropriate for their EE. Thus, the Goldberg cut-off becomes irrelevant	• Applying the EI:(BMR x PAL) ratio is dependent on knowing energy requirements and EE • The EI/EE ratio of 1.55 only identifies 50% of under-reporters, ignoring those who may have high energy requirements. It is therefore essential to know the individual's PAL, to determine accurate energy requirements • Small studies (n<100) will ideally require measures of PAL, by using activity diaries or accelerometers. However, this makes the Goldberg cut-off irrelevant • Misreporting is strongly associated with obese participants and those who are dieting
Dietary patterns are associated with body mass index in multi-ethnic women (Maskarinec et al., 2000)	• 3-day measured food record • ~209-item, semi-quantitative, self-administered FFQ	• Cross-sectional study • 514 women • Different ethnicities including Caucasian, Chinese, Japanese,	• Incomplete data • Variables with irreparable skewness after logarithmic transformations	

Study	Dietary assessment method	Study design and participants	Participant exclusion criteria	Other considerations
Hawaii	• 24-hour recall • Short questionnaire on 10 soy food items	Native Hawaiian, Other • Pre-menopausal and post-menopausal		
Magnitude, determinants and impact of under-reporting of energy intake in a cohort study in Greece (Gnardellis, Boulou, & Trichopoulou, 1998) Greece	• 150-item, semi-quantitative, self-administered FFQ	• 9262 participants, 30-82 years 5378 women	• Under-reporting was defined by an EI lower than 1.14*BMR	• Under-reporting EI is at least twice that in over-weight individuals than in normal-weight individuals, especially in participants with lower education
Reproducibility and Validity of a Food Frequency Questionnaire in European and Polynesian New Zealanders (Metcalf, Swinburn, Scragg, & Dryson, 1997) New Zealand	• 142-item, semi-quantitative, self-administered FFQ • FFQ was compared with a 3-day food diary	• 176 participants, 40-65 years • 17 Māori participants • 35 Pacific Island participants	• Under-reporters were identified using EI/RMR ratios <1.55 (WHO criteria) and <1.38 (Goldberg et al. criteria)	• Under-reporting was more common than over-reporting because total EIs were 8% higher in Māori and 22% higher in Pacific participants for FFQ intakes compared to the 3-day food diaries • Under-reporting dietary intake, using the 3-day diary method, was more likely in obese Māori than obese Pacific • The FFQ was more suitable for European than Māori and Pacific participants: ○ Habitual EI was more commonly underestimated in Māori and Pacific than European, using the 3-day diary assessment method ○ Pacific participants were more likely to over-estimate their total EI in the FFQ

BF = Body fat; BMI = Body mass index; BMR = Basal metabolic rate; CHD = Coronary heart disease; EE = Energy expenditure; EI = Energy intake; FFQ = Food frequency questionnaire; NZ = New Zealand; NZANS = New Zealand Adult Nutrition Survey; PAL = Physical activity level; RCT = Randomised controlled trial; RMR = Resting metabolic rate; SD = Standard deviation; TEE = Total energy expenditure; T2DM = Type 2 diabetes mellitus; WHO = World Health Organization

2.6.2 Data processing

Once food nutrient profiles have been derived using Dietary assessment software, the data can be cleaned. Data cleaning helps reduce the workload burden for researchers by identifying - and possibly eliminating - the most obvious mis-reporters.

A commonly used method includes EI cut-off points, where participants with values over or under pre-specified ranges are eliminated or minimised in some way. EI cut-offs are a quick and easy way to eliminate obvious outliers, namely, participants who are likely to have misreported (Livingstone & Black, 2003). Most of the studies in Table 2.8 have excluded participants with EI above and below certain thresholds (Esmaillzadeh & Azadbakht, 2008; Ibiebele et al., 2009; Michels & Willett, 2009; Schulze et al., 2006; Vadiveloo et al., 2015; Zazpe et al., 2008). Table 2.9 sorts those studies into categories relating to the size of the EI range. Cut-offs for EI may be used independently or in conjunction with other exclusion criteria, such as the omission of participant data if some of their answers are missing (Astrup, Grunwald, Melanson, Saris, & Hill, 2000; Cade, Thompson, Burley, & Warm, 2002; Esmaillzadeh & Azadbakht, 2008; Ibiebele et al., 2009; Maskarinec et al., 2000; Metcalf et al., 2008; Michels & Willett, 2009; Newby et al., 2004; Schulze et al., 2006).

Expressing macronutrient intake as a percentage of total EI, and comparing ethnic differences between studies, can also help minimise the effect of possible over-/under-reporters (Metcalf et al., 2008). For example, there may be a trend of high carbohydrate intake in a particular ethnicity, across studies, which is not seen in the current study. Such results would probe the researcher to investigate further to find possible reasons for the discrepancy. To avoid bias in reporting dietary intake, Subar et al. (2003) used biomarkers: doubly-labelled water and urinary nitrogen to find participants' energy and protein intake, respectively. Biomarkers allow objective assessment of dietary intake and are therefore useful in validating the degree of error in dietary reports. Nonetheless, biomarkers can be onerous to collect, are specific to certain nutrients, and costly to analyse (Thompson, Subar, Loria, Reedy, & Baranowski, 2010). In Subar et al.'s (2003) study, the under- and over-reporters were defined by values above and below the 95% confidence interval of the log ratio of reported intakes to biomarker measurements. Using that cut-off, he found that women underreported EI by 34–38% and protein intake by 27–32% on the FFQs.

After general data cleaning, the less obvious over-/under-reporters are identified using population-specific processes, such as Goldberg cut-offs (Black, 2000a; Ferrari et al., 2002;

Houston, 2014; Livingstone & Black, 2003; Metcalf et al., 2008, 1997). This method requires participant EI and estimated EE values, with EE in the form of Resting Metabolic Rate (RMR) or Basal Metabolic Rate (BMR). Taking EE into account helps identify validity of the reported EI (Livingstone & Black, 2003). Numerous studies have used variations of the Goldberg method to assess under-reporting, where values below the 95% cut-off limit of EI/RMR may be excluded. Cut-off values may include EI/RMR <1.55 (Black, 2000a, Black, 2000b; Goldberg et al., 1991; Metcalf et al., 1997) or <1.38 (Metcalf et al., 1997; Metcalf et al., 2008). However, Black et al. found the commonly used value of 1.55 identifies only about 50% of under-reporters, especially if the population is highly active (Black, 2000a). This suggests Goldberg's cut-offs are rough guidelines, adjustable according to participants' energy requirements.

Similarly, there were studies which calculated participant EI and compared it with EE (Cade, Thompson, Burley, & Warm, 2002; Gnardellis, Boulou, & Trichopoulou, 1998; Rush t al., 2004). EI requirements are determined by many factors including PAL, gender, body composition and age. Fat free mass (FFM) is a strong determinant of RMR, accounting for roughly 80% of variation (Mahan, 2012; Metcalf et al., 1997). As Polynesians tend to have a greater FFM for any particular body size (Rush et al., 2009b; Rush et al., 2015), cut-off equations can be adjusted by applying the formula of Borgardus and Ravussin (Metcalf et al., 1997). This formula links RMR to FFM, accounting for differences in FFM between individuals of the same weight. Regardless, using BMR and RMR with a constant will never be as accurate as directly measuring participants' EE e.g. using activity diaries or heart-rate monitoring. Black (2000b) recommends that smaller studies measure individuals' EE to reduce inter-participant variation in activity levels (Black, 2000b).

Ultimately, researchers need to know why people misreport (Livingstone & Black, 2003). Only then can they devise the best ways of assessing or adjusting food and drink intake to produce the most accurate dietary data. For instance, many studies have found participants tend to over-report foods which are perceived to be healthy, through the concept of "social desirability bias" (MOH, 2011b). This is the tendency of participants to provide answers which they believe would be most socially acceptable but are not necessarily a reflection of their true thoughts, feelings, or behaviours, thus compromising study findings (Fisher, 1993; Klesges, Baranowski, Beech, Cullen, Murray, Rochon & Pratt, 2004; Nederhof, 1985). Foods such as fruit and vegetables (FAVs) are commonly over-reported, especially if the vegetables are presented in a long list (Cade, Thompson, Burley, & Warm, 2002). Similarly, overweight and obese participants are more likely to under-report their dietary intake (Black, 2000a; Gemming et al., 2014; Gnardellis, Boulou, & Trichopoulou, 1998; Houston, 2014; Subar et al., 2003), particularly of foods which are perceived to be unhealthy, such as biscuits, fats, cakes and desserts (MOH, 2011a, 2011b). Once trends like this have been discovered, adjustments can be made to data accordingly, thereby increasing the accuracy and therefore usability of dietary analysis studies. In this case, Fisher (1993) and Lusk & Norwood (2010) suggested that social desirability bias could be minimised by asking indirect questions.

Studies with EI cut-offs above/ below a certain range have been sorted into size categories (Table 2.9).

Table 2.9 Similar energy intake cut-offs

Study	Small range (kcal/day)	Medium range (kcal/day)	Extreme range (kcal/day)
Dietary Variety Is Inversely Associated with Body Adiposity among US Adults Using a Novel Food Diversity Index (Vadiveloo et al., 2015) Hispanic, non-Hispanic black, non-Hispanic white, and other women, aged ≥20 years	-	<400 and >7000 (6600)	-
2008/09 Adult Nutrition Survey NZ. Methodology Report for the 2008/09 New Zealand Adult Nutrition Survey (Gemming et al., 2014; MOH, 2011a, 2011b) Māori and Pacific women, aged >15 years. Actual EI, respectively	-	~300 to 6550 (6250)	~200 to 10170 (9970)
Reproducibility of food and nutrient intake estimates using a semi-quantitative FFQ in Australian adults (Ibiebele et al., 2009) Australian women, aged 22-79 years	<500 and >3500 (3000)	-	-
Self-administered semiquantitative food frequency questionnaires: patterns, predictors, and interpretation of omitted items (Michels & Willett, 2009) Mostly Caucasian women, aged 25-42 years	<600 and >3500 (2900)	-	-
Major dietary patterns in relation to general obesity and central adiposity among Iranian women(Esmaillzadeh & Azadbakht, 2008) Iranian women, aged 40-60 years	<800 and >4200 (3400)	-	-
A Large Randomized Individual and Group Intervention Conducted by Registered Dietitians Increased Adherence to Mediterranean-Type Diets: The PREDIMED Study (Zazpe et al., 2008) Spanish women, aged 60-80 years	<500 and >3500	-	-
Dietary patterns and changes in body weight in women (Schulze et al., 2006) Mostly Caucasian women, aged 26-46 years	<500 and >3500 (3000)	-	-

EI = Energy intake

2.6.3 Data analysis

Food data has been analysed in many different ways, depending on the purpose of the study and the type of data collected. Food data can also be analysed in relation to changes in body composition, such as in Brooking et al. (2012) and Dale et al.'s (2009) RCTs.

Brooking et al. (2012) and Dale et al. (2009) assigned Māori women (n=59 and n=30, respectively) to macronutrient-specific diets e.g. high protein (HP), high carbohydrate and high DF diet (HCHF), high MUFA, and controls. The women were encouraged and given advice on consuming macronutrients at a certain percentage of their EI. Afterwards, diet histories were analysed at various intervals to find EI and contribution of carbohydrate, DF, protein, total fat, SFA, MUFA, and PUFA. Participants also had anthropometric markers measured, to see if diets of different macronutrient composition would help reduce BW, BMI, WC, and BF percentage.

Tomisaka et al.'s (2002) cross-sectional study also analysed EI and macronutrient intake, to find if there was any correlation with BMI, BF percentage and WHR. However, instead of collecting data through a diet history, Tomisaka et al. (2002) used 3-day, 24-hour recalls and his participants were 200 Fijian women, rather than Māori. The benefit of 24-hour recalls is that they are less dependent on memory than diet histories, which often require a highly trained interviewer to ask non-probing questions about dietary intake over the past month (Gibson, 2005). Thus, 24-hour recalls can reduce the chance of overestimating intake in comparison to diet histories.

The NZANS also analysed participant food data using 24-hour recalls but only over one day, rather than three (MOH, 2011b). The NZANS recruited Māori (n=588) and Pacific (n=343) women aged >15 years (MOH, 2011b) and similarly, participants in the DHHS were Māori (n=562) and Pacific (n=508) women aged 35-74 years (Metcalf et al., 2008). Unlike Brooking et al. (2012) and Dale et al.'s (2009) RCTs, the NZANS and DHHS analysed participant dietary intake and body composition as separate measures. Therefore, interpretations could not be made about the effect of particular foods or macronutrients on anthropometry.

Nonetheless, instead of focussing solely on macronutrient intake, the NZANS and DHHS also analysed the women's micronutrient and food intake. The NZANS went one-step further than the other studies, by listing the top 10 foods contributing to particular macro-/micro-nutrients. For instance, bread (11.1%) was the highest contributor of protein intake in Māori women, yet poultry (12.4%) was the highest contributor of protein intake in Pacific women, followed by bread (10.8%). However, it must be noted that foods which are consumed in large amounts and by multiple participants (e.g. bread) are more likely to feature as the top contributors to nutrient intake than those foods which are consumed by fewer participants.

The 2014/15 NZHS was similar to the NZANS because the population group included Māori (n=1913) and Pacific women (n=518) and both weight and height were measured (MOH, 2015a). Although the 2014/15 NZHS is more recent than the 2008/09 NZANS and included more participants, the NZHS only analysed participant's fruit and vegetable intake. In comparison, the NZANS analysed a plethora of different food groups, macronutrients, micronutrients, and percentage contribution of foods to particular macro-/micro-nutrients (MOH, 2011a). Therefore, the NZHS was missing a range of dietary factors, which may have contributed towards changes in body composition and overall health.

Table 2.10 shows that red and processed meat were eaten slightly more frequently by Māori than Pacific women, whereas chicken and fish were eaten almost twice as frequently by Pacific than Māori women (Metcalf et al., 2008; MOH, 2012a). Intakes are represented as SSE of foods in each food group, as outlined in the Eating and Activity Guidelines for New Zealand Adults (EAGNZA) (MOH, 2015b).

Daily/ weekly SSE of food consumed by Māori and Pacific women in comparable NZ studies (Table 2.10).

Table 2.10 Food intake of Māori and Pacific women in New Zealand

Food group	Recommended SSE[1] of foods, in each food group	Māori women		Pacific women		
		DHHS[2]	NZANS[3]	DHHS[2]	NZANS[3]	DPRF[4]
Mean SSE per week:[5]						
Red meat	2 x weekly	7.09	3	7	2.70	
Chicken		1.40	~2.17	2.58	~2.67	
Fish	≥2 per week fish	2.70		4.51		
Processed meat			~1.92		~1.75	
Mean SSE per day:[6]						
Vegetables	≥3 vegetables per day	4.37	~2.67	4.55	~2.41	
Vegetables, ≥3 SSE (%)		79.9%	59.1%	79.3%	49.1%	48.3%
Fruit	≥2 fruit per day	2.37	~1.92	2.88	~1.98	
Fruit, ≥2 SSE (%)		42.0%	56.9%	44.5%	62.2%	61.1%
Eggs (number eggs)		0.418		0.477		
Cheese (excludes low fat)	≥2 SSE milk and milk products per day (mostly low and reduced fat)	0.286		0.128		
Milk (cups)	≥2 SSE milk and milk products per day (mostly low and reduced fat)	1.46		1.31		
Bread (slices)	≥6 grain foods per day (wholegrain varieties)	0.885	~2.91	1.01	~3.10	
Breakfast cereal	≥6 grain foods per day (wholegrain varieties)	0.490		0.329		

DHHS = Diabetes, Heart and Health Study; DPRF = Dietary Patterns and Risk Factors study; EAGNZA = Eating and Activity Guidelines for New Zealand Adults; NZANS = New Zealand Adult Nutrition Survey; SSE = Standard serving equivalents

1. SSE of foods in each food group, as outlined in the Eating and Activity Guidelines for New Zealand Adults (MOH, 2015b)
2. 2008 DHHS: Participants were Māori (n=562) and Pacific (n=508) women aged 35-74 years (Metcalf et al., 2008)
3. 2008/09 NZANS: Participants were Māori (n=588) and Pacific (n=343) women aged >15 years (MOH, 2011a)
4. 2002 DPRF: Participants were Pacific/ Fijian women (n=200) aged 30-39 years (Tomisaka et al., 2002)
5. Monthly intakes were converted to weekly intakes by dividing the value by 4.3 (average number of weeks in a month)
6. Monthly intakes were converted to daily intakes by dividing the value by 30.4 (average number of days in a month)

Fruit and vegetables (FAVs) eaten per day were relatively similar between Māori and Pacific women within the separate studies, but were considerably higher in the DHHS women compared with those in the NZANS (Metcalf et al., 2008; MOH, 2012a). FAV intake was at least 20% and 40% higher (respectively) in the DHHS. The EAGNZA recommend consuming at least 2 SSE of fruit and 3 SSE of vegetables per day (MOH, 2015b). With average SSE, Māori and Pacific women in the NZANS fell just short of this mark, whereas women in the DHHS had at least 1 SSE more of vegetables and at least 0.37 SSE more of fruit than the minimum recommendation.

At least 20% of Māori and Pacific women fell short of the recommended SSE of vegetables (≥3 SSE) and at least 38% fell short of the recommended SSE of fruit (≥2 SSE). Between ethnicities, a higher percentage of Māori women met recommended SSE of vegetables than Pacific women (Metcalf et al., 2008; MOH, 2012a), yet a higher percentage of Pacific women met the recommended SSE of fruit (Metcalf et al., 2008; MOH, 2012a).

The NZANS results were similar to Dietary Patterns and Risk Factors study (DPRF) results. For instance, 49.1% and 48.3% of Pacific women consumed ≥3 SSE of vegetables per day in the NZANS and DPRF, compared with 79.3% in the DHHS. This suggests the NZANS and DPRF may be more representative of Māori and Pacific women's diets than the DHHS. However, the DHHS provided data on Māori and Pacific women that was not available in the NZANS, such as SSE of cheese per day. The DHHS show Māori women had a 45% higher intake of cheese than Pacific women (Metcalf et al., 2008). This is considerable because cheese can be a significant source of fat, protein and calcium (Walther, Schmid, Sieber, & Wehrmüller, 2008).

Regarding grain foods, bread intake was similar between Māori and Pacific women but consumption of breakfast cereal was 33% higher for Māori (Metcalf et al., 2008). There are numerous studies relating consumption of breakfast to weight maintenance and a lower BMI (Cho, Dietrich, Brown, Clark, & Block, 2003; Odegaard, Jacobs, Steffen, Van Horn, Ludwig, & Pereira, 2013), especially the consumption of breakfast cereal (Cho et al., 2003; Deshmukh-Taskar, Radcliffe, Liu, & Nicklas, 2010).

Overall, results from the DHHS are higher than for the NZANS (Metcalf et al., 2008; MOH, 2012a). This discrepancy could be due to the way data was extracted from the study. NZANS results were presented in a format which showed the percentage of participants who ate specific SSE of food (MOH, 2012a). Instead of using percentages, the DHHS presented their results in SSE per month, which were easily converted to weekly, then daily SSE for analysis

(Metcalf et al., 2008). Results extracted from the NZANS may not be very precise because assumptions were made to ensure the NZANS data was comparable with the DHHS data. For instance, if the frequency of eating red meat in the past 4 weeks was 1-2 times, this would be entered as 1.5 times per week, then converted to daily SSE. Regardless, trends can be seen which are also apparent in the other two studies.

Daily intake of energy, macronutrients and micronutrients among Māori and Pacific women in comparable NZ studies (Table 2.11).

Table 2.11 Daily nutrient intake of Māori and Pacific women in New Zealand

Nutrient and unit of measure	Reference value[1]	Māori women		Pacific women		
		NZANS[2]	DHHS[3]	NZANS[2]	DHHS[3]	DPRF[4]
Energy intake, KJ		8011	9600	8355	10300	9460
KJ from fat, %	20-35[5]	35.4	34.3	34.1	33.4	33
Total fat, g		76	89	76.7	93	
KJ from saturated fat, %	<10[5]	14.3	12.7	13.5	12.9	
Saturated fat, g	<20	30.8	33	30.6	36	
KJ from carbohydrate, %	45-65[5]	47.5	49.9	49.0	51.3	52
Carbohydrate, g		231	282	241	311	
Starch, g			136		154	
Sugar (sucrose), g		116 (61.4)	(58)	112 (57.1)	(63)	
Fibre, g	22-25[6] (28[8])	16.1 *Mean*	26 *Geo. mean*	16.9 *Mean*	28 *Geo. mean*	
KJ from protein, %	15-25	15.7	15.9	16.3	17.8	16
Protein, g	35-37 (0.62-0.60g/kg)[7]	74.7	90	78	108	
Ca, mg	840-1050[7] (2500[9])	729	796	653	800	710
Fe, mg	8[7] (45[9])	9.77		10.4		15
Prevalence low Fe stores, % (serum ferritin <12μg/L)		27.6		26.7		
Zinc, mg	6-6.5[7]	9.43		10.9		
Selenium, μg	50[7]	50		52.1		
Retinol, μg retinol equivalents (RE)	485-500[7] (1220[8])	669		622		400 (did not specify RE)
Carotene, μg	5000[8]	2022		1821		5430
Vitamin B12, μg	2.0[7]	3.9		3.9		
Vitamin B1, mg	0.9[7]	1.2		1.2		1.1
Vitamin B2, mg	0.9[7]	1.7		1.5		1.4
Niacin, mg	11[7]	32.1		33.1		20
Vitamin C, mg	28-30[7] (190[8])	87		92		160

AI = Adequate Intake; AMDR = Acceptable macronutrient distribution range; DHHS = Diabetes, Heart and Health Study; DPRF = Dietary Patterns and Risk Factors study; EAR = Estimated Average Requirement; EI = Energy intake; MOH = Ministry of health; NHMRC = National Health and Medical Research Council; NRVs = Nutrient reference values; NZ = New Zealand; NZANS = New Zealand Adult Nutrition Survey; SDT = Suggested dietary target; UL = Upper Level of Intake

1. NRVs for Australia and NZ (NHMRC, 2006)
2. 2008/09 NZANS: Participants were Māori (n=588) and Pacific (n=343) women aged ≥15 years (MOH, 2011a)
3. 2008 DHHS: Participants were Māori (n=562) and Pacific (n=508) women aged 35-74 years (Metcalf et al., 2008)
4. 2002 DPRF: Participants were Pacific/ Fijian women (n=200) aged 30-39 years (Tomisaka et al., 2002)
5. AMDR for adults. Macronutrients are expressed as a percentage of EI, in KJ (NHMRC, 2006)
6. AI for women ≥19 years (NHMRC, 2006)
7. EAR for women ≥19 years (NHMRC, 2006)
8. SDT for women ≥19 years (NHMRC, 2006)
9. UL for women ≥19 years (NHMRC, 2006)

2.7 Nutrient intake of Māori and Pacific women

Table 2.11 shows the average EI of Pacific women was higher than Māori women by 344 KJ and 700 KJ in the NZANS and DHHS, respectively (Metcalf et al., 2008; MOH, 2012a). However, the percentages EI from carbohydrate, protein and fat were all very similar between ethnicities (Metcalf et al., 2008; MOH, 2012a; Tomisaka et al., 2002). This could be the result of Pacific women consuming more servings of food per month, usually of larger portion sizes, as shown in the DHHS (Metcalf et al., 2008).

Macronutrient intakes were within the AMDR, apart from total fat, which Māori women exceeded by 0.4% in the NZANS (MOH, 2012a). Percentage EI from fat should be between 20-35% of total EI (NHMRC, 2006). However, both Māori (~35%) and Pacific women (~34%) were consuming fat at the upper end of the AMDR (Metcalf et al., 2008; MOH, 2012a; NHMRC, 2006; Tomisaka et al., 2002). Furthermore, SFA should be <10% of EI but both Māori and Pacific women exceeded this limit by >2.7% and >2.9%, respectively (Metcalf et al., 2008; MOH, 2012a). SFA is the most concerning type of fat because it has been related to increasing CHD risk (Mozaffarian, Micha, & Wallace, 2010; NHMRC, 2006).

Significant contributors to SFA include meat fat, chocolate, cakes, desserts, milk and cheese (MOH, 2015b). In the NZANS, Māori and Pacific women were equally likely to remove fat from meat (48.2%), use light or reduced fat margarine (~20%) and eat takeaways ≥3 times per week (~18.5%) (MOH, 2012a). Although Māori women were 5% more likely to drink reduced fat, skim, or trim milk than Pacific women, they were also 6.5% more likely to eat lollies, sweets, chocolate and confectionery ≥3 times per week, and have 123% more cheese per day (MOH, 2012a). Furthermore, 21.3% of Māori participants ate larger than standard serving sizes of cakes or desserts in the DHHS compared with 15.4% of the Pacific participants (Metcalf et al., 2014).

Dissimilar to fat, carbohydrate intake was at the lower end of the AMDR. Percentage EI from carbohydrate was no more than 4.9% and 7% above the lowest AMDR value in Māori (~49% of EI) and Pacific women (51% of EI), respectively (Metcalf et al., 2008; Tomisaka et al., 2002). Furthermore, 50% and 46% of the carbohydrate was sugar (MOH, 2012a). However, this included all types of sugar, such as the sugar within foods like fruit and vegetables. Sucrose (commonly known as table sugar) makes up at least 20% of carbohydrate consumed in the diets of both Māori and Pacific women (Metcalf et al., 2008; MOH, 2012a). As a percentage of total EI, sucrose makes up ~10% (Metcalf et al., 2008), yet the WHO recommend ≤10% of total EI is from added sugars (NHMRC, 2006).

When comparing mean intake, both Māori (16.1g) and Pacific women (16.9g) consumed at least 5g lower than the AI, in the NZANS (MOH, 2012a; NHMRC, 2006). Dissimilarly, Māori and Pacific women in the DHHS were exceeding the AI of 25g per day, by 1g and 3g (Metcalf et al., 2008). Perhaps the difference in DF intake, between studies, is due to using a geometric mean for DHHS data, versus using an arithmetic mean, as seen in NZANS data. Alternatively, a greater intake of DF could be the outcome of DHHS participants consuming more fruit and vegetables (FAVs) than the NZANS participants (Metcalf et al., 2008; MOH, 2012a). This explanation is feasible considering most FAVs are high in DF, contributing 12% and 16% to overall DF intake, in the NZANS (MOH, 2012a).

Like carbohydrates, protein intake was consumed at the lower end of the AMDR for both Māori (~16%) and Pacific women (~17%) (Metcalf et al., 2008; MOH, 2012a). Nonetheless, Māori and Pacific women still obtained adequate iron, zinc, vitamin B12, Vitamin B2, and Niacin (MOH, 2011a). All of these are rich in protein foods, such as meat (NHMRC, 2006).

It is also surprising that Māori and Pacific women met the EAR (50µg) for selenium because NZ soils are particularly low in this mineral (Thomson, 2004). However, they consumed at least 2.7 SSE of fish, 1.4 SSE chicken and 2.9 SSE eggs per week, which are the main sources of selenium in NZ (NHMRC, 2006).

Finally, intake of vitamin C was 87mg in Māori and 92mg Pacific women (MOH, 2011a). This exceeded the EAR (30mg) by 57mg and 62mg, respectively. Perhaps this is because vitamin C is widely abundant in FAVs, particularly kiwifruit, citrus fruit, guava, broccoli and blackcurrants (NHMRC, 2006).

2.8 Summary

Table 2.4 shows Māori and/or Pacific women were obese in 11 studies and overweight in 3, with Pacific BMI between 7.4-12.5% higher than Māori women. None of the Māori or Pacific women had a normal BMI (18.5-24.9 kg/m^2). However, few used sophisticated measuring equipment, such as the Bodpod and DXA. Instead, many findings were based on BMI, which does not always demonstrate reliable predictions of BF percentage between different ethnicities.

Although macronutrients were all consumed within the AMDR, fat was skewed towards the top-most value, with SFA exceeding the 10% EI limit. Fat has the highest calorific value of all the macronutrients, with each gram of fat equating to 9 kcal of energy compared with the 4kcal/gram for carbohydrate and protein. Intake of carbohydrate and protein were skewed towards lower values in the AMDR. Furthermore, the types of carbohydrate were at least 46% simple sugars (24% and 27% EI sucrose in Māori and Pacific women), rather than complex carbohydrates such as those found in wholegrains.

Māori and Pacific women met the EAR and AI of most micronutrients except for DF, calcium and carotene. Low intake of DF may be due to high inadequacy of fruit and vegetables (FAVs) and low intake of complex carbohydrates. Calcium intake was 44mg lower than the EAR in Māori women and 40mg lower in Pacific. Carotene intake was 2978µg and 3179µg lower than the suggested dietary target (SDT) of 5000µg. Foods rich in carotene are vegetables, vegetable oils, particularly the dark, green, leafy vegetables and orange-/red-coloured FAVs (NHMRC, 2006).

High intake of red meat and low intake of dairy may be reflective of high SFA and low calcium intake, respectively. Red meat was consumed above the 2 SSE/week recommendation by 1-5 SSE and only 48.2% of Māori and Pacific women removed fat from meat. Regarding high-calcium foods, daily SSE of dairy appeared to be 1.7 and 1.4, in Māori and Pacific women. Although this is below the 2 SSE/day recommendation, the count only included milk and cheese, which may have underestimated SSE of dairy food because foods such as yoghurt were not included.

As well as analysing the spread of macronutrient intake and SSE in comparison with the guidelines, it may also be beneficial to assess links between the types of foods most commonly consumed by those with a higher BF percentage compared with those with a lower BF percentage. The majority of findings on Māori and Pacific women were based on dietary intake and/or body composition as separate entities. None specifically explored relationships between their dietary intake and BF percentage. Investigating this relationship may highlight specific foods that are contributing to adverse BF percentage. Once these pathways are established, tailored dietary solutions can be mediated with Māori and Pacific women, to address the high rate of obesity. A multidisciplinary approach may need to be implemented because nutrition knowledge alone has not been a strong predictor of healthful behaviour (Bell et al., 1997).

3.0 Materials and methods

3.1 The women's EXPLORE study

New Zealand European, Māori, and Pacific women were recruited for the women's EXPLORE (EXamining Predictors Linking Obesity Related Elements) study. The study was a cross-sectional analytical design, investigating predictors of body composition (Kruger et al., 2015). Taken into account were participants' diet, physical activity, risk of metabolic disease, and levels of miRNA (micro ribonucleic acid) expression. It was hypothesised that participants with "hidden fat" (normal BMI and high BF percentage) would be at a higher metabolic risk than those who may have a high BMI and low BF. Additionally, that women could modulate the expression of particular miRNA (those associated with energy expenditure and storage) through their dietary and physical activity patterns, thus predicting particular body compositions. Further details on the women's EXPLORE study protocol can be read elsewhere (Kruger et al., 2015).

3.2 Study design

This study was a sub-study of the women's EXPLORE study, which investigated dietary intakes of all the Māori and Pacific women in relation to their body composition. Dietary intake was estimated using a FFQ and body composition was analysed by air displacement plethysmography. It was hypothesised that participants with excessive energy intake, including consumption of energy-dense and nutrient poor foods (e.g. sugar-sweetened beverages and takeaways), would have adverse body compositions, unfavourable to health.

3.3 Ethics

The study protocol was reviewed and accepted by the Massey University Human Ethics Committee: Southern A, Reference No. 13/13.

3.3.1 Ethical matters

Many ethical principles were taken into account, including (but not limited to) respect for persons, minimisation of harm, informed and voluntary consent, respect for privacy and confidentiality, avoidance of conflict of interest, social and cultural sensitivity, and justice. Examples are given, as follows:

Before commencing data collection (section 3.5.2), participants were provided with an information sheet on the study and encouraged to ask questions for clarification. Afterwards, they were invited to give written consent for participating in the study. Participants were also reminded they could withdraw from the study at any time, with no consequences of any kind.

To protect the privacy of participants, they were assigned unique number identifiers, rather than names, addresses, or other information which could be traced back to them. Data was kept in locked cabinets and computer files were protected by passwords. Researchers were only issued data they specifically needed for their study, attached to the unique number identifiers.

Cultural sensitivity was expressed when researchers asked participants if they were able to touch their head for height measurements, using a Stadiometer. The head is tapu (sacred) to Māori people, so it is respectful to ask for permission. Sensitivity was also expressed regarding body image, where separate rooms were provided for participants to have privacy when removing items of clothing, for procedures such as BodPod measurements. This requires minimal clothing, to reduce error caused by the trapped air.

Afterwards, participants were entitled to information obtained about themselves, such as their BF percentage. Participants can then be assessed and, if necessary, treated by health professionals, should they choose to disclose their body composition and/or dietary data.

3.4 Participants

All of the Māori (n=84) Pacific (n=91) participants from the women's EXPLORE study were included in this sub-study. Power calculations from the women's EXPLORE study found that the sample sizes were sufficient to provide 80% power at significance levels of $p < 0.05$ (Kruger et al., 2015). Participants were recruited from Massey University's Albany Campus and throughout Auckland via researchers' friends, colleagues, clubs, groups and various other organisations. Recruitment included communication through telephone calls, emails, pamphlets, and face-to-face interactions. Following recruitment, participants were prompted to complete an online screening questionnaire. The questionnaire determined eligibility, based on specific inclusion and exclusion criteria. Included, were women who were healthy, post-menarcheal and pre-menopausal, between 16-45 years old, living in Auckland, NZ. Exclusion criteria included women who were pregnant, lactating, trying to lose/gain weight, and diagnosed with chronic disease or illness, especially illness of metabolic consequence (e.g. type 2 diabetes mellitus). Those eligible, according to the online screening questionnaire, were invited to participate in on-site screening (Section 3.5.1). Following on-site screening was data collection, as explained in Section 3.5.2 below.

3.5.1 Screening

Simple anthropometric measures were taken from recruited participants, at Massey University's Albany Campus, in the Human Nutrition Research Unit. Trained research assistants measured participant height with a Stadiometer, using international standards for anthropometric assessment (Marfell-Jones, Stewart, & de Ridder, 2006). Following, they measured participant weight with a bioelectrical impedance analysis scale (Biospace, Inbody 230, Cerritos, CA, USA). Lastly, body mass index (BMI) was calculated using the following equation: weight (kg)/ height (cm)^2.

3.5.2 Data collection

Participants arrived at Massey Human Nutrition Research Unit between 7am and 9:45am, to complete consent forms, health questionnaires, and approximately two hours' worth of tests. For purposes of this sub-study, the following anthropometric and dietary data was used: weight, height, WC, hip circumference, BF percentage (from air displacement plethysmography air displacement plethysmography) and the type / amount / frequency of food intake over the past month.

3.5.2.1 Anthropometric measurements

Trained researchers, using International standards for anthropometric assessment protocol (Marfell-Jones et al. 2006), obtained the anthropometric results: weight, height, waist circumference, hip circumference, and BF percentage. BF percentage was measured using an air displacement plethysmography (ADP) machine, the BodPod (2007A, Life Measurement Inc, Concord, Ca., using software V4.2+ as supplied by the manufacturer). ADP is a more sophisticated, reliable and valid method of assessing BF percentage compared with BIA (Noreen & Lemon, 2006; Wingfield et al., 2014). Yet it requires multiple preliminary procedures: no drinking, eating or exercising two hours prior to assessment, an empty bladder, only tightly-fitted clothing, and removal of any metal (e.g. jewellery). Wearing tight-fitted clothing and a swimming cap minimised errors in body volume, which would be caused by air trapped in clothing and hair. Furthermore, lung volume was calculated by measuring the airway and chamber pressures, as the participant breathed into a disposable tube.

3.5.2.2 Dietary assessment

Participants completed the validated, 220-item, self-administered, semi-quantitative NZ women's food frequency questionnaire (NZWFFQ) (Houston, 2015) (See Appendix 1) online, at the Massey Human Nutrition Research Unit. The FFQ was validated on Māori and Pacific women, 16-45 years, living in Auckland, NZ. The NZWFFQ assesses participant dietary intake over the previous month and has been adapted from the 1997/98 NZANS (Houston, 2015). Included, are typical NZ foods as well as traditional Māori and Pacific foods, such as Rewena bread and taro, respectively. With each food, participants chose a frequency ranging from “Never” to “4+/day”, or to “7+/day”. Amounts of food were based on standard serving equivalents (SSE), for analysis. SSE are needed because portion sizes can vary between individuals and on a day-to-day basis, but serves are consistent and measured amounts of particular foods (Daggett & Rigdon, 2006). SSE of foods are outlined in the EAGNZA (MOH, 2015b). Where SSE were not defined in the EAGNZA, SSE sizes were sourced from Australian Dietary Guidelines (AGDH, 2015). For decisions regarding SSE, refer to Appendix 2.

3.5 Procedures

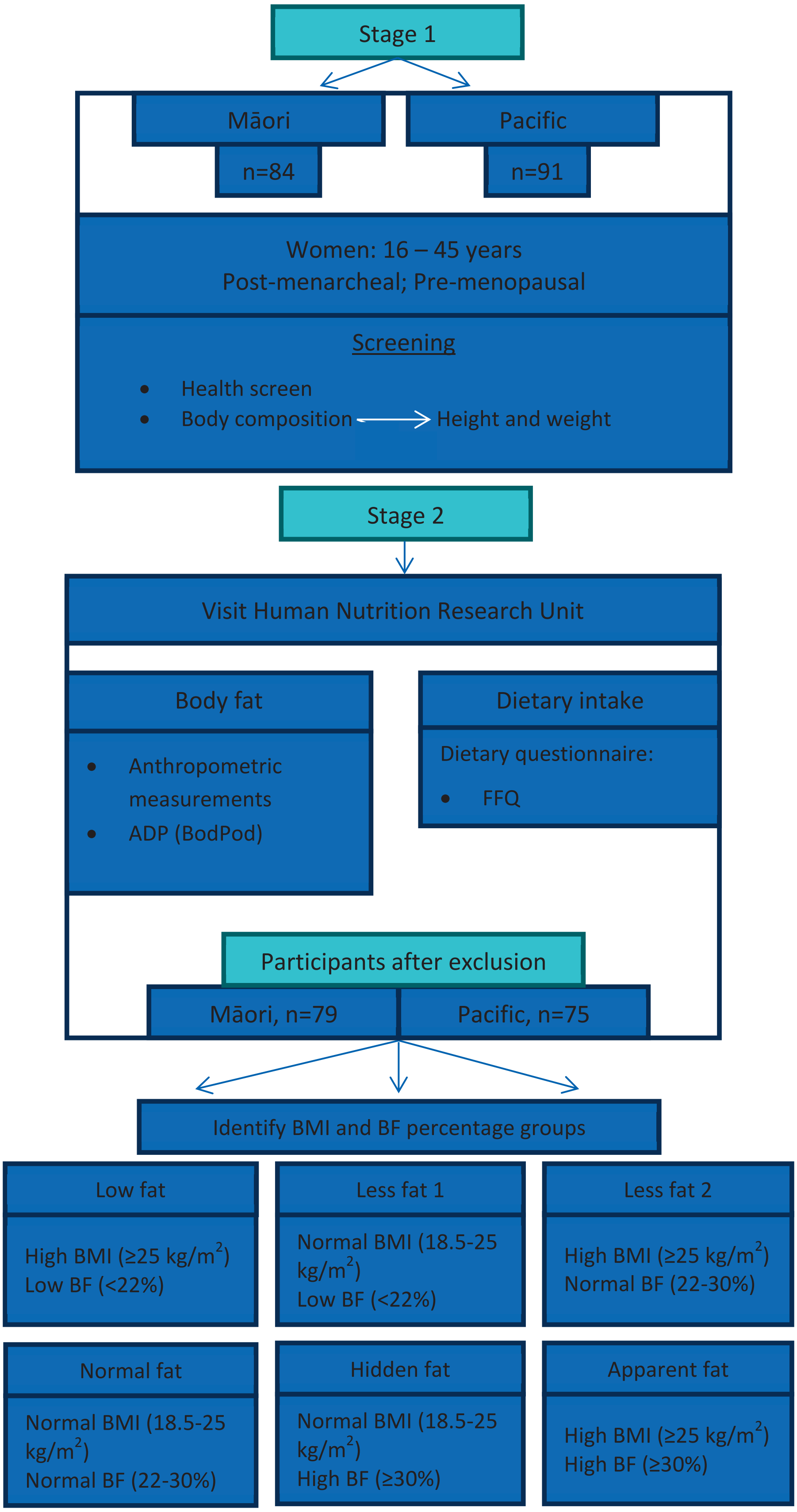

Figure 3.1 Study design and procedures.

3.6 Data processing

3.6.1 Dietary assessment software

Questionnaire data was processed in FoodWorks 8, 2015 (Xyris Software (Australia) Pty Ltd, Queensland, Australia), which utilises NZ FOODfiles 2014 (developed by the NZ Institute for Plant & Food Research and the NZ MOH) as the reference food composition database (FoodWorks Professional, 2016). Researchers cross-checked data within FoodWorks, to help increase accuracy. Afterwards, data was extracted from FoodWorks 8 and converted to daily equivalent frequencies (Table 3.1).

Table 3.1 Processing extracted food frequencies, for data analysis

Frequency (most food)	**Average frequency**	**Daily frequency**
Never	0m	0.00
<1x/month	0.25m	0.01
1-3x/month	2m	0.07
1x/week	1w	0.14
2-3x/week	2.5w	0.36
4-6x/week	5w	0.71
Once/day	1d	1.00
2-3x/day	2.5d	2.50
≥4x/day	4d	4.00
Frequency (Butter, Margarine or Spreads)	**Average frequency**	**Daily frequency**
Not applicable	0d	0.00
<1x/day	0.25d	0.25
1-2x/day	1.5d	1.50
3-4x/day	3.5d	3.5
5-6x/day	5.5d	5.5
≥7/day	7d	7
Frequency (Fats and Oils used for Cooking)	**Average frequency**	**Daily frequency**
Not applicable	0w	0.00
<1x/week	0.25d	0.07
1-3x/week	1.5w	0.21
4-7x/week	5.5w	0.79
8-10x/week	9w	1.29
11-14x/week	12.5w	1.79
≥15/week	15w	2.14
Frequency (Protein supplements)	**Average frequency**	**Daily frequency**
3x/week	3w	0.43
4x/week	4w	0.57
Other		
	0.5d	0.5
	2w	0.29
	7.5w	1.07

3.6.2 Exclusion criteria

Participants were excluded from the study if their data met the criteria outlined below:

- Incomplete or missing dietary data
- Over-reporting of EI (>27,000 KJ), based on the highest reported EI value for Māori women in the NZANS (MOH, 2011b)
- Under-reporting of EI (<4200 KJ), based on criteria for questionable data in the NZANS: participants were asked to clarify their intake when it revealed <4200 KJ (MOH, 2011b)
- Participants with EI <4200 KJ also had a reported EI below their BMR, calculated using Schofield equations (Schofield, 1985). BMR is the energy required at rest, for essential, involuntary functions, such as breathing.
- Unrealistic dietary intake e.g. 1990 grams of protein, >10 SSE of vegetables, >28 SSE of meat per day
- Unrealistic patterns reported in the FFQ e.g. selects "4+/day" for every food in the food group(s)

3.6.3 Food groups

FoodWorks 8 food groups were different to the food groups created for analysis and for comparison with similar studies, namely the Eating and Activity Guidelines for New Zealand Adults (EAGNZA). There were 22 food groups in the FFQ (those entered into FoodWorks 8) and up to 27 groups were created for analysis. To view the disaggregated list of food groups, see Appendix 3.

Decisions regarding food groups included creating some discretionary food groups. Discretionary foods were those concentrated in sugar and/or fat, with little or no nutritional benefit e.g. SSB. The discretionary food groups branched from the main food groups e.g. SSB were separated from the 'Drinks' group, to establish which SSE of fluid had included some form(s) of added sugar e.g. fruit drinks, flavoured water, carbonated or fizzy drinks, cordial, powdered drinks, energy drinks, and sports drinks.

The 'Miscellaneous' group was split into 'Discretionary savoury snacks' and 'Discretionary sweet snacks', allowing comparison with results from the 2008 DHHS and the 2008/09 NZANS, where Māori women were found consuming more sweet snacks (lollies, sweets, chocolate, confectionary and desserts) than Pacific women (Metcalf et al., 2008; MOH, 2011).

‘Supplements providing energy’ was a food group used in the NZANS. It included meal replacements and protein supplements, such a as protein powders and bars. Only two Māori participants consumed food from this group, as protein powder and a protein shake.

“Juice,grapefruit,sweetened” is sparkling grape juice, which has no alcohol content. Hence, it was moved from the ‘Alcohol’ group to the ‘SSB’ and ‘Fluids’ groups in the Analysis and EAGNZA tables, respectively. Similarly, Avocados were in the ‘Vegetable’ group of the FFQ, yet it is scientifically classified as a fruit. Hence, avocados were moved to the ‘Fruits’ group, for analysis and comparison with fruit intake of participants in other studies.

Additionally, some foods were entered into FoodWorks 8 as a list of separate ingredients. These foods were converted into a single entry, with respect to their weight, SSE (discussed in section 3.6.4) and nutrient make-up. Examples include Indian takeaway food, which had a three-part entry in FoodWorks 8: “Butter chicken curry”, “Basmati rice”, and “Naan bread” (see Appendix 4).

3.6.4 Standard serving equivalents

Quantities of each food were converted into SSE (see Appendix 2), outlined in the Eating and Activity Guidelines for New Zealand Adults and Australian Dietary Guidelines (MOH, 2015b; AGDH, 2015). Daily SSE of food were calculated by multiplying total SSE by the Daily Frequency of consumption. These values were entered into pivot tables, separate for Māori and Pacific women. The pivot tables displayed daily SSE of food group totals, in a visual and simple way, which enabled calculation of group means.

3.7 Data analysis

Throughout analysis, Māori and Pacific data were kept separate. Where relevant, comparisons were made between Māori and Pacific women regarding body composition and dietary intake. All data was entered into the Windows statistics programme SPSS 21.0 (SPSS Inc., Chicago, IL). Anthropometric measures (Tables 4.1) and daily macro-/micro-nutrients (Tables 4.2 and Table 4.3, respectively) were tested for normality. Consequently, appropriate measures were reported e.g. the mean (95% confidence interval) and median [25th - 75th percentiles]. In contrast, the central limit theorem was applied to daily SSE of food and food groups because the requirement of n=≥30 was met. With this assumption of normality, means ± standard deviation (SD) were reported for daily SSE of food and food groups.

The top twenty foods, by weight and by frequency, were found through ordering average intake: from heaviest to lightest and most frequent to least frequent, respectively. Food groups were highlighted in different colours, to better illustrate the spread of intake.

Next, foods with the highest contribution towards overall intake of energy, protein, fat, SFA, carbohydrate, and added sugar were calculated. Again, discretionary foods groups (such as SSB and takeaways) were highlighted in different colours, to emphasize their significant contribution.

There is no agreement in the literature regarding a BF percentage cut-off to define obesity (Romero-Corral, et al., 2008; Gallagher, Heymsfield, Heo, Jebb, Murgatroyd & Sakamoto, 2000; WHO, 1995). Proposed cut-off points for obesity among women ranged between 30-37% BF (Oliveros et al., 2014). Hence, a relatively central value of 35% was chosen to separate Māori and Pacific women into lower (<35%) versus higher (≥35%) BF percentage groups. With a BF percentage cut-off at 35%, roughly half of the Māori (51.9%) and Pacific women (62.7%) were placed in the higher (≥35%) BF percentage group, leaving the other half in the lower (<35%) BF percentage group. Consequently, this allowed for investigation of any statistically significant differences (p=<0.05) in consumption of energy, macronutrients and food between the two BF percentage groups.

Further processing was done in order to format the study data in a way which was comparable with similar data in literature. For instance, bread types were further disaggregated into categories of white, high-DF white, light/heavy grain, and other. This enabled comparison with intake of Māori and Pacific women from the NZANS.

4.0 Results

4.1 Participants

Participants recruited were 84 Māori and 91 Pacific women, aged 16-45 years, living in Auckland, NZ. Of these participants, 79 Māori and 75 Pacific were included in data analysis. Several participants were excluded/ included from analysis, as explained in Figure 4.1.

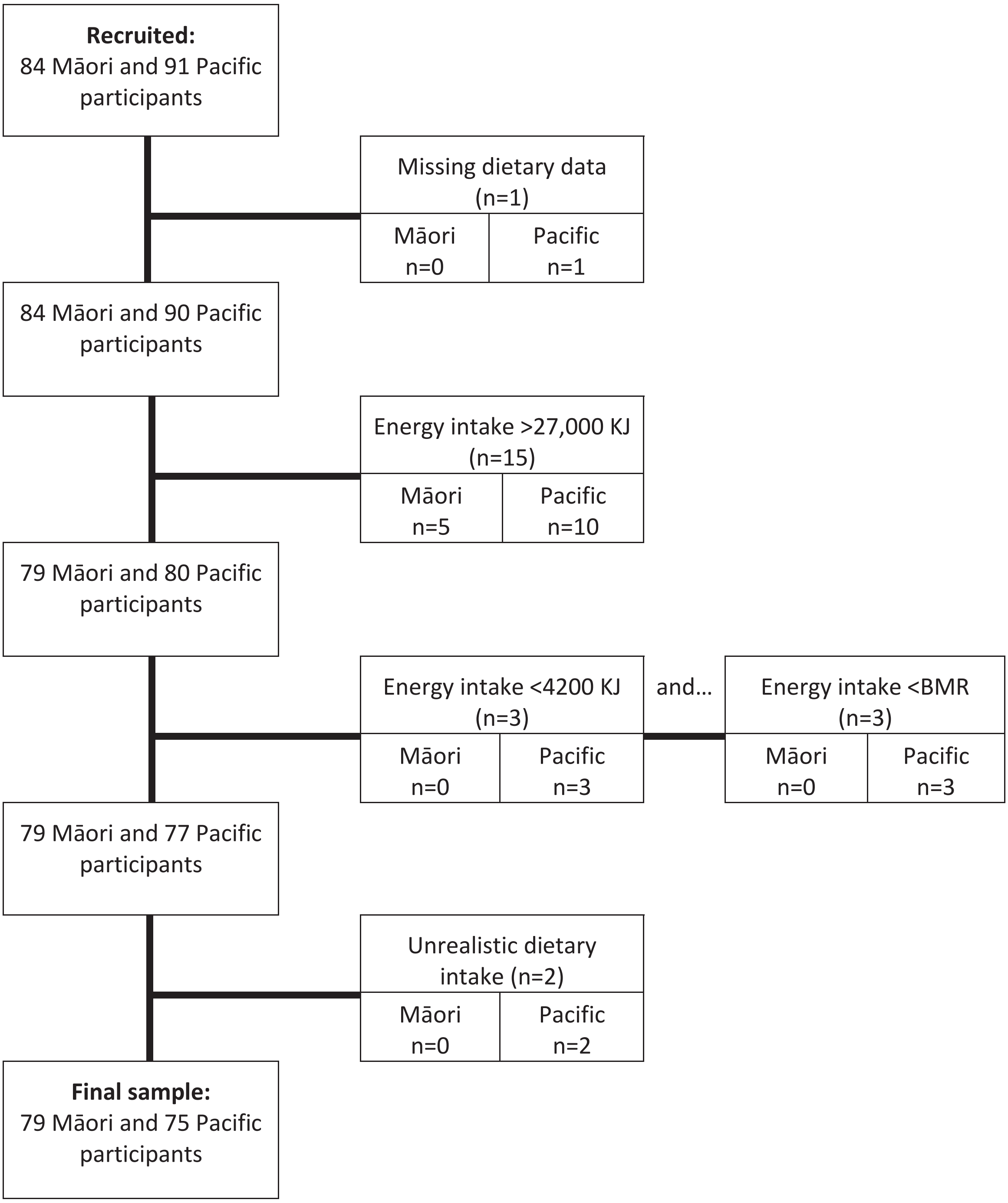

Figure 4.1 Exclusion criteria and resulting participants

4.2 Demographics and anthropometry

Demographic and anthropometric data from Māori (n=79) and Pacific women (n=75) and presented in Table 4.1.

Table 4.1 Demographics and anthropometry of Māori and Pacific women

Characteristics	**Māori**	**Pacific**
Age [a] (years)	30.0 ± 9.2	29.1 ± 9.2
Age group (years), n (%)		
16-25	31 (39.2)	33 (44.0)
26-35	21 (26.6)	20 (26.7)
36-45	27 (34.2)	22 (29.3)
Height [a] (cm)	166 ± 6.1	167 ± 5.8
Weight [a] (kg)	77.9 ± 17	89.4 ± 19
BMI [a] (kg/m^2)(18.5-24.9) [1]	28.2 ± 6.0	31.9 ± 6.5
Body fat [a] (%)(<35%) [2]	34.6 ± 8.2	37.8 ± 7.7
Waist circumference [a] (cm)(<80) [1]	83.9 ± 12	91.2 ± 14
Hip circumference [b] (cm)	105 [99 - 114]	112 [107 - 123]
Waist-Hip ratio [a] (<0.85) [1]	0.776 ± 0.06	0.792 ± 0.06
Waist-Height ratio [a] (<0.5) [3]	0.505 ± 0.08	0.545 ± 0.08
BMI group (kg/m^2) [c]		
Underweight (<18.5) [1]	0 (0)	0 (0)
Normal (18.5-24.9) [1]	28 (35.4)	12 (16.0)
Pre-obesity (25.0-29.9) [1]	28 (35.4)	22 (29.3)
Obesity class I (30.0-34.9) [1]	13 (16.5)	13 (17.3)
Obesity class II (35.0–39.9) [1]	6 (7.59)	20 (26.7)
Obesity class III (≥40) [1]	4 (5.06)	8 (10.7)
Total	79 (100)	75 (100)
Body fat group [c]		
Low (<22%) [4]	4 (5.1)	0 (0)
Normal (22-29.9%) [4]	23 (29.1)	15 (20.0)
Overweight (30-34.9%) [4]	11 (13.9)	13 (17.3)
Obese (≥35%) [4]	41 (51.9)	47 (62.7)
Total	79 (100)	75 (100)
Combined group, BMI and Body fat [5 c]	0.857*	0.871*
Low fat: high BMI (≥25 kg/m^2), low BF percentage (<22%)	0 (0)	0 (0)
Less fat 1: normal BMI (18.5-24.9 kg/m^2), low BF percentage (<22%)	4 (5.1)	0 (0)
Less fat 2: high BMI (≥25 kg/m^2), normal BF percentage (22-30%)	8 (10.1)	6 (8.00)
Normal Fat: normal BMI (18.5-24.9 kg/m^2), normal BF percentage (22-30%)	15 (19.0)	9 (12.0)
Hidden Fat: normal BMI (18.5-24.9 kg/m^2), high BF percentage (≥30%)	8 (10.1)	2 (2.7)
Apparent Fat: high BMI (≥25 kg/m^2), high BF percentage (≥30%)	44 (55.7)	58 (77.3)
Total	79 (100)	75 (100)
BMI (<30/ ≥30 kg/m^2), Body fat (<30/ ≥30%)	0.00**	0.00**

[a] = Mean ± Standard deviation; [b] = Median [25th - 75th percentiles]; [c] = number of participants (% of participants); * = Correlation coefficient; ** = Chi-squared test; BF = Body fat; BMI = Body mass index; CVD = Cardiovascular disease

1. Standard reference values (WHO, 2016a; WHO Consultation, 2008)
2. Cut-off point for obesity among women (≥35%), as defined by the American Society of Endocrinologists and also within the range of cut-offs (30-37% BF) proposed by other reputable studies (Oliveros et al., 2014)
3. Reference value to predict risk of CVD and diabetes (Browning, Hsieh, & Ashwell, 2010)
4. Reference values derived from literature on the association between BF percentage, BMI and risk of chronic disease, such as CVD (De Lorenzo, Martinoli, Vaia, & Di Renzo, 2006; Marques-Vidal et al., 2008; Oliveros et al., 2014; Romero-Corral et al., 2009)
5. Combined groups were based on the women's EXPLORE study data

Māori and Pacific women were between 16-45 years old, with no significant difference ($p>0.05$) in their mean age of ~30 years (Table 4.1). Consequently, NRVs were referenced from the adult age brackets: 19-30 years and 31-50 years.

On average, the BMI (28.2 kg/m^2) and BF (34.6%) of Māori women classified them as overweight, while the BMI (31.9 kg/m^2) and BF (37.8%) of Pacific women classified them as obese (WHO, 2016a). Almost half of the Māori (51.9%) and Pacific women (62.7%) had a BF ≥35% ("obese" BF percentage group), leaving the other half in the lower BF (<35%) group (outlined in section 3.7).

Very few Māori (10.1%) and Pacific women (2.7%) were found in the "Hidden fat" group (normal weight obesity (NWO)) (De Lorenzo, Martinoli, Vaia, & Di Renzo, 2006; Marques-Vidal et al., 2008; Oliveros et al., 2014; Romero-Corral et al., 2009). Instead, most Māori (55.7%) and Pacific women (77.3%) were found in the "Apparent Fat" group (BMI (≥25 kg/m^2) and BF (≥30%)). Consequently, there were significant positive correlations between the BMI and BF percentage of Māori (0.857) and Pacific women (0.871). Furthermore, Chi-square tests revealed significantly positive associations between BMI and BF percentage of Māori women, X^2 (1, n=79) = 32.0, $p<0.05$ and of Pacific women, X^2 (1, n=75) = 34.8, $p<0.05$.

The mean WC of Māori (83.9cm) and Pacific women (91.2cm) put them at an increased (>80cm) and substantially-increased (>88cm) risk of metabolic complications associated with obesity, respectfully (WHO, 2008). Similarly, average measures for Māori (0.505 ± 0.08) and Pacific women (0.545 ± 0.08) exceeded the WHtR cut-off of <0.5 (Browning, Hsieh, & Ashwell, 2010).

4.3 Energy and macronutrients

Dietary intake of energy, macronutrients, DF, and fluid of Māori (n=79) and Pacific women (n=75) were compared with NRVs, to find the percentage of participants with inadequate intake (Table 4.2).

Table 4.2 Energy and macronutrients among Māori and Pacific women

Nutrient and unit of measure	Reference value	Intake, daily average		Difference between intake and recommendations (%)		Inadequate intake compared with reference value (% of participants)	
		Māori	Pacific	Māori	Pacific	Māori	Pacific
Energy, including DF [a] (KJ)	8800 KJ[1]	9761 (8933, 10590)	11484 (10278, 12690)	10.9↑	30.5↑	41.8↓, 58.2↑	37.3↓, 62.7↑
Protein [a] (g)	46.7g/53.6g (0.60g/kg)[2]	107 (97, 116)	120 (108, 131)	129↑	124↑	2.53↓	8.00↓
Protein as a % of energy [a] (%)	15-25%[1]	18.6 (18, 20)	18.1 (17, 19)	0	0	13.9↓, 3.80↑	17.3↓, 4.00↑
Total fat [a] (g)	**	94.5 (86, 103)	110 (98, 122)				
Total fat as a % of energy [a] (%)	20-35%[3]	36.0 (34, 37)	35.6 (34, 37)	2.86↑	1.71↑	2.53↓, 51.9↑	0↓, 56.0↑
Saturated fat [b] (g)[4]	**	35.1 [25 - 43]	37.0 [25 - 53]				
Saturated fat as a % of energy [a] (%)[4]	<10%[3]	14.5 (14, 15)	14.2 (13, 15)	45.0↑	42.0↑	68.4↑	57.3↑
Polyunsaturated fat [a] (g)	8.89g[5]	13.0 (12, 14)	15.3 (13, 17)	46.2↑	72.1↑	19.0↓	52.0↓
Monounsaturated fat [b] (g)	**	29.9 [21 - 38]	35.0 [24 - 47]				
Cholesterol [b] (mg)	**	330 [204 - 422]	333 [246 – 505]				
Carbohydrate [a] (g)	**	240 (215, 264)	298 (261, 334)				
Carbohydrate as a % of energy [b] (%)	45-65%[3]	40.0 [37 - 45]	42.8 [37 - 47]	12.5↓	5.14↓	76.0↓, 0↑	60↓, 0↑
Added sugars (glucose and sucrose) as a % of energy [b] (%)	<10%[6]	12.8 (12, 14)	12.4 (11, 13)	28.0↑	25.0↑	63.3↑	53.3↑
Starch [a] (g)	**	116 (101, 130)	159 (136, 182)				
Dietary fibre [a] (g)	25g[5] (28g[7])	30.4 (27, 33)	35.1 (31, 39)	21.6↑[5], 8.57↑[7]	40.4[5]↑, 25.4[7]↑	34.2[5]↓, 49.4[7]↓	33.3[5]↓, 37.3[7]↓
KJ from fibre [a] (%)	**	2.55 (2.4, 2.7)	2.50 (2.3, 2.7)				
Total water [a] (g)	2800g[5]	2598 (2409, 2787)	2662 (2458, 2865)	7.78↓	5.18↓	60.8↓	54.7↓
Alcohol [b] (g)	<20g[8]	2.53 [0.44 - 6.2]	0.089 [0.02 - 1.6]	87.4↓	99.6↓	8.86↑	1.33↑
Alcohol as a % of energy [b] (%)	**	0.765 [0.18- 2.1]	0.018 [0.00 – 0.55]				

[a] = Mean (95% confidence interval); [b] = Median [25th - 75th percentiles]; ** = Nutrients without a NRV; AI = Adequate Intake; AMDR = Acceptable macronutrient distribution range; DF = Dietary fibre; EAR = Estimated Average Requirement; EER = Estimated Energy Requirement; EI = Energy intake; NRVs = Nutrient reference values; PAL = Physical activity level; SDT = Suggested dietary target; SFA = Saturated fat; WHO = World Health Organization

1. EER calculation for women 31-50 years, with an average height of 1.6 metres, and a PAL[6] of ~1.6 (Schofield, 1985; Black, Coward, Cole, & Prentice, 1996; German Nutrition Society, 2002; Trumbo, Schlicker, Yates, & Poos, 2002; NHMRC, 2006)
2. EAR for participants 19-50 years (NHMRC, 2006)
3. AMDR for adults: Macronutrients are expressed as a percentage of EI, in KJ (NHMRC, 2006)
4. Inadequate intake of SFA is intake above the limit provided, rather than below
5. AI for participants 19-50 years (NHMRC, 2006)
6. The WHO, UK and Germany recommend ≤10% EI is from added sugars, such as sucrose (NHMRC, 2006; WHO, 2015; WHO & FAO, 2003)
7. SDT (NHMRC, 2006)
8. Alcohol intake guidelines were retrieved from the MOH (MOH, 2016a)
9. A PAL of 1.6 represents someone who is minimally active (Black et al., 1996; Trumbo et al., 2002)

The average EI of Māori women exceeded their EER (8800 KJ) by 10.9% (Table 4.2). The percentage of participants with an EI above this EER was 58.2%. This was similar to the 51.9% of women with total fat above the AMDR. More significantly, the percentage of EI from SFA exceeded the 10% limit among 68.4% of Māori women. In contrast, carbohydrate intake was below the AMDR for 76% of women. Carbohydrates were inclusive of DF and added sugars. Despite low intakes of carbohydrate, 65.8% of women met the AI for DF (25g) and 63.3% consumed more added sugars (28% ↑) than the internationally recognised limit of 10% EI (NHMRC, 2006).

The average EI of Pacific women exceeded their EER (8800 KJ) by 30.5%. The percentage with an EI above this EER was 62.7%. Total fat intake exceed the AMDR (1.71% ↑) in 56% of women, while 57.3% exceeded the limit (10% of EI) for SFA. In contrast, carbohydrate intake was below the AMDR for 60% of women. Despite low intakes of carbohydrate, 66.7% of women met the AI for DF and 53.3% consumed more added sugars (25% ↑) than the internationally recognised limit of 10% EI (NHMRC, 2006).

Overall, Māori and Pacific women reported adequate intakes of protein and inadequate intakes of carbohydrate and total water (combined fluid from both food and drinks). They reported excessive EI, total fat, SFA and added sugars.

4.4 Micronutrients

Micronutrient intakes of Māori (n=79) and Pacific women (n=75) were compared with each other and with NRVs, allowing for the calculation of participants with inadequate intake (Table 4.3).

Table 4.3 Micronutrient intake among Māori and Pacific women

Nutrient and unit of measure	Reference value	Intake, daily average		Difference between intake and recommendations (%)		Inadequate intake compared with reference value (% of participants)	
		Māori	Pacific	Māori	Pacific	Māori	Pacific
Thiamin [b] (mg)	0.9mg[1]	1.38 [1.0 – 2.1]	1.75 [1.2 – 2.7]	53.3↑	94.4↑	16.5↓	10.7↓
Riboflavin [a] (mg)	0.9mg[1]	2.77 (2.4, 3.1)	2.94 (2.6, 3.3)	208↑	227↑	5.06↓	5.33↓
Niacin equivalents [a] (mg)	11mg[1]	49.3 (44, 54)	54.2 (49, 59)	348↑	393↑	0↓	0↓
Vitamin C [a] (mg)	30mg[1]	162 (137, 186)	171 (147, 195)	540↑	570↑	1.27↓	1.33↓
Vitamin E [a] (mg)	7mg[2] (14mg[3])	13.8 (12, 15)	15.5 (14, 17)	97.1↑	121↑	10.1↓	10.7↓
Vitamin B6 by analysis [b] (mg)	1.1mg[1]	2.91 [1.8 – 3.6]	3.02 [2.2 – 4.3]	165↑	175↑	3.80↓	2.67↓
Vitamin B12 [a] (µg)	2.0µg[1]	6.67 (5.8, 7.5)	6.63 (5.9, 7.4)	234↑	232↑	5.06↓	4↓
Folate total DFE [a] (µg)	320µg[1] (300-600µg[3])	471 (415, 526)	551 (472, 631)	47.2↑	72.2↑	32.9↓	22.7↓
Total vit A eq (RAE) [a] (µg)	500µg[1] (1220µg[3])	1589 (1411, 1766)	1595 (1394, 1795)	218[1]↑, 30.2[3]↑	219[1]↑, 30.7[3]↑	2.53[1]↓, 36.7[3]↓	2.7[1]↓, 41.3[3]↓
Retinol [a] (µg)	3000µg[4]	418 (370, 467)	467 (406, 527)	0↑	0↑	0↑	0↑
Beta carotene equivalents [a] (µg)	5000[3]	7007 (6013, 8002)	6754 (5664, 7845)	40.1↑	35.1↑	32.9↓	44.0↓
Sodium [a] (mg) [5]	460-920mg[2], (2300mg[4])	2813 (2494, 3132)	3764 (3240, 4288)	206[2]↑, 22.3[4]↑	309[2]↑, 63.7[4]↑	98.7[2]↑, 58.2[4]↑	98.7[2]↑, 73.3[4]↑
Potassium [b] (mg)	2800mg[2] (4700mg[3])	3699 [2842 - 4643]	3849 [3113 - 5408]	32.1[2]↑, 27.1[3]↓	37.5[2]↑, 22.1[3]↓	22.8[2]↓, 75.9[3]↓	21.3[2]↓, 65.3[3]↓
Magnesium [a] (mg)	255-265mg[1]	381 (349, 413)	429 (386, 473)	43.8↑	61.9↑	20.3↓	16.0↓
Calcium [a] (mg)	840mg[1]	1119 (994, 1243)	1125 (977, 1273)	33.2↑	33.9↑	32.9↓	38.7↓
Phosphorus [a] (mg)	580mg[1], (4000mg[4])	1723 (1568, 1878)	1853 (1669, 2037)	63.3↑	75.6↑	1.27↓	0↓

Nutrient and unit of measure	Reference value	Intake, daily average		Difference between intake and recommendations (%)		Inadequate intake compared with reference value (% of participants)	
		Māori	Pacific	Māori	Pacific	Māori	Pacific
Iron [a] (mg)	8mg[1]	13.7 (12, 15)	16.0 (14, 18)	71.3↑	100↑	13.9↓	9.33↓
Zinc [a] (mg)	6.5mg[1]	12.6 (11, 14)	14.9 (13, 16)	93.8↑	129↑	6.33↓	6.67↓
Manganese [a] (µg)	5000µg[2]	4179 (3784, 4573)	4980 (4399, 5562)	19.6↓	0.402↓	68.4↓	66.7↓
Copper [b] (mg)	1.2mg[2]	1.45 [1.1 – 1.8]	1.65 [1.1 – 2.0]	20.8↑	37.5↑	35.4↓	25.3↓
Selenium [a] (µg)	50µg[1]	84.6 (74, 95)	91.1 (80, 102)	69.2↑	82.2↑	22.8↓	20↓
Iodine [a] (µg)	100µg[1]	82.4 (72, 93)	84.4 (75, 94)	21.4↓	18.5↓	72.2↓	65.3↓

[a] = Mean (95% confidence interval); [b] = Median [25th - 75th percentiles]; AI = Adequate Intake; DFE = Dietary folate equivalents; EAR = Estimated Average Requirement; RAE = Retinol activity equivalents; SDT = Suggested dietary target; UL = Upper level of intake

1. EAR for women 19-50 years (NHMRC, 2006)
2. AI for women 19-50 years (NHMRC, 2006)
3. SDT for women 19-50 years (NHMRC, 2006)
4. UL for women 19-50 years (NHMRC, 2006)
5. Inadequate intake of sodium is intake above the limit provided, rather than below

On average, Māori women reported adequate intakes of all the micronutrients, except for sodium, manganese and iodine (Table 4.3). Sodium was 22.3% above the UL (2300mg), manganese was 19.6% below the AI, and iodine was 21.4% below the EAR. Over half (58.2%) the women had sodium levels above the UL. Although most mean intakes met guidelines, over thirty percent of Māori women had inadequate intakes of folate (32.9%), beta-carotene equivalents (32.9%), calcium (32.9%), manganese (68.4%), copper (35.4%) and iodine (72.2%).

On average, Pacific women reported adequate intakes of all the micronutrients, except for sodium and iodine. Sodium was 63.7% above the UL, while iodine was 18.5% lower than the EAR. Most women (73.3%) were consuming sodium above this UL. Although most mean intakes met guidelines, over thirty percent of Pacific women had inadequate intakes of beta-carotene equivalents (44%), calcium (38.7% of participants), manganese (66.7%) and iodine (65.3%).

4.5 Food groups

Table 4.4 presents the recommended SSE of foods in each food group, as outlined in the Eating and Activity Guidelines for New Zealand Adults (EAGNZA). These values were compared with SSE consumed by Māori (n=79) and Pacific women (n=75) in the women's EXPLORE study.

Table 4.4 Food groups consumed by Māori and Pacific women

Food group from the EAGNZA	Recommended SSE[1] of foods, in each food group, per day	Daily intake, as SSE[1]		Difference between intake and recommendations (%)		Inadequate intake (% participants)	
		Māori	Pacific	Māori	Pacific	Māori	Pacific
Vegetables and fruit[a]	≥5 SSE	7.05 ± 4.3	7.17 ± 4.7	41.4↑	43.4↑	31.7↓	42.7↓
Vegetables[a]	≥3 SSE	4.12 ± 2.4	4.14 ± 3.0	37.3↑	38.0↑	32.9↓	44.0↓
Fruit[a]	≥2 SSE	2.93 ± 2.6	3.03 ± 2.6	46.5↑	51.5↑	39.2↓	45.3↓
Grain foods[a]	≥6 SSE	3.07 ± 2.5	4.14 ± 3.2	95.4↓	44.9↓	93.7↓	81.3↓
Milk products and alternatives[a]	≥2 SSE	1.77 ± 1.3	1.70 ± 1.5	13.0↓	17.6↓	60.8↓	69.3↓
Meat and meat alternatives[a2]	≥1 SSE meat (and/or ≥2 SSE legumes, nuts or seeds)	3.37 ± 1.6	3.37 ± 1.7	237↑ (68.5↑)	237↑ (68.5↑)	5.06↓ (17.7↓)	2.67↓ (22.7↓)
Fluids[a3]	8.4 SSE (2.1L)[4]	5.61 ± 2.1	5.68 ± 2.6	49.7↓	47.9↓	92.4↓	86.7↓
Total water, from food and fluids[a]	11.2 SSE (2.8L)[4]	10.2 ± 2.8	10.6 ± 3.5	9.80↓	5.66↓	60.8↓	54.7↓

[a] = Mean **±** Standard deviation; EAGNZA = Eating and Activity Guidelines for New Zealand Adults; MOH = Ministry of health; SSE = Standard serving equivalents

1. SSE of foods in each food group, as outlined in the Eating and Activity Guidelines for New Zealand Adults (MOH, 2015b). Where food SSE were not defined in the Eating and Activity Guidelines for New Zealand Adults, SSE sizes were sourced from Australian dietary guidelines (AGDH, 2015)
2. Meat and meat-alternatives describe the protein foods for non-vegetarians and vegetarians, respectively. These include legumes, nuts, seeds, fish and other seafood, eggs, poultry and red meat
3. Water-based soup and all drinks, except for drinks of milk
4. One SSE of fluid equates to 250ml

Māori and Pacific women met the recommended SSE of vegetables, fruit, and meat and meat alternatives (Table 4.4). However, SSE of grain foods; milk products and alternatives; fluids and total water did not meet the guidelines.

Māori women consumed about half (3.07 SSE) the recommended SSE of grain foods (≥6 SSE), with inadequate intake prevalent in 93.7% of women. Average intake of milk products and alternatives was only 0.23 SSE lower than the guidelines but inadequate intake was prevalent among 60.8% of participants. Fluid intake was 2.79 SSE lower than the guidelines (8.4 SSE), yet total water (all fluid from food and drinks) was 1 SSE below the guidelines (11.2 SSE).

Pacific women consumed 69% (4.14 SSE) of the recommended SSE of grain foods (≥6 SSE), with inadequate intake prevalent in 81.3% of participants. The average intake of milk products and alternatives was only 0.30 SSE lower than the guidelines but inadequate intake was prevalent among 69.3%. Fluid intake was 2.72 SSE lower than the guidelines (8.4 SSE), yet total water was 0.6 SSE below the guidelines (11.2 SSE).

Table 4.5 presents SSE of food groups disaggregated from the Eating and Activity Guidelines for New Zealand Adults (EAGNZA), as consumed by Māori (n=79) and Pacific women (n=75).

Table 4.5 Food groups (disaggregated) consumed by Māori and Pacific women

Food group from the EAGNZA	Food group for analysis	Daily intake, as SSE[1]	
		Māori	Pacific
Vegetables and fruit	Starchy vegetables[2]	0.596 ± 0.6	0.775 ± 0.8
	Vegetables (other)	3.52 ± 2.2	3.37 ± 2.6
	Fruit	2.93 ± 2.6	3.03 ± 2.6
Grain foods	Bread	1.67 ± 1.6	2.36 ± 2.4
	Cereal	0.711 ± 0.9	0.665 ± 0.8
	Starchy foods	0.461 ± 0.4	0.632 ± 0.7
	Discretionary breads, cereals and starchy foods	0.223 ± 0.5	0.482 ± 0.8
Milk products and alternatives	Milk	1.01 ± 0.9	1.04 ± 1.0
	Cheese	0.328 ± 0.5	0.252 ± 0.4
	Dairy-based foods	0.360 ± 0.5	0.231 ± 0.5
	Discretionary dairy products	0.327 ± 0.4	0.514 ± 0.8
Meat and meat alternatives[3]	Red meat[4]	0.631 ± 0.5	0.667 ± 0.5
	Poultry	0.629 ± 0.5	0.616 ± 0.6
	Fish and seafood	0.484 ± 0.5	0.510 ± 0.5
	Eggs	0.547 ± 0.6	0.539 ± 0.6
	Legumes, nuts and seeds	0.666 ± 0.7	0.617 ± 0.6
	Discretionary meat and meat alternatives	0.410 ± 0.3	0.419 ± 0.4
Fluids	Drinks	4.43 ± 2.3	3.93 ± 2.1
	SSB[5]	1.18 ± 1.3	1.76 ± 2.4
	Alcohol	0.574 ± 0.9	0.227 ± 0.5
Other	Takeaways	0.641 ± 0.5	1.17 ± 1.5
	Discretionary savoury snacks	0.160 ± 0.2	0.278 ± 0.4
	Discretionary sweet snacks	1.07 ± 1.0	1.24 ± 1.2
	Butter, margarine, oils and fats	1.32 ± 1.0	1.52 ± 1.1
	Sauces, spreads and flavourings (savoury)	0.649 ± 0.5	0.991 ± 1.1
	Sauces, spreads and flavourings (sweet)	0.497 ± 0.5	0.670 ± 0.7
	Supplements providing energy	0.118 ± 3.5	0

All values are presented as Mean **±** Standard Deviation; EAGNZA = Eating and Activity Guidelines for New Zealand Adults; MOH = Ministry of health; SSB = Sugar-sweetened beverages; SSE = Standard serving equivalents

1. SSE of foods in each food group, as outlined in the Eating and Activity Guidelines for New Zealand Adults (EAGNZA) (MOH, 2015b). Where food SSE were not defined in the EAGNZA, SSE sizes were sourced from Australian dietary guidelines (AGDH, 2015)
2. Starchy vegetables include kumara, potatoes, taro, yams and green bananas (green plantains) in the EAGNZA (MOH, 2015b)
3. Meat and meat alternatives include legumes, nuts, seeds, fish and other seafood, eggs, poultry and red meat.
4. Red meat includes beef, lamb, mutton, goat, venison and pork
5. The EAGNZA define SSB as fruit drinks, flavoured water, carbonated or fizzy drinks, cordial, powdered drinks, energy drinks, and sports drinks (MOH, 2015b)

The highest contributor of grain foods among Māori women was bread (1.67 SSE). The highest contributor of milk products and alternatives was milk (1.01 SSE) (Table 4.5). Of the meat and meat alternatives, the mean intake of legumes, nuts and seeds (0.666 SSE) was highest, followed by red meat (0.631 SSE) and poultry (0.629 SSE). Within 'Other,' the mean intake of butter, margarine, oils and fats (1.32 SSE) was greatest, followed by discretionary sweet snacks (1.07 SSE), which were eaten daily. Participants also drank SSB (1.18 SSE) daily.

Among Pacific women, the highest contributor of grain foods was bread (2.36 SSE). The highest contributor of milk products and alternatives was milk (1.04 SSE). Of the meat and meat alternatives, their mean intake of red meat (0.667 SSE) was highest, followed by poultry (0.616 SSE) and legumes, nuts and seeds (0.617 SSE). Within ‘Other’, the mean intake of butter, margarine, oils and fats (1.52 SSE) was greatest, followed by discretionary sweet snacks (1.24 SSE) and takeaways (1.17 SSE), which were eaten daily. Participants also drank SSB (1.76 SSE) daily.

Table 4.6 presents daily SSE of the type(s) of bread, milk and fluid consumed by Māori (n=79) and Pacific women (n=75).

Table 4.6 Type of bread, milk and fluid

Food group	Food	Daily intake, as SSE[1]	
		Māori	Pacific
Bread	White	0.452	0.428
	High fibre white	0.050	0.153
	Light and heavy grain	0.776	1.30
	Other bread[2]	0.293	0.248
Milk	Whole or standard	0.446	0.298
	Reduced fat	0.254	0.570
	Skim or trim (incl. light soy)	0.140	0.100
	Soy	0.216	0.089
	Calcium enriched (yellow/orange lid)	0.018	0.030
	Other milk[3]	0.004	0.004
	None, % participants	0%	1.33% (1 Ppt)
Fluid	Water	2.74	2.48
	Milk[4]	1.01	1.04
	Tea and coffee	1.63	1.38
	Juice	0.367	0.315
	Soft drinks and energy drinks	0.424	0.410
	Sugar-free energy drinks[5]	0.171	0.129
	Sports drinks	0.126	0.238
	Total SSB[6]	1.18	1.76
	Alcohol	0.574	0.227

EAGNZA = Eating and Activity Guidelines for New Zealand Adults; MOH = Ministry of health; Ppt = Participant; SSB = Sugar-sweetened beverages; SSE = Standard serving equivalents

1. SSE of drinks were usually 250ml, with the exception of specialty coffees (flat whites, cappuccinos, lattes), at 166ml
2. Other breads included croissants, crumpets or muffin splits, focaccia, bagel, pita, panini or other speciality breads, fruit bread or fruit buns, iced buns, paraoa parai (fry bread), scones, wraps
3. Other milk included fermented or evaporated milk (buttermilk)
4. Milk was not included within the total fluid count because it was preferred in the milk products and alternatives group
5. Sugar-free energy drinks (e.g. sugar-free V, Monster, Red Bull) were also included in the SSB category, because they are carbonated and have a high caffeine content (Reissig, Strain, & Griffiths, 2009; Seifert, Schaechter, Hershorin, & Lipshultz, 2011)
6. The Eating and Activity Guidelines for New Zealand Adults define SSB as fruit drinks, flavoured water, carbonated or fizzy drinks, cordial, powdered drinks, energy drinks, and sports drinks (MOH, 2015b)

The most common type of bread consumed by Māori women was light and heavy grain (0.776 SSE) (Table 4.6). The most common type of milk was whole or standard (0.446 SSE), which was consumed at least twice as much as the other types of milk. The most frequently consumed fluid was water (2.74 SSE). SSB were consumed daily (1.18 SSE) and more often than milk (1.01 SSE). The most popular SSB were soft drinks and energy drinks (0.424 SSE), followed closely by juice (0.367 SSE). Similarly, Table 4.7 shows the largest contributors toward total SSB intake were soft/ fizzy/ carbonated drinks (Coke, Sprite) and fruit juice (Just Juice, Freshup, Charlie's, Rio Gold).

The most common type of bread among Pacific women was light and heavy grain (1.30 SSE). The most common type of milk was reduced fat (0.570 SSE), which was consumed almost twice-as-often as whole or standard (0.298 SSE). Water was the most frequently consumed fluid (2.48 SSE). SSB were consumed daily (1.76 SSE) and 69.2% more often than milk (1.04 SSE). The most popular SSB were soft drinks and energy drinks (0.410 SSE), followed closely by juice (0.315 SSE).

4.5.1 Top 20 foods/drinks

The top 20 foods, by frequency and by weight, are presented in Table 4.7. Foods consumed by Māori (n=79) and Pacific women (n=75) were ordered from most-frequent to least-frequent, and heaviest to lightest.

Table 4.7 Top 20 foods/drinks consumed by Māori and Pacific women

Top 20 foods (frequency)		Top 20 foods (weight, g)	
Māori	**Pacific**	**Māori**	**Pacific**
Water (unflavoured mineral water, soda water, tap water)	Water (unflavoured mineral water, soda water, tap water)	Water (unflavoured mineral water, soda water, tap water)	Water (unflavoured mineral water, soda water, tap water)
Cooking oils (all varieties)	Wholemeal or wheat meal bread	Blue milk or Lacto free whole milk	Light blue milk or Lacto free skim milk
Coffee instant or brewed with or without milk (Nescafe, expresso)	Wholegrain bread	Coffee instant or brewed with or without milk (Nescafe, expresso)	Coffee instant or brewed with or without milk (Nescafe, expresso)
Banana	Light blue milk or Lacto free skim milk	Tea (English breakfast tea, Earl Grey)	Blue milk or Lacto free whole milk
Plain white bread	Coffee instant or brewed with or without milk (Nescafe, expresso)	Herbal tea or Green tea	Herbal tea or Green tea
Blue milk or Lacto free whole milk	Cooking oils (all varieties)	Light blue milk or Lacto free skim milk	Instant noodles (2 minute noodles)
Apple	Banana	Banana	Tea (English breakfast tea, Earl Grey)
Wholegrain bread	Apple	Apple	Flavoured water (Mizone, H2Go flavoured)
Whole eggs (hardboiled, poached, fried, mashed, omelette, scrambled)	Orange, mandarin, tangelo, grapefruit	Orange, mandarin, tangelo, grapefruit	Banana
Orange, mandarin, tangelo, grapefruit	Plain white bread	Soft/fizzy/carbonated drinks (Coke, Sprite)	Sport's drinks (Gatorade, Powerade)
Tea (English breakfast tea, Earl Grey)	Whole eggs (hardboiled, poached, fried, mashed, omelette, scrambled)	Tomatoes	Apple
Herbal tea or Green tea	Sauces (tomato, BBQ, sweet chilli, mint)	Yoghurt, plain or flavour	Orange, mandarin, tangelo, grapefruit
Tomatoes	Cauliflower, broccoli or broccoflower	Fruit juice (Just Juice, Freshup, Charlie's, Rio Gold)	Soft/fizzy/carbonated drinks (Coke, Sprite)
Yoghurt, plain or flavour	Mixed frozen vegetables	Sugar-free energy drinks (sugar-free V, Monster, Red Bull), small can	Rice, white
Chocolate including chocolate bars (Moro bars)	Tomatoes	Soy drinks	Tomatoes
Cauliflower, broccoli or broccoflower	Milo	Beer – ordinary	Fruit juice (Just Juice, Freshup, Charlie's, Rio Gold)
Wholemeal or wheat meal bread	Carrots	Sport's drinks (Gatorade, Powerade)	Breakfast drinks (Up and Go)
Carrots	Chocolate including chocolate bars (Moro bars)	Energy drinks small-medium can (V, Red Bull)	Pear
Potato (boiled, mashed, baked, roasted)	Avocado	Chicken breast	Sugar-free energy drinks (sugar-free V, Monster, Red Bull), small can
Butter	Rice, white	Cauliflower, broccoli or broccoflower	Chinese takeaways

Colour key:

	Vegetables and fruit
	Grain foods
	Milk products and alternatives
	Meat and meat alternatives
	SSB
	Alcohol
	Drinks (other)
	Fats, oils and sauces
	Discretionary sweet snacks and takeaways

Food weight was a more accurate representation of the level of consumption than frequency because serving sizes varied, whereas the unit of measure for weight (in grams) stayed constant (Table 4.7). Both Māori and Pacific women had vegetables, fruit, milk and fluids (including SSB) within their top 20 foods/drinks by weight. There were five different SSB in the top 20 drinks for both Māori and Pacific women, thus making-up 25% of the list. Additionally, Māori women had one food item from the meat and meat alternatives group (poultry), while Pacific had food from the grain foods group (two starchy foods) and 'Other' group (takeaways).

4.6 Contribution of foods to energy intake, macronutrient intake and added sugar

Table 4.8 displays the percentage contribution of food groups towards EI, particular macronutrients and added sugar, in Māori women (n=79). The top ten food groups were displayed for each category. Furthermore, SSB and discretionary food groups (including takeaways) were highlighted in red and turquoise colours, respectively.

Table 4.8 Percentage contribution of food groups to selected nutrients, in Māori women

Energy, KJ		Protein, g		Fat, g		Saturated fat, g		Carbohydrate, g		Added sugar, g		Sodium, mg	
Food group	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**
Takeaways	9.44	Poultry	13.5	Butter, margarine, oils and fats	15.2	Butter, margarine, oils and fats	17.4	Fruit	15.7	SSB	15.2	Takeaways	16.3
Fruit	9.01	Red meat	12.9	Takeaways	11.7	Cheese	10.8	Bread	11.6	Discretionary sweet snacks	11.0	Bread	10.6
Milk	7.13	Fish and Seafood	10.0	Milk	8.20	Takeaways	10.7	Discretionary sweet snacks	9.07	Discretionary dairy products	4.98	Discretionary meat and meat-alternatives	10.1
Discretionary sweet snacks	6.99	Takeaways	9.17	Discretionary sweet snacks	8.00	Milk	10.6	Takeaways	8.08	Dairy-based foods	4.77	Sauces, spreads and flavourings (savoury)	9.45
Bread	6.66	Milk	8.89	Red meat	7.90	Discretionary sweet snacks	10.1	SSB	7.97	Sauces, spreads and flavourings (sweet)	3.49	Cheese	6.37
Butter, margarine, oils and fats	5.50	Discretionary meat and meat-alternatives	4.86	Eggs	7.32	Eggs	8.37	Starchy Foods	6.92	Cereal	1.89	Discretionary breads, cereals and starchy foods	6.06
Red meat	5.40	Vegetables (other)	4.73	Cheese	6.80	Red meat	8.00	Vegetables (other)	6.48	Takeaways	1.81	Fish and Seafood	5.96

Energy, KJ		Protein, g		Fat, g		Saturated fat, g		Carbohydrate, g		Added sugar, g		Sodium, mg	
Food group	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**
Vegetables (other)	4.73	Bread	4.68	Legumes, nuts and seeds	5.72	Discretionary meat and meat-alternatives	4.95	Cereal	6.44	Supplements providing energy	1.24	Red meat	4.81
Poultry	4.16	Cheese	4.65	Discretionary meat and meat-alternatives	5.36	Discretionary dairy products	3.79	Milk	6.01	Discretionary breads, cereals and starchy foods	1.04	Milk	3.89

Colour key:

(green)	Takeaways and Discretionary foods
(red)	Sugar-Sweetened Beverages (SSB)

Table 4.8 showed that the highest contributor of total EI among Māori women were takeaways (9.44%). Takeaways (16.3%) were also the highest contributors of sodium and featured within the top four foods across all macronutrients, except for added sugar, where SSB (15.2%) featured as the top 'food'. The highest contributors of protein were poultry (13.5%) and red meat (12.9%), while total fat (15.2%) and SFA (17.4%) were influenced mostly by butter, margarine, oils and fats.

Table 4.9 displays the percentage contribution of food groups towards EI, particular macronutrients and added sugar, in Pacific women (n=75). The top ten food groups were displayed for each category. Furthermore, the SSB and discretionary food groups (including takeaways) were highlighted in red and turquoise colours, respectively

Table 4.9 Percentage contribution of food groups to selected nutrients, in Pacific women

Energy, KJ		Protein, g		Fat, g		Saturated fat, g		Carbohydrate, g		Added sugar, g		Sodium, mg	
Food group	%	Food group	%	Food group	%	Food group	%	Food group	%	Food group	%	Food group	%
Takeaways	13.4	Takeaways	13.4	Takeaways	17.7	Butter, margarine, oils and fats	18.8	Fruit	13.4	SSB	17.3	Takeaways	19.6
Fruit	8.20	Poultry	12.2	Butter, margarine, oils and fats	16.2	Takeaways	16.6	Bread	12.3	Discretionary sweet snacks	11.7	Discretionary breads, cereals and starchy foods	11.7
Bread	7.46	Red meat	11.9	Discretionary sweet snacks	8.05	Discretionary sweet snacks	9.80	Takeaways	10.3	Discretionary dairy products	7.37	Sauces, spreads and flavourings (savoury)	11.3
Discretionary sweet snacks	7.09	Fish and Seafood	9.74	Red meat	7.73	Milk	8.09	Discretionary sweet snacks	8.80	Sauces, spreads and flavourings (sweet)	3.93	Bread	11.0
Butter, margarine, oils and fats	5.83	Milk	8.14	Eggs	6.08	Red meat	8.06	SSB	8.22	Dairy-based foods	2.74	Fish and seafood	7.64
Milk	5.76	Bread	5.67	Milk	5.75	Cheese	7.55	Starchy Foods	7.54	Takeaways	2.15	Discretionary meat and meat-alternatives	7.12
Red meat	5.02	Vegetables (other)	4.39	Legumes, nuts and seeds	4.80	Eggs	6.96	Discretionary breads, cereals and starchy foods	7.00	Discretionary breads, cereals and starchy foods	1.95	Cheese	3.48

Energy, KJ		Protein, g		Fat, g		Saturated fat, g		Carbohydrate, g		Added sugar, g		Sodium, mg	
Food group	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**	**Food group**	**%**
Vegetables (other)	4.24	Discretionary meat and meat-alternatives	4.36	Cheese	4.74	Discretionary dairy products	4.79	Vegetables (other)	5.60	Cereal	1.34	Red meat	3.48
Discretionary breads, cereals and starchy foods	4.06	Eggs	4.05	Discretionary meat and meat-alternatives	4.62	Discretionary meat and meat-alternatives	4.20	Milk	5.12	Sauces, spreads and flavourings (savoury)	0.98	Milk	2.86

Colour key:

	Takeaways and Discretionary foods
	Sugar-Sweetened Beverages (SSB)

The top contributor towards total EI among Pacific women were takeaways (13.4%) (Table 4.9). Takeaways were also the highest contributors of protein (13.4%), total fat (17.7%) and sodium (19.6%). Overall, takeaways featured within the top three foods across all macronutrients, except for added sugar, where SSB (17.3%) featured as the top 'food'. Although takeaways (17.7%) contributed the most towards total fat, the highest contributors of SFA were butter, margarine, oils and fats (18.8%).

4.7 Dietary intake of women in higher versus lower body fat percentage groups

Daily EI and macronutrients among Māori women (n=79) in lower (<35%) versus higher (≥35%) BF percentage groups are displayed in Table 4.10.

Table 4.10 Energy and macronutrient intake according to body fat percentage group of Māori women

Macronutrient and unit of measure	**Reference value**	**Intake, daily average**		***P-Value***
		BF ≥35%	**BF <35%**	
Energy, including DF [a] (KJ)	8800 KJ[1]	9556 (8414, 10699)	9982 (8727, 1237)	0.613
Protein [a] (g)	35-37g (0.62-0.60g/kg)[2]	105 (91, 119)	108 (94, 123)	0.737
Protein as a % of energy [a] (%)	15-25%[3]	18.8 (17, 20)	18.5 (18, 19)	0.685
Total fat [a] (g)	**	91.9 (81, 103)	97.3 (83, 112)	0.554
Total fat as a % of energy [a] (%)	20-35%[3]	36.3 (34, 39)	35.6 (33, 38)	0.627
Saturated fat [b] (g)	**	30.6 [17 - 42]	22.8 [0.0 - 38]	0.166
Saturated fat as a % of energy [a] (%)	<10%[4]	11.8 (9.7, 13.9)	9.67 (7.2, 12)	0.188
Carbohydrate [a] (g)	**	235 (200, 270)	244 (210, 279)	0.705
Carbohydrate as a % of energy [b] (%)	45-65%[3]	39.3 [36 - 43]	41.3 [37 - 45]	0.465
Added sugars (glucose and sucrose) as a % of energy [a]	<10%[5]	12.9 (12, 14)	13.0 (12, 14)	0.619

[a] = Mean (95% confidence interval); [b] = Median [25th - 75th percentiles]; ** = Nutrients without a NRV (nutrient reference value); * = P-Value <0.05; AMDR = Acceptable macronutrient distribution range; DF = Dietary fibre; EAR = Estimated Average Requirement; EER = Estimated Energy Requirement; EI = Energy intake; PAL = Physical activity level; SFA = Saturated fat; WHO = World Health Organization

1. EER calculation for women 31-50 years, with an average height of 1.6 metres, and a PAL[6] of ~1.6 (Schofield, 1985; Black et al., 1996; German Nutrition Society, 2002; Trumbo et al., 2002; NHMRC, 2006)
2. EAR for participants 19-50 years (NHMRC, 2006)
3. AMDR for adults: Macronutrients are expressed as a percentage of EI, in KJ (NHMRC, 2006)
4. Inadequate intake of SFA is intake above the limit provided, rather than below
5. The WHO, UK and Germany recommend ≤10% EI is from added sugars (NHMRC, 2006; WHO, 2015; WHO & FAO, 2003)
6. The PAL of 1.6 represents someone who is minimally active (Black et al., 1996; Trumbo et al., 2002)

Table 4.10 presents no statistically significant difference ($p > 0.05$) between reporting of EI and macronutrients in Māori with BF ≥35% versus BF <35%. No differences were observed in the outcomes when different BF percentage cut-offs (≥30%/ <30% BF) and BMI (≥30/ <30 kg/m^2) were used ($p > 0.05$).

Daily EI and macronutrients among Pacific women (n=75) in lower (<35%) versus higher (≥35%) BF percentage groups are displayed in Table 4.11.

Table 4.11 Energy and macronutrient intake according to body fat percentage group of Pacific women

Macronutrient and unit of measure	Reference value	Intake, daily average		*P-Value*
		BF ≥35%	BF <35%	
Energy, including DF [a] (KJ)	8800 KJ[1]	12912 (11269, 14555)	9089 (7718, 10460)	0.001*
Protein [a] (g)	35-37g (0.62-0.60g/kg)[2]	133 (117, 149)	96.9 (82, 112)	0.001*
Protein as a % of energy [a] (%)	15-25%[3]	17.9 (17, 19)	18.5 (17, 20)	0.571
Total fat [a] (g)	**	124 (109, 140)	87.1 (70, 104)	0.002*
Total fat as a % of energy [a] (%)	20-35%[3]	36.1 (34, 38)	34.8 (33, 37)	0.366
Saturated fat [b] (g)	**	29.7 [0.0 - 52]	18.8 [0.0 - 32]	0.110
Saturated fat as a % of energy [a] (%)	<10%[4]	9.41 (7.1, 12)	8.01 (5.4, 11)	0.418
Carbohydrate [a] (g)	**	338 (285, 391)	230 (197, 263)	0.001*
Carbohydrate as a % of energy [b] (%)	45-65%[3]	42.9 [37 - 47]	42.3 [36 - 47]	0.599
Sugars [a] (g)	**	156 (129, 183)	110 (95, 124)	0.003*
Added sugars (glucose and sucrose) as a % of energy [a]	<10%[5]	12.4 (11, 13)	12.6 (11, 14)	0.577

[a] = Mean (95% confidence interval); [b] = Median [25th - 75th percentiles]; ** = Nutrients without a NRV (nutrient reference value); * = P-Value <0.05; AMDR = Acceptable macronutrient distribution range; DF = Dietary fibre; EAR = Estimated Average Requirement; EER = Estimated Energy Requirement; EI = Energy intake; PAL = Physical activity level; SFA = Saturated fat; WHO = World Health Organization

1. EER calculation for women 31-50 years, with an average height of 1.6 metres, and a PAL[6] of ~1.6 (Schofield, 1985; Black et al., 1996; German Nutrition Society, 2002; Trumbo et al., 2002; NHMRC, 2006)
2. EAR for participants 19-50 years (NHMRC, 2006)
3. AMDR for adults. Macronutrients are expressed as a percentage of EI, in KJ (NHMRC, 2006)
4. Inadequate intake of SFA is intake above the limit provided, rather than below
5. The WHO, UK and Germany recommend ≤10% EI is from added sugars (NHMRC, 2006; WHO, 2015; WHO 2003)
6. The PAL of 1.6 represents someone who is minimally active (Black et al., 1996; Trumbo et al., 2002)

Table 4.11 shows intake of energy (42.1% ↑), protein (37.3% ↑), total fat (42.4% ↑), carbohydrate (47.0% ↑), and sugars (41.8% ↑) were statistically significantly higher ($p < 0.05$) in Pacific women with BF ≥35% than those with BF <35%.

Average daily SSE of particular food groups in Māori women (n=79) with lower (<35%) versus higher (≥35%) BF percentage are displayed in Table 4.12.

Table 4.12 Food group intake according to body fat percentage group of Māori women

Food	**Daily intake, as SSE[1]**		***P-Value***
	BF ≥35%	**BF <35%**	
Alcohol	0.594 ± 0.9	0.553 ± 1.0	0.846
Bread	1.77 ± 1.5	1.57 ± 1.8	0.587
Butter, margarine, oils and fats	1.43 ± 1.0	1.20 ± 1.0	0.300
Cereal	0.533 ± 0.6	0.903 ± 1.1	0.078
Cheese	0.341 ± 0.6	0.315 ± 0.4	0.811
Dairy-based foods	0.288 ± 0.4	0.437 ± 0.5	0.161
Discretionary breads, cereals and starchy foods	0.230 ± 0.5	0.214 ± 0.5	0.884
Discretionary dairy products	0.315 ± 0.4	0.339 ± 0.5	0.813
Discretionary meat and meat-alternatives	0.430 ± 0.3	0.389 ± 0.3	0.544
Discretionary savoury snacks	0.193 ± 0.2	0.124 ± 0.2	0.121
Discretionary sweet snacks	1.10 ± 1.0	1.03 ± 1.1	0.777
Drinks	4.42 ± 2.0	4.44 ± 2.5	0.963
Eggs	0.411 ± 0.3	0.694 ± 0.8	0.047*
Fish and Seafood	0.506 ± 0.5	0.461 ± 0.5	0.669
Fruit	2.76 ± 2.6	3.12 ± 2.5	0.534
Legumes, nuts and seeds	0.499 ± 0.6	0.847 ± 0.9	0.043*
Milk	0.748 ± 0.7	1.29 ± 1.0	0.010*
Poultry	0.630 ± 0.6	0.629 ± 0.5	0.995
Red meat	0.653 ± 0.4	0.607 ± 0.6	0.698
Sauces, spreads and flavourings (savoury)	0.617 ± 0.4	0.684 ± 0.5	0.537
Sauces, spreads and flavourings (sweet)	0.569 ± 0.5	0.420 ± 0.3	0.141
SSB[2]	1.26 ± 1.4	1.09 ± 1.2	0.550
Starchy Foods	0.445 ± 0.4	0.477 ± 0.4	0.736
Starchy vegetables	0.651 ± 0.7	0.535 ± 0.4	0.402
Takeaways	0.749 ± 0.5	0.525 ± 0.5	0.048*
Vegetables (other)	3.43 ± 1.9	3.62 ± 2.5	0.698

Values presented as Mean ± Standard Deviation; * = P-Value <0.05; EAGNZA = Eating and Activity Guidelines for New Zealand Adults; SSB = Sugar-sweetened beverages; SSE = Standard serving equivalents

1. SSE of foods in each food group, as outlined in the Eating and Activity Guidelines for New Zealand Adults (EAGNZA) (MOH, 2015b)
2. The EAGNZA define SSB as fruit drinks, flavoured water, carbonated or fizzy drinks, cordial, powdered drinks, energy drinks, and sports drinks (MOH, 2015b)

Table 4.12 shows there were significantly different (p <0.05) intakes of eggs; legumes, nuts and seeds; milk; and takeaways between the higher (≥35%) and lower (<35%) BF groups in Māori women. Those with a higher BF percentage consumed 42.7% more takeaways, whereas those with a lower BF percentage consumed 68.9% more eggs; 69.7% more legumes, nuts and seeds; and 72.5% more milk.

Average daily SSE of particular food groups in Pacific women (n=75) with lower (<35%) versus higher (≥35%) BF percentage are displayed in Table 4.13.

Table 4.13 Food group intake according to body fat percentage group of Pacific women

Food	Daily intake, as SSE[1]		*P-Value*
	BF ≥35%	BF <35%	
Alcohol	0.136 ± 0.4	0.379 ± 0.7	0.086
Bread	2.80 ± 2.7	1.63 ± 1.7	0.026*
Butter, margarine, oils and fats	1.81 ± 1.2	1.03 ± 0.8	0.002*
Cereal	0.725 ± 0.9	0.565 ± 0.5	0.335
Cheese	0.285 ± 0.4	0.196 ± 0.3	0.326
Dairy-based foods	0.228 ± 0.6	0.234 ± 0.3	0.956
Discretionary breads, cereals and starchy foods	0.645 ± 0.9	0.208 ± 0.4	0.006*
Discretionary dairy products	0.589 ± 0.9	0.389 ± 0.5	0.232
Discretionary meat and meat-alternatives	0.470 ± 0.4	0.332 ± 0.3	0.117
Discretionary savoury snacks	0.319 ± 0.5	0.209 ± 0.2	0.206
Discretionary sweet snacks	1.44 ± 1.4	0.896 ± 0.7	0.027*
Drinks	4.01 ± 2.1	3.80 ± 2.1	0.677
Eggs	0.617 ± 0.6	0.408 ± 0.5	0.122
Fish and Seafood	0.538 ± 0.5	0.462 ± 0.4	0.519
Fruit	3.42 ± 3.0	2.37 ± 1.6	0.052
Legumes, nuts and seeds	0.637 ± 0.6	0.585 ± 0.6	0.734
Milk	1.07 ± 1.0	0.997 ± 1.0	0.749
Poultry	0.670 ± 0.7	0.525 ± 0.4	0.261
Red meat	0.764 ± 0.6	0.504 ± 0.3	0.018*
Sauces, spreads and flavourings (savoury)	1.21 ± 1.3	0.616 ± 0.5	0.007*
Sauces, spreads and flavourings (sweet)	0.797 ± 0.8	0.457 ± 0.4	0.018*
SSB[2]	2.06 ± 2.7	1.25 ± 1.5	0.108
Starchy Foods	0.772 ± 0.8	0.398 ± 0.3	0.007*
Starchy vegetables	0.803 ± 0.8	0.728 ± 0.8	0.698
Takeaways	1.25 ± 1.3	1.03 ± 1.7	0.574
Vegetables (other)	3.50 ± 2.7	3.16 ± 2.2	0.566

Values presented as Mean ± Standard Deviation; * = P-Value <0.05; EAGNZA = Eating and Activity Guidelines for New Zealand Adults; SSB = Sugar-sweetened beverages; SSE = Standard serving equivalents

1. SSE of foods in each food group, as outlined in the Eating and Activity Guidelines for New Zealand Adults (EAGNZA) (MOH, 2015b)
2. The EAGNZA define SSB as fruit drinks, flavoured water, carbonated or fizzy drinks, cordial, powdered drinks, energy drinks, and sports drinks (MOH, 2015b)

Table 4.13 shows there were significantly different (p <0.05) intakes of bread; butter, margarine, oils and fats; discretionary breads, cereals and starchy foods; discretionary sweet snacks; red meat; sauces, spreads and flavourings (savoury/sweet); and starchy foods between the Pacific women in higher (≥35%) and lower (<35%) BF percentage groups. Those with a higher BF percentage had 71.8% more bread; 75.7% more butter, margarine, oils and fats; 210% more discretionary breads, cereals and starchy foods; 60.7% more discretionary sweet snacks; 51.6% more red meat; 96.4% more sauces, spreads and flavourings (savoury); 74.4% more sauces, spreads and flavourings (sweet); and 94.0% more starchy foods.

5.0 Discussion

5.1 Overall findings

The average BMI and BF of Māori and Pacific women classified them as overweight and obese, respectively. There were significant positive correlations between the BMI and BF percentage, suggesting BMI is a good indicator of BF percentage in these populations. Comparing dietary intake with NZ guidelines revealed that both groups of women consumed inadequate carbohydrate, yet excess total fat and excess SFA. Regarding micronutrients, more than half of the Māori and Pacific women had inadequate intake of manganese and iodine, while almost all women exceeded the UL for sodium. Takeaways contributed the most towards total sodium intake in Māori (16.3%) and Pacific women (19.6%). In Pacific women, takeaways were also the top contributor of total EI (13.4%), protein (13.4%) and fat (17.7%). Māori women with BF ≥35% consumed more takeaways, yet women with a BF <35% consumed more healthy foods e.g. eggs,legumes, nuts and seeds; and milk ($p < 0.05$). Pacific women with BF ≥35% consumed more discretionary breads, cereals and starchy foods.

5.2 Anthropometry

On average, 35.4% of Māori women from the current study were overweight (28.2 kg/m^2 and 34.6%), as defined by both BMI (25.0-29.9 kg/m^2) and BF (30-34.9%) (Table 4.1) (De Lorenzo, Martinoli, Vaia, & Di Renzo, 2006; Marques-Vidal et al., 2008; Oliveros et al., 2014; Romero-Corral et al., 2009). In addition, there was a high percentage of obesity (29.2%), according to BMI categories. Comparable studies reported varied results for BMI, ranging between 29.1-33.3 kg/m^2 (Brooking, Williams, & Mann, 2012; Mihaere et al., 2009; MOH, 2015a, 2012a; Swinburn et al., 1999; Taylor et al., 2010; Rush et al., 2009a; Rush et al., 2009b; Rush et al., 2007). Although most studies found Māori women were obese (≥30 kg/m^2), women in Mihaere et al.'s (2009) study had an overweight BMI (29.1 kg/m^2), which was closest to women in the current study (28.2 kg/m^2). Since Mihaere et al. (2009) had data from more participants (1732 Māori women), their average BMI is likely to better represent NZ Māori women.

On average, 54.7% of Pacific women from the current study were obese (31.9 kg/m^2 and BF of 37.8%) (Table 4.1) (De Lorenzo, Martinoli, Vaia, & Di Renzo, 2006; Marques-Vidal et al., 2008; Oliveros et al., 2014; Romero-Corral et al., 2009), whilst 29.3% were overweight. Comparable studies reported similar results for Pacific women, with BMIs ranging between 30.7-35.2

kg/m^2, all in the obese range (Amosa, Rush, & Plank, 2001; Bell, Amosa, & Swinburn, 1997; MOH, 2015a, 2011a; Rush et al., 2009b; Rush et al., 2007; Swinburn et al., 1999; Tomisaka et al., 2002).

Very few Māori (10.1%) and Pacific women (2.7%) were categorised in the "Hidden fat" or normal weight obesity (NWO) group (De Lorenzo, Martinoli, Vaia, & Di Renzo, 2006; Marques-Vidal et al., 2008; Oliveros et al., 2014; Romero-Corral et al., 2009), compared with Māori (55.7%) and Pacific (77.3%) women categorised in the "Apparent Fat" group (BMI (≥25 kg/m^2) and BF (≥30%)). Consequently, there were significant positive correlations between the BMI and BF of Māori (r=0.857) and Pacific women (r=0.871). This is consistent with other studies where a higher BF percentage is often correlated with a higher BMI (McAdams, Van Dam, & Hu, 2007; Taylor et al., 2010), especially in women with BMIs ≥24 kg/m^2 (Shah & Braverman, 2012). This is likely to hold true for the Māori (28.2 kg/m^2) and Pacific women (31.9 kg/m^2) in this study, who both have an average BMI ≥24 kg/m^2.

Despite previous literature documenting rising rates of obesity, there were fewer obese Māori and Pacific women in the 2015/16 EXPLORE study compared with the 2014/15 NZHS and the 2008/09 NZANS (MOH, 2011, 2012) (Table 5.1). The age-range of women in the EXPLORE study was between 16-45 years, whereas participants in the NZHS and NZANS were aged ≥15 years, allowing for greater variance in body composition. Women in older age brackets tend to have higher BMIs than younger women (Villareal, Apovian, Kushner, & Klein, 2005).

Ultimately, BF location (regional adiposity) is more important than BF percentage because fat stored around the organs (visceral fat), increases CVD risk (Cameron et al., 2009; Huxley et al., 2010; Kramer, Zinman, & Retnakaran, 2013; Martinez et al., 2008) and mortality (Mason, Craig, & Katzmarzyk, 2008). In comparison, thigh and arm circumference appears to be relatively benign, even showing a protective effect against mortality in a longitudinal study on all-cause mortality (Mason, Craig, & Katzmarzyk, 2008). Visceral adiposity can be indirectly measured by WC. Central adiposity is a useful marker of obesity because it relates directly to metabolic and cardiovascular risks (Cameron et al., 2009; Huxley et al., 2010; Kramer, Zinman, & Retnakaran, 2013; Martinez et al., 2008). Most Māori (55.7%) and Pacific women (73.3%) had a WC >80cm. Above this point (>80cm), there is an increased risk of metabolic complications associated with obesity (WHO, 2008). Further research should investigate the relationship between WC and specific dietary components or food, because WC is a better indicator of health than total BF percentage.

Table 5.1 presents the percentage of Māori and Pacific women from the women's EXPLORE study who were overweight and obese compared with the NZHS (2014/15) and NZANS (2008/09).

Table 5.1 BMI categories of Māori and Pacific women in comparable New Zealand studies

BMI category	EXPLORE, 2015/16		NZHS, 2014/15		NZANS, 2008/09	
	Māori (n=79)	Pacific (n=75)	Māori (n=1913)	Pacific (n=518)	Māori (n=588)	Pacific (n=343)
Overweight, 25.0-29.9 kg/m^2 (% participants)	35.4	29.3	26.2	19.1	28.9	25.9
Obese, ≥30.0 kg/m^2 (% participants)	29.2	54.7	47.6	69.5	49.0	61.5

BMI = Body mass index; EXPLORE = Examining the Predictors Linking Obesity Related Elements; NZANS = New Zealand Adult Nutrition Survey; NZHS = New Zealand Health Survey

5.3 Energy intake

The EXPLORE study Māori (9761 KJ) and Pacific women (11484 KJ) reported a higher average EI than those in the NZANS and DHHS (Table 5.2) (MOH, 2012a). This may partly be due to the analysis of butter, margarine, oils and fats (BMOF), which have the highest energy density (fats) of all the macronutrients. EXPLORE's FFQ enquired the type, amount and frequency of BMOF (Appendix 1). In comparison, the NZANS coupled BMOF with the foods to which they were added, rather than in a separate 'BMOF' group (MOH, 2011a). This may have under-estimated the amount of BMOF consumed by participants in the NZANS. The EXPLORE FFQ also utilised cross-checking, through different questions on SSE of BMOF, in separate sections of the FFQ. For instance, the number of SSE used per dish and per week in food preparation/ cooking, and the frequency of using dressings and sauces, including BMOF. Therefore, cross-checking questions are a useful way to validate answers (Gibson, 2005) and helped to minimise the chance of under-reporting EI in this study.

Table 5.2 compares daily EI from Māori and/ or Pacific women in the women's EXPLORE study, NZANS (2008/09) and DHHS (2008).

Table 5.2 Energy intake among Māori and Pacific women in comparable New Zealand studies

Daily energy intake	EXPLORE, 2015/16		NZANS, 2008/09		DHHS, 2008	
	Māori (n=79)	Pacific (n=75)	Māori (n=588)	Pacific (n=343)	Māori (n=562)	Pacific (n=508)
Energy Intake (KJ)	9761	11484	7632	7970	9600	10300

BMI = Body mass index; EXPLORE = Examining the Predictors Linking Obesity Related Elements; NZANS = New Zealand Adult Nutrition Survey; NZHS = New Zealand Health Survey

General under-reporting could have contributed towards disparity in EI between the current study and NZANS. Gemming et al. (2014) found that under-reporting was highest in Māori (31.8%) and Pacific (34.3%) women from the NZANS, especially if they were overweight or obese. These findings were consistent in multiple studies (Black, 2000a; Gnardellis, Boulou, & Trichopoulou, 1998; Houston, 2014; Livingstone & Black, 2003; Rush et al., 2004; Subar et al., 2003) because it is likely that obese people are more ambivalent of dietary (energy) intake (Vandenbroeck et al., 2007). Furthermore, social desirability bias can cause under-reporting of foods that are perceived to be unhealthy, such as biscuits, fats, cakes and desserts. Social desirability bias encompasses the propensity of participants to provide what they believe would be the most socially acceptable answers but does not necessarily reflect their true eating behaviours (Fisher, 1993; Klesges, Baranowski, Beech, Cullen, Murray, Rochon, & Pratt, 2004; Nederhof, 1985).

There also may have been under-reporting of EI in the DHHS because participants did not specify whether they were trying to lose/ gain weight, or were free from chronic disease and illness, whereas participants in the current study did. These factors could have affected the usual relationship between EI and EE/ storage. For instance, if participants were trying to lose weight, they are likely to have a lower EI than the EER for their current body weight/ height. However, compared to NZANS participants, Māori (9600 KJ) and Pacific women (10300 KJ) from the DHHS had similar EI to those in the current study.

Similarity in EI between the current study and DHHS may partly be due to their method of dietary assessment, using a FFQ. The current study used a 220-item, self-administered, semi-quantitative FFQ, while the DHHS had a 142-item FFQ, which was validated and reproducible in Māori and Pacific participants (Metcalf et al., 2008). Cade, Thompson, Burley, & Warm (2002) reviewed the development, validation and utilisation of FFQs. They found FFQs over-estimated dietary intake under certain circumstances, such as when participants were presented with a long list of FAVs, with numerous food items, and with options for consuming the food item multiple times a day (Cade, Thompson, Burley, & Warm, 2002). More specifically, Metcalf et al. (1997) tested the reproducibility and validity of a FFQ in Polynesian NZers and found Pacific participants were more likely to over-estimate their total EI (Metcalf et al., 1997). Instead of a FFQ, the NZANS used multiple-pass 24-hour dietary recalls to overcome this. Although 24-hour dietary recalls have demonstrated more precision than FFQs, they are time-consuming and require skilled assessors (Livingstone & Black, 2003).

The EER of Māori and Pacific women (8800 KJ) in the current study was calculated from a formula based on women aged 31-50 years, with an average height of 1.6 metres, and a PAL of ~1.6 (Schofield, 1985; Black et al., 1996; German Nutrition Society, 2002; Trumbo et al., 2002; NHMRC, 2006). These variables took into account the age-range, height and probable PAL of most of the Māori and Pacific women in the current study. The percentage of Māori women who exceeded their 8800 KJ guideline was 58.2%, which is similar to the percentage (51.9%) of women found in the in the obese BF group (BF ≥35%). Similarly, 62.7% of Pacific women exceeded their EER (8800 KJ), which is identical to the percentage (62.7%) of women found in the obese BF group. This suggests a link between excess EI with excess BF percentage, which has been well documented in the literature (Peters, Wyatt, Donahoo, & Hill, 2002; Rodriguez et al., 2015; Vadiveloo et al., 2015).

Women in this study were less likely to be obese than those in the NZANS, even though they reported higher average EIs (↑ 27.9%-44.1%) (Table 5.2) (MOH, 2012a). Average EI may have been higher because of under-reporting found among Māori (31.8%) and Pacific (34.3%) women from the NZANS (Gemming et al., 2014). Similarly, Pacific BMI (31.9 kg/m^2) was 11.6% lower than women in the DHHS (35.6 kg/m^2), despite women in the current study having an 11.5% higher EI (Metcalf et al., 2008). However, it is expected for women in an older age bracket (35-74 years in the DHHS) to have a higher BMI than those in a younger age bracket (16-45 years in the current study), reaching a peak around 50-59 years (Villareal, Apovian, Kushner, & Klein, 2005).

Depending on their activity levels, EE could have made a huge difference to the estimation of energy requirements and relation to BF percentage. For instance, it was expected for participants with a greater EE to have a greater EI (National Research Council, 1989), rather than an increase in body weight. However, more recent studies found that increases in EE did not necessarily increase hunger or EI (Blundell & King, 1998). Instead, EI would increase with EE when participants misjudged the rate at which they could expend energy or rewarded themselves with inappropriate foods, such as those which are energy-dense and nutrient-poor (Blundell & King, 1998). Despite all these findings on EI, the most up-to-date research recommends avoiding use of self-reported EI as a true measure of EI (Subar et al., 2015). Instead, Subar et al. (2015) suggested using both short-term (e.g. food recalls) and long-term (e.g. FFQ) approaches to assessing dietary intake of study populations because it would help maximise the strengths of each method. Although this would take more time, the data would be more reliable.

5.4 Macro and micronutrient intake

The mean macronutrient distribution of the total EI of Māori women (9761 KJ) revealed a high percentage of fat (36%), SFA (14.5%) and added sugars (12.8%) (Table 5.3). Total fat should be within the AMDR of 20-35% of EI, while SFA should be <10% of EI to reduce the risk of CHD (Mozaffarian, Micha, & Wallace, 2010; NHMRC, 2006). Similarly, added sugars should not exceed 10% of EI (NHMRC, 2006; WHO, 2015; WHO 2003). Nonetheless, 63.3% of participants exceeded this guideline (Table 4.2), suggesting there are sugar-rich foods in their diet, particularly SSB (see Table 4.7 and Table 4.8). Their intake of added sugar is likely to be more accurate than for women in the NZANS and the DHHS (Table 2.11) because both sucrose and glucose were included in the count, rather than sucrose on its own. Perhaps the poorly satiating effect of these added sugars (Malik, Popkin, Bray, Després, & Hu, 2010) and appetite-stimulating effect of fat (Prentice, 1998; Gaysinskaya, Karatayev, Chang, & Leibowitz, 2007; Jaworowska et al., 2013) encouraged women in this study to consume extra energy (10.9% ↑), additional to that required for weight maintenance (8800 KJ). Ultimately, it is the extra EI rather than the proportion of macronutrients that cause changes in weight (Austin, Ogden, & Hill, 2011; National Research Council, 1989; Van Dam & Seidell, 2007).

Despite consuming 28% excess added sugar, their average intake of carbohydrate (40% of EI) was 5% below the AMDR (45-65% of EI). Carbohydrates provide less energy, per gram, than fat (Zou, Moughan, Awati, & Livesey, 2007); therefore, an imbalance between fat and carbohydrate in an ad libitum diet is likely to cause excessive EI. Complex carbohydrates, such as those found in wholegrain breads, cereals, legumes and vegetables, are an excellent source of DF and B vitamins (Sivakumaran, Huffman, Sivakumaran, & Athar, 2015). In particular, soluble DF has demonstrated significant satiating effects, thus aiding weight loss/maintenance (Aller et al., 2004; James, Muir, Curtis, & Gibson, 2003; Lunn, & Buttriss, 2007; Threapleton et al., 2013). However, the DAS used (FoodWorks 8 (Xyris Software (Australia) Pty Ltd, Queensland, Australia)) did not differentiate between different types of DF (soluble versus insoluble) (FoodWorks Professional, 2016). This was due to limitations in the extent of food analysis in the food composition database (NZ FOODfiles 2014). Regardless, 65.8% of women met the AI for total DF (25g), perhaps due to their high intake of fruits (~3) and vegetables (~4) (Table 4.4). Nevertheless, FAVs are usually over-reported in FFQs (Cade, Thompson, Burley, & Warm, 2002). Zou et al. (2007) discovered that high-DF diets over-estimate EI because of the inaccuracy of Atwater factors (food energy conversion factors). Participants in the NZANS and DHHS consumed at least 16.9% less DF than those in the current study (Table 5.3). Perhaps this higher intake of DF contributed towards the falsely greater EI of women in this study compared with participants in the NZANS and DHHS (Table 5.2).

Like Māori women, the total EI of Pacific women (11484 KJ) also consisted of a high percentage of fat (35.6%), SFA (14.2%) and added sugars (12.4%) (Table 5.3). Their average intake of carbohydrates (42.8% of EI) was also below the AMDR and DF (35.1g) met the AI (NHMRC, 2006).

Compared with the DHHS, NZANS, and NZHS, both Māori and Pacific women in the current study reported higher intakes of protein, fat and SFA, yet lower carbohydrate intakes (Table 5.3). During the data collection phase for this study (2014/15), there was a lot of media coverage that proposed the benefits of Low-carbohydrate High-fat (LCHF) diets (DNZ, 2016). Celebrities and some health professionals endorsed these ideas. However, consuming high-fat meat and full-fat dairy products goes against the NZ dietary guidelines, which promote the consumption of low-/reduced-fat options to minimise intake of SFA and thus reduce the risk of CVD (Castelli, Garrison, Wilson, Abbott, Kalousdian, & Kannel, 1986; Mensink & Katan, 1992). Furthermore, advising against legumes (as many low-carbohydrate diets do) would remove a rich source of DF and vegetarian protein. The soluble DF in legumes, oats, and FAVs acts to reduce total and low-density lipoprotein (LDL) cholesterol (James, Muir, Curtis, & Gibson, 2003; Lunn, & Buttriss, 2007), reducing the risk of CVD (Castelli et al., 1986). Since women in this study reported consuming higher amounts of protein and SFA, it is likely that they were consuming high amounts of animal products (such as meat and full-fat dairy), which may be increasing their risk of CVD and death.

Diets which are high in fat (≥35% of EI) and low in carbohydrate (<45% of EI) may only be beneficial towards weight loss and heart health if the majority of those fats are unsaturated, the carbohydrates are complex, and EI does not exceed EE (Eguaras et al., 2015; Zazpe et al., 2008). Unsaturated fats, such as MUFAs and PUFAs, are rich in avocado, almonds, walnuts, flax seeds, olive oil, sunflower oil, and fish (especially oily fish e.g. salmon, mackerel, sardines and tuna). Complex carbohydrates are found in FAVs, legumes, wholegrain breads, cereals (e.g. oats) and grains (e.g. quinoa). These foods are typically part of the Mediterranean diet, frequently referred to in the literature (Eguaras et al., 2015; Salas-Salvadó et al., 2008; Zazpe et al., 2008). It may be easier for the women in the EXPLORE study, who have shown a high-fat and low-carbohydrate diet, to change their type of fats (SFA to MUFA and PUFA) and type of carbohydrates (simple to complex), rather than reduce their overall EI or change the distribution of macronutrients. Furthermore, results from Eguaras et al. (2015) and Zazpe et al.’s (2008) studies (participants on a high healthy-fat, Mediterranean-style diet) were similar to results from participants on a low-fat dietary pattern (Howard et al., 2006). This shows that is may be possible to achieve the same effect (weight loss and/ or improvement in CVD risk markers) using various dietary adjustments, depending on what the individual feels is more likely to be sustainable in their lifestyle.

Women in the EXPLORE study may have had a high intake of fat and low intake of carbohydrate because of increasingly poor cooking/ food literacy (Gorton, 2016; RSFSE, 2016). However, cooking and food literacy were not assessed in the current study. Without basic cooking and food preparation skills, children may transition into adulthood with a high reliance on convenient, energy-dense and nutrient-poor foods, such as takeaways (Gorton, 2016, Vegetables.co.nz, 2016). Takeaways, including chicken nuggets, fries, pizza, and burgers, are often high in total fat, SFA and sodium (Jaworowska et al., 2013). Considering the rising rates of obesity (MOH, 2015a) and associated healthcare costs (between $722-$849 million a year) (Lal, Moodie, Ashton, Siahpush, & Swinburn, 2012), it may be prudent for the Ministry of Education to reprioritise school curriculums with some focus on food literacy and cooking.

Regarding micronutrients, Māori women were consuming inadequate amounts of manganese (4179µg) and iodine (82.4µg), yet excess levels of sodium (2813mg) (Table 4.3). Manganese is rich in wholegrains and leafy green vegetables (Sivakumaran et al., 2015), which suggests participants had low intake of these foods. Leafy green vegetables (such as broccoli, asparagus and spinach) are also a rich source of folate and beta-carotene (Sivakumaran et al., 2015). Consequently, a high percentage of women (32.9%) had low intakes of these two nutrients. Folate is especially important for women of child-bearing age because they have higher requirements (at least double) to support the development of their newborn baby and prevent neural tube defects (NHMRC, 2006).

Iodine intake may have been low because of low levels of iodine in NZ soil (Thomson, 2004). Hence, locally grown FAVs and animal produce will also be low in iodine. Dairy products used to be contaminated with iodine but fewer farmers are using these sanitisers (Cressey, 2003). Instead, iodine can be sourced from marine food (e.g. fish, shellfish and seaweed), commercially prepared bread and iodised salt (FSANZ, 2016). However, fish and seafood were the least-consumed (non-discretionary) source of meat and meat alternatives (Table 4.5). Additionally, consumption of bread (assuming it was commercially prepared and therefore iodised) has fallen since the previous studies on dietary intake of Māori women in NZ. On average, Māori women ate 1.67 SSE of bread per day, which would provide about 25.6µg of iodine. If they were to eat one more slice of bread (preferably wholemeal), their average intake (82.4µg) would meet the daily requirement of 100µg.

Salt was iodised in 1924 in NZ, to help correct deficiencies (Thomson, 2004). Unfortunately, this has not always been very effective because there are non-iodised salts on the market (e.g. rock salt) and widespread health messages promoting the reduction in salt, for heart health e.g. Slash the Salt campaign (Stroke Foundation of NZ, n.d.). Instead of adding salt to meals, processed food have been estimated to contribute about 65-80% towards total dietary sodium (Brown, Tzoulaki, Candeias, & Elliott, 2009; He & MacGregor, 2009; Thomson, Vannoort, & Haslemore, 2008). This reflected findings in the current study, where Takeaways (16.3%) and Bread (10.6%) were the highest contributors towards total sodium intake (Table 4.8). Nearly all the Māori women (98.7%) had excess sodium intake. Mean intake exceeded the AI by 206% and exceeded the UL by 22.3%. The UL is a value used to protect the public from adverse health effects of nutrient toxicity (NHMRC, 2006). It is therefore concerning that over half of the women (58.2%) exceeded the UL for sodium. Adverse effects from excess sodium include hypertension, stroke, and CVD (NHMRC, 2006; Sacks et al., 2001).

Although the average intake of calcium was adequate (1119 mg), 32.9% of Māori women failed to meet guidelines (840 mg) (Table 4.3). It is concerning that these women were consuming inadequate levels of calcium and manganese (4179µg) because both elements are essential for bone formation (NHMRC, 2006). Dairy products have highly absorbable calcium and are the richest food source, per serve (NHMRC, 2006). Other sources of calcium include dark green, leafy vegetables and the bones of canned fish (Sivakumaran et al., 2015). However, these foods have varying levels of absorbable (bioavailable) calcium and are not eaten as often as dairy products (MOH, 2015b; NHMRC, 2006). With the help of vitamin D, calcium is absorbed into the bones. From birth until the age of ~22 years, women are accruing bone mass at a very fast rate (Teegarden et al., 1995). To reach their peak bone mass, women must consume adequate calcium. After this window of opportunity, bone mass accrual is very slow and begins to fall during menopause (Teegarden et al., 1995). Therefore, it is important for women to consume adequate calcium during their younger years, so they can optimise their peak bone mass and thus increase the time it takes for them to reach the osteoporosis/fracture threshold.

Like Māori women, Pacific consumed inadequate amounts of manganese (4980µg) and iodine (84.4µg), yet excess levels of sodium (3764mg). This study was unique in assessing intake of manganese, iodine and sodium because comparable studies (NZHS, NZANS, and DHHS) did not

(Table 4.3 and Table 5.3). However, data from these three micronutrients could be inaccurate because of difficulty assessing dietary sources, such as levels of manganese in drinking water, varying iodine content of food (depending on how it is made and where it is grown), and quantification of sodium added in recipes or at the table (Bentley, 2006; Daughney, 2003; McLean, 2014; Thomson et al., 2008). Nonetheless, women (≥25 years) in the 2003/04 New Zealand Total Diet Survey (NZTDS) had an average daily exposure to sodium of 2150mg per day, which is similar to the 2813mg consumed by Māori women in the current study (Table 4.3). The NZTDS also failed to account for addition of sodium in recipes and at the table, which is estimated to contribute 11-20% of total sodium intake (Thomson et al., 2008). Furthermore, the NZTDS found participants had a low (and decreasing) exposure to dietary iodine and excessive exposure to sodium (Thomson et al., 2008). These results could explain why women in the current study had inadequate and excessive intakes of iodine and sodium, respectively.

Although average intake of manganese was only 0.40% below the AI, 66.7% of Pacific women had inadequate intakes, similar to Māori women (68.4%). As discussed above, foods such as wholegrains (unprocessed grain foods) and leafy green vegetables are rich in manganese (NHMRC, 2006; Sivakumaran et al., 2015), which suggests Māori and Pacific women had low intake of these foods. It is difficult to ascertain the SSE of wholegrains and leafy green vegetables because food groups were not disaggregated into these particular categories (Appendix 3). However, 93.7% of Māori women and 81.3% of Pacific women consumed inadequate SSE of grain foods, with averages at 51.2% and 69% of the daily requirement (≥6 SSE), respectively (Table 4.4). Grain foods are inclusive of wholegrains and hence, participants were probably not consuming amounts necessary to meet manganese requirements. Green leafy vegetables were included in the non-starchy vegetables group called, 'Vegetables (other)'. Despite vegetables (other) being more popular than starchy vegetables (Table 4.5), 32.9% of Māori and 44% of Pacific women consumed inadequate SSE of total vegetables (<3 SSE) (Table 4.4). Therefore, it is also unlikely that participants were consuming adequate SSE of green leafy vegetables.

Despite consuming 3.57 SSE of seafood per week (Table 4.5) and 2.36 SSE of bread per day (Table 4.5), 65.3% of Pacific women had inadequate intakes of iodine. This highlights how difficult it is to achieve adequate levels of iodine (100µg) without consuming seaweed (3000µg iodine/ 100g) or sufficient iodine-fortified foods e.g. iodised salt and commercial bread (FSANZ, 2016; Sivakumaran et al., 2015). However, iodised salt (sodium) would not be an appropriate option because nearly all Pacific women (98.7%) exceeded the AI for sodium, with takeaways (19.6%) as the highest contributors (Table 4.9). Mean intake of sodium exceeded the AI by 309% and exceeded the UL by 63.7%, therefore increasing their risk of hypertension, stroke, and CVD (NHMRC, 2006; Sacks et al., 2001). Prentice, Smith, and McLean (2016) analysed the sodium content of food from 523 takeaway outlets. They found that fried chicken and sauces/ salad dressings had the highest sodium content (per 100g) in chain restaurants, whereas the mince/ cheese pies and battered hotdogs had the highest sodium content (per 100g) of independent outlets (Prentice, Smith, & McLean, 2016). These results suggest that efforts to gradually decrease the sodium content of supermarket foods (Monro, Mhurchu, Jiang, Gorton, & Eyles, 2015) are ineffective and should instead be directed towards reformulating the composition of takeaway foods.

Although their average intake of calcium was adequate (1125 mg), 38.7% of Pacific women failed to meet guidelines (840 mg). This may be due to only consuming an average 1.70 SSE of milk products and alternatives per day, which is 0.3 SSE less than the recommendation (≥2 SSE per day). Discretionary dairy products (0.514 SSE/ day) were consumed at least twice as often as cheese (0.252 SSE) and dairy-based foods (0.231 SSE). Discretionary dairy products include foods such as ice-cream, milk puddings, milkshakes, cream, and sour cream. These have varying amounts of calcium and are high in sugar and/or fat, perhaps contributing to their excess EI (11484 KJ).

There appears to be a general increase in protein over the years. However, with all of the studies in Table 5.3, protein intake was within guidelines (15-25% of EI). Intake of SFA also increased over the years, yet it exceeded the 10% limit among all studies in NZ: the women's EXPLORE study (14.5%), NZANS (14.2%) and DHHS (12.7%). Furthermore, those from the current study (36% of EI) and NZANS (35.6% of EI) also exceeded the 35% limit for total fat. Since fat has the highest amount of energy per gram, an excessive consumption of fat could have contributed towards excessive EI (>8800 KJ) of women in this study (Table 4.2).

Opposite to the incremental increase in protein, was the incremental decrease in carbohydrate, from 49.9% of EI in the 2008 DHHS, to 46.6% of EI in the NZANS, until 40% of EI in the current study (Table 5.3). At 40% of EI, carbohydrate was 12.5% below the guidelines (45-65% of EI). Although Māori women in the current study consumed inadequate carbohydrate, their average intake of calcium (1119mg) met guidelines (840mg), whereas women in previous studies had inadequate intakes of calcium (<840mg). In contrast, average retinol intake was adequate in the NZANS women (710μg), yet 19.6% below the guideline (500μg) for women in the current study (418μg). In contrast, intake of protein has increased

(16-18.1%), yet it has stayed within guidelines (15-25% of EI) throughout the years. Intake of SFA also increased, yet it exceeded the 10% limit in the women's EXPLORE study (14.2%), NZANS (13.5%), and DHHS (12.9%).

Table 5.3 shows daily nutrient intake among Māori and Pacific women in the women's EXPLORE study, NZANS, DHHS, and the DPRF.

Table 5.3 Daily macro and micronutrient intake among Māori and Pacific women in comparable studies

Nutrient and unit of measure	Reference value	EXPLORE, 2015/16		NZANS, 2008/09		DHHS, 2008		DPRF, 2002
		Māori (n=79)	Pacific (n=75)	Māori (n=588)	Pacific (n=343)	Māori (n=562)	Pacific (n=508)	Pacific (n=200)
Protein (% total EI)	15-25%[1]	18.6	18.1	16.3	16.9	15.9	17.8	16
Fat (% total EI)	20-35%[1]	36.0	35.6	35.6	34.7	34.3	33.4	33
Saturated fat (% total EI)	<10%[1]	14.5	14.2	14.2	13.5	12.7	12.9	
Carbohydrate (% total EI)	45-65%[1]	40.0	42.2	46.6	48.1	49.9	51.3	52
Fibre (g)	25g[2] (28g[3])	30.4	35.1	16.1	16.9	26	28	
Calcium (mg)	840mg[4]	1119	1125	711	604	796	800	710
Iron (mg)	8mg[4]	13.7	16.0	9.77*	10.4*			15
Zinc (mg)	6.5mg[4]	12.6	14.9	9.1	10.6			
Selenium (µg)	50µg[4]	84.6	91.1	51	57			
Retinol (µg)	500µg[4] (1220µg[3])	418	467	710	655			400
Carotene (µg)	5000µg[3]	7007	6754					5430
Vitamin B12 (µg)	2.0µg[4]	6.67	6.63	3.8	3.8			
Vitamin B1 (mg)	0.9mg[4]	1.82	1.74					1.1
Vitamin B2 (mg)	0.9mg[4]	2.77	2.94	1.7	1.5			1.4
Niacin equivalents (mg)	11mg[4]	49.3	54.2					20
Vitamin C (mg)	30mg[4]	162	171					160

* = Sourced from NZDep 2006 participants (Salmond et al., 2007); AI = Adequate Intake; AMDR = Acceptable macronutrient distribution range; DHHS = Diabetes, Heart and Health Study; DPRF = Dietary Patterns and Risk Factors study; EAR = Estimated Average Requirement; EI = Energy intake; EXPLORE = Examining the Predictors Linking Obesity Related Elements; NZANS = New Zealand Adult Nutrition Survey; SDT = Suggested dietary target

1. AMDR for adults. Macronutrients are expressed as a percentage of EI, in KJ (NHMRC, 2006)
2. AI for participants 19-50 years (NHMRC, 2006)
3. SDT (NHMRC, 2006)
4. EAR for participants 19-50 years (NHMRC, 2006)

Among Pacific women, consumption of protein (18.1%), total fat (35.6%) and SFA (14.2%) was higher in the current study than in the other three studies (NZANS, DHHS, DPRF) (Table 5.3). However, carbohydrate was lower (52% of EI in the 2002 DPRF, 51.3% in the DHHS, 48.1% in the DHHS, and 42.2% of EI in the current study). At 42.2% of EI, carbohydrate was 6.64% below the guidelines (45-65% of EI). Dissimilar to carbohydrate, women in this study (14.2%), NZANS (13.5%) and DHHS (12.9%) exceeded the SFA limit (10% of EI), by at least 29%. Furthermore, women in the current study (35.6% of EI) exceeded the 35% limit for total fat. Excessive consumption of fat (>35% of EI) could have contributed towards excessive EI (>8800 KJ) (Table 4.2).

Protein consumption from all studies, including this one, was within the guidelines (15-25% of EI). On average, Pacific women (1119mg) in the current study also met guidelines for calcium (840mg), whereas women in the other studies were 5.00-39.1% below the guideline (840mg). Comparatively, average retinol intake was adequate among the NZANS women (655µg), yet 7.07% below the guideline (500µg) for women in the current study (467µg).

Overall, the Māori and/ or Pacific women in this study reported higher average intakes of protein; fat; SFA; DF; calcium; zinc; selenium; carotene; vitamin B12; vitamin B1; vitamin B2; niacin equivalents and vitamin C than women in the other studies (Table 5.3). However, their carbohydrate intake was lower and failed to meet the minimum requirement of 45% of EI. They also consumed inadequate retinol (<500µg), which is required for healthy reproduction, vision and immunity (NHMRC, 2006; Tee & Lee, 1992).

AMDRs estimate the ideal range of intake for each macronutrient, expressed as a percentage contribution to EI (NHMRC, 2006). By consuming macronutrients within these AMDRs, individuals allow for adequate intake of all other nutrients (NHMRC, 2006). Therefore, consuming carbohydrate below the AMDR (as seen in this study) is likely to result in deficiencies of other nutrients such as fibre and various B-vitamins, which are found in unrefined carbohydrate sources (e.g. wholemeal bread and cereals) (Sivakumaran et al., 2015).

5.5 Food groups

On average, Māori women (7.05 SSE) met the recommended SSE for fruit and vegetables (FAVs) (≥5 per day) (Table 4.4). However, individual results revealed that approximately one third of participants had inadequate fruit (39.2%) and vegetable (32.9%) intake. Consuming FAVs (above the guidelines) is associated with a lower risk of developing CHD and stroke, compared with populations who ate less than the guidelines (<5 SSE) (He, Nowson, Lucas, & MacGregor, 2007; He, Nowson, & MacGregor, 2006; Hung et al., 2004).

Furthermore, FAVs are the most commonly over-reported food, especially when presented in a long list (see Appendix 1) (Cade, Thompson, Burley, & Warm, 2002; Kristjansdottir, Andersen, Haraldsdottir, De Almeida, & Thorsdottir, 2006). The current study's FFQ was comprehensive, including a list of ~80 FAVs (50 vegetables and 30 fruit) (Appendix 1). Many of these items were grouped, such as citrus fruit (oranges, mandarins, tangelos, and grapefruit) and Pacific root vegetables (taro, cassava and breadfruit). Furthermore, FAVs do not contribute as much towards total EI compared with foods high in fat, which are the most energy-dense macronutrient, per gram (9kcal/gram) (Zou et al., 2007). Although cross-checking questions have been employed to identify potential misreporters, these can lead to underestimation of intake e.g. when asked about the SSE of fruit, participants may not have considered canned peaches as a SSE, or they may not be able to distinguish all vegetables from fruit (Cade, Thompson, Burley, & Warm, 2002).

Fruits and vegetables provide DF, a wide variety of vitamins, and minerals such as potassium and magnesium (Sivakumaran et al., 2015). If participants eat a variety of FAVs of different colours, they are likely to meet most of their requirements for DF and micronutrients. Instead, Māori women may have consumed a selective group of FAVs because 32.9% had low intakes of folate and beta-carotene, while 68.4% had inadequate manganese (Table 4.3). These three nutrients are high in leafy green vegetables, such as broccoli, asparagus and spinach (Sivakumaran et al., 2015). Legumes, including lentils, soybeans and kidney beans, are also rich in folate, while orange-/ red-coloured FAVs, such as kumara, pumpkin and carrots, are also rich in beta-carotene (Sivakumaran et al., 2015). Instead, Table 4.7 showed that the top FAVs (by weight) were bananas, apples and citrus fruit. These particular FAVs require little preparation and are relatively inexpensive, with a low/ moderate fluctuation in price throughout the year (ENZ, 2016; SNZ, 2013a). Price is highly influential in determining food choice (Metcalf et al., 2006; Metcalf et al., 2014; SNZ, 2013b).

Almost all Māori women (93.7%) consumed inadequate SSE of grain foods. Their average intake of 3.07 SSE was about half the SSE required to meet guidelines (≥6 SSE). Grain foods would have contributed towards the total carbohydrate count (40% of EI), which was also below guidelines (45-65% of EI). Furthermore, of the carbohydrates consumed, ~ 32% were added sugars, rather than the complex carbohydrates found foods such as wholegrain breads and cereals (Knudsen, 2015; Slavin, 2004). Complex carbohydrates are harder for the body to digest than simple/ refined carbohydrates because they contain longer chains of sugar (starches) and non-digestible DF (Knudsen, 2015). Therefore, complex carbohydrates have the ability to increase satiety and regulate blood glucose (James, Muir, Curtis, & Gibson, 2003; O'Keefe, Gheewala, & O'Keefe, 2008). Many epidemiological studies have also indicated protective effects of wholegrains against obesity, CVD, T2DM and some forms of cancer (Aune, Chan, Lau, Vieira, Greenwood, Kampman, & Norat, 2011; de Munter, Hu, Spiegelman, Franz, & van Dam, 2007; Fardet, 2010; Slavin, 2004). Carbohydrate complexity depends on how processed the grain is. Complex carbohydrates are normally referred to as wholegrains because they have not had their bran and germ removed. These components provide DF, B vitamins, minerals, phytochemicals and vitamin-E (Slavin, 2004). Most (~90%) Māori and Pacific women in this study had adequate intake of B vitamins and vitamin E (Table 4.3).

Simple sugars, added sugars and excessive amounts of refined carbohydrates (such as SSB, sweets and white bread) can cause participants to have spikes in blood glucose (Arora & McFarlane, 2005). Over time, these frequent spikes in blood glucose can lead to T2DM (Arora & McFarlane, 2005; Kahn, Hull, & Utzschneider, 2006). The WHO defines free sugars as the "monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates" (WHO, 2015). However, there is no structural or chemical difference between added sugars and those inherent in food ('natural' sugars) (Goldfein & Slavin, 2015). This makes it difficult to ascertain the portion of added sugar from a database of various monosaccharides and disaccharides (simple sugars). Even sophisticated equipment, such as high-performance liquid chromatography and gas chromatography, cannot differentiate between added sugar and that which is naturally occurring in the food (BeMiller, 2010). This lack of a universally-accepted definition of 'added sugars' has made it challenging for food regulatory authorities to determine food labelling compliance (Goldfein & Slavin, 2015).

Foods with natural sugars include milk and other dairy products, fruit, vegetables and honey (Goldfein & Slavin, 2015). These foods contain a combination of monosaccharides and disaccharides (simple sugars) such as lactose, fructose, glucose and sucrose (Goldfein & Slavin, 2015). Sucrose, also known as table sugar, is most commonly added to food (Goldfein & Slavin, 2015). In FoodWorks 8, 'Sugars' were the sum of glucose, fructose, sucrose, lactose and maltose. However, we wanted to differentiate between sugars which are more likely to occur naturally in foods, namely fructose (fruit and vegetables), lactose (milk and dairy products) and maltose (cereal, grains, legumes and nuts). Therefore, glucose and sucrose (table sugar) remained. The sum of glucose and sucrose encapsulate the definition of ‘added sugars’ in this study. Nonetheless, it was difficult to determine the amount of table sugar (sucrose) the participants have added to beverages (such as tea) because this was not a question included in the FFQ.

As well as grain foods, 60.8% of Māori women consumed inadequate SSE of milk products and alternatives, with a mean intake of 1.77 SSE compared with the recommended ≥2 SSE per day. Milk products and alternatives are a good source of protein, minerals and vitamins (Sivakumaran et al., 2015). However, some milk alternatives (e.g. soy, oat and rice milk) do not naturally contain very high amounts of these nutrients and/ or the same level of bioavailability (Craig & Mangels, 2009; Heaney, Dowell, Rafferty, & Bierman, 2000; Sivakumaran et al., 2015; Vavrusova & Skibsted, 2014); hence, they need to be fortified with compounds such as calcium salts (Vavrusova & Skibsted, 2014). Nonetheless, average intake of these milk alternatives was only 0.220 SSE per day (Table 4.6).

Instead, the highest contributor of milk products and alternatives was milk (1.01 SSE) (Table 4.5), with whole or standard (0.446 SSE per day) as the most popular type (Table 4.6). Whole or standard milk was consumed 75.6% more often than the second most-popular milk type (reduced fat (0.254 SSE)). However, guidelines suggest opting for low- and reduced-fat over the whole or standard varieties due to its lower total fat and SFA content (MOH, 2015b; Sivakumaran et al., 2015). Discretionary dairy products (e.g. ice cream, milkshakes, milk puddings and condensed milk) are higher in fat than other dairy products and may have added sugar. Consequently, these foods were not included in the total count towards milk products and alternatives. Overall, inadequate SSE of milk products and alternatives (1.77 SSE per day) may have contributed towards the percentage of Māori women (32.9%) with inadequate calcium intake (Table 4.3).

Meat is an excellent source of protein, iron, zinc, vitamin B12 and some PUFAs (Sivakumaran et al., 2015; Williams, 2007). However, too much red and processed meat has been associated with an increased risk of colon cancer, particularly if the red meat is grilled or fried (Chan, Lau, Aune, Vieira, Greenwood, Kampman, & Norat, 2011; Norat et al., 2005; WCRF & AICR, 2007). In the 2008 DHHS, Māori women consumed red meat 7.09 times per week (Metcalf et al., 2008), whereas women in the current study consumed 4.42 SSE per week (Table 5.4). Not only was this 2.67 SSE less than in the DHHS, it also falls 0.58 SSE below the weekly limit of 5 SSE. The World Cancer Research fund proposed a weekly limit of 500g cooked red meat (5 SSE) in order to decrease the risk of colorectal cancer (WCRF & AICR, 2007). Since women in the current study had a relatively low intake of red meat, it can be concluded that their high intake of SFA (14.5% of EI) was coming from other foods, such as butter, margarine, oils and fats (17.4% of total SFA) (Table 4.8).

Although Māori women consumed less red meat (4.42 SSE per week) than those in the DHHS (7.09 SSE per week), they consumed 3 SSE more chicken (4.40 SSE per week) (Table 5.4). Chicken is a lean meat but it has a high amount of SFA in the skin. However, participant dietary habits, regarding the removal of fat from chicken, was not accounted for when entering data into the Dietary assessment software (FoodWorks 8) (FoodWorks Professional, 2016), even though this question was asked of in the FFQ (Appendix 1). It would have been useful to know whether participants removed fat/ skin from meat because this could have significantly contributed to total and SFA intake. Nevertheless, their daily mean intake of legumes, nuts and seeds (0.666 SSE) was higher than their consumption of red meat (0.631 SSE) and poultry (0.629 SSE) (Table 4.5). The insoluble DF in legumes, nuts and seeds can help reduce the risk the risk of colorectal cancer by decreasing gut transit time, thus reducing exposure of carcinogens to the gut wall (Aune et al., 2011). Additionally, the soluble DF in legumes prevents absorption of some LDL cholesterol from the small intestine, reducing the risk of CVD (James, Muir, Curtis, & Gibson, 2003).

Māori women in this study were consuming ≥2 SSE per week of seafood (Table 4.5). However, there were a high percentage of women with inadequate intake of copper (35.4%) and iodine (72.2%), both of which are rich in seafood, particularly oysters and seaweed, respectively (Sivakumaran et al., 2015). Furthermore, the seafood group was not disaggregated and thus, SSE of fish remains unknown. Fish are of importance because they contain essential omega-3 PUFA, which are protective against CVD, colon cancer and stroke (Heart Foundation, 2015b; Hu et al., 2002; Norat et al., 2005). Oily fish, such as salmon and mackerel, are particularly high in essential omega-3 PUFA (Sivakumaran et al., 2015), including eicosapentaenoic acid and docosahexaenoic acid (Balk, Lichtenstein, Chung, Kupelnick, Chew, & Lau, 2006; Sivakumaran et al., 2015). These fats have demonstrated significant reductions in plasma triacylglycerides, thus contributing to the amelioration and prevention of CVD (Agren et al., 1996; Balk et al., 2006). Therefore, the NZHF recommend consuming 2-3 serves of fish per week (Heart Foundation, 2015a). It is unlikely that women in this study were consuming adequate SSE of oily fish because 19% had inadequate intake of PUFA (Table 4.2).

Like Māori, there were also a high percentage of Pacific women who had inadequate intake of fruit (45.3%) and vegetables (44%) (Table 4.4). Furthermore, the variety of fruit and vegetables

(FAVs) may have been limited because Pacific women consumed inadequate folate (22.7%), beta-carotene equivalents (44%) and manganese (66.7%) (Table 4.3). The top FAVs (by weight) were bananas, apples, and citrus fruit, which are relatively low in these nutrients (folate, beta-carotene equivalents and manganese) compared with green, leafy vegetables (Table 4.7).

Additionally, most Pacific women (81.3%) consumed inadequate SSE of grain food (4.14 SSE) (Table 4.4). Consequently, total carbohydrate count was below the guidelines in 60% of participants, and of the carbohydrates consumed, ~ 29% were added sugars rather than the complex carbohydrates found in wholegrain breads and cereals (Knudsen, 2015; Slavin, 2004). In this study, average intake of carbohydrate (42.8% of EI) was between 5.9% to 9.8% lower than Pacific women in the other 3 studies (NZANS, DHHS, and DPRF) (Table 5.3). However, these studies are at least 6 years older than the women's EXPLORE study and may be reflecting subtle changes in the ratio of macronutrients over time. Additionally, the NZANS and DPRF study assessed the dietary intake of women outside of Auckland, the recruitment area for women in the EXPLORE study. The DHHS assessed the diet of Pacific women in Auckland but instead of using a FFQ, they used a 24-hour recall. One day of dietary recall is unlikely to reflect 'usual' intake, especially if participants completed the 24-hour recall in the weekend (Vadiveloo et al., 2015). Moreover, the DHHS recruited women aged 35-74 years, which is older than the age bracket for women in the current study (16-45 years). Age may have contributed to discrepancies in food intake because Wansink, Cheney and Chan (2003) found age-related preferences in comfort food.

Milk products and alternatives (SSE) were also inadequate among most women (69.3%), with a mean intake of 1.77 SSE. The highest contributor of milk products and alternatives was milk (1.04 SSE) (Table 4.5), with reduced fat (0.570 SSE per day) as the most popular type (Table 4.6). Despite consuming reduced-fat milk more often than whole or standard varieties, many Pacific women exceeded the AMDR for total fat (56%) and SFA (57.3%) (Table 4.2). However, the highest contributor of total fat was takeaways (17.7%), and the highest contributor of SFA was butter, margarine, oils and fats (18.8%) (Table 4.9). These latter foods are not included in the Eating and Activity Guidelines for New Zealand Adults (EAGNZA), whereas the prior (milk) is within the 'Milk products and alternatives' group (MOH, 2015b). Therefore, demonstrating how challenging it can be to achieve an adequate macronutrient balance (within the AMDRs) when regularly consuming foods outside of the guidelines (EAGNZA).

In the DHHS, Pacific women consumed red meat 7 times per week (Metcalf et al., 2008), whereas women in the current study consumed 4.67 SSE per week (Table 5.4). This was 2.33

SSE lower than in the DHHS and fell 0.33 SSE below the weekly limit. Their high intake of SFA (14.2% of EI) was therefore likely to have come from other foods, such as butter, margarine, oils and fats (18.8% of total SFA) and takeaways (16.6%) (Table 4.9). Although participants consumed less red meat (4.62 SSE per week) than those in the DHHS (7 SSE per week), they consumed 1.73 SSE more chicken (4.31 SSE per week). Furthermore, their daily mean intake of legumes, nuts and seeds (0.617 SSE) was higher than their consumption of red meat (0.667 SSE) and poultry (0.616 SSE) (Table 4.5).

Pacific women in this study were consuming ≥2 SSE per week of seafood but results did not specify whether this included fish (Table 4.5). It is unlikely that these women were consuming adequate SSE of oily fish per week because 52% had inadequate intake of PUFA (Table 4.2). Furthermore, there were a high percentage of women with inadequate intake of copper (25.3%) and iodine (65.3%), both of which are rich in seafood (Sivakumaran et al., 2015). These results indicate that participants may need to consume more seafood, particularly oily fish.

Overall, both Māori and Pacific women in this study consumed inadequate SSE of grain foods, milk products and alternatives, and total water (Table 4.4). Inadequate SSE of grain foods contributed to their low carbohydrate intake, which was below the AMDR in 76% of Māori and 60% of Pacific women. Inadequate SSE of milk products and alternatives would have contributed to the high percentage of Māori (32.9%) and Pacific women (38.7%) with calcium below the EAR (840mg).

Finally, if participants consumed adequate SSE of fluids, excluding the energy-dense SSB, they may have consumed fewer calories. Fluid intake was lower than the guideline (8.4 SSE) in both Māori (5.61 SSE) and Pacific women (5.68 SSE), yet it did not account for drinks of milk. Milk was preferred in the 'Milk products and alternatives' group, thus under-representing SSE of fluid. Instead, SSE of total water (10.2 SSE) is a more accurate representation of their hydration because it included fluid from all of the food and drink groups. There were 60.8% of Māori and 54.7% of Pacific women with inadequate total water intake. Similarly, over half of the Māori (51.9%) and Pacific women (62.7%) were in the obese BF percentage category (≥35%). Studies have found that participants will habitually consume a particular weight of food (Jaworowska et al., 2013). Therefore, if participants had an adequate amount of calorie-poor fluid (e.g. water and tea), they may have been satiated by the volume in their stomach and thus, consumed less energy-dense and nutrient-poor foods (e.g. takeaways and discretionary sweet snacks). Although there is no conclusive evidence for this particular theory, studies have found that SSB and high glycaemic load diets tend to stimulate appetite, resulting in greater EI at meals (Daniels & Popkin, 2010; Ludwig, 2002).

Māori women consumed discretionary sweet snacks (1.07 SSE) and SSB (1.18 SSE) daily (Table 4.5). Similarly, Pacific women consumed daily discretionary sweet snacks (1.24 SSE), SSB (1.76 SSE) and takeaways (1.17 SSE). These foods are generally high in fat (particularly SFA), sodium and added sugar (Sivakumaran et al., 2015). On average, 250ml of Coke (1 SSE of SSB) contributes 28g of added sugar to a consumer’s diet (Coca-Cola, 2017). This already uses 5.35% of their EER allowance (8800 KJ). With a 10% (of EI) limit on added sugar, there is little room (4.65%) left for added sugar from foods such as discretionary sweet snacks and takeaways (NHMRC, 2006; WHO, 2015; WHO 2003).

Māori (4.42 SSE) and Pacific women (4.67 SSE) in the women’s EXPLORE study were eating SSE of red meat within guidelines, yet those in the DHHS ate at least 2 SSE more than the weekly limit (5 SSE) (Table 5.4). To fully comprehend the food consumption profile of Māori and Pacific women in the women’s EXPLORE study, their intakes of red meat, chicken and fish were compared with the EAGNZA and those reported in the DHHS (Table 5.4).

Table 5.4 Meat intake among Māori and Pacific women in comparable studies

Type of meat	Recommended SSE[1] of foods	EXPLORE, 2015/16 SSE[1] per week		Difference between EXPLORE and EAGNZA (%)		DHHS, 2008 SSE[1] per week		Difference between EXPLORE and DHHS (%)	
		Māori (n=79)	Pacific (n=75)	Māori	Pacific	Māori (n=562)	Pacific (n=508)	Māori	Pacific
Red meat (SSE[1])	≤5 SSE/ week[2]	4.42	4.67	0	0	7.09	7	60.4% ↑	49.9% ↑
Chicken (SSE[1])		4.40	4.31			1.40	2.58	214% ↓	67.1% ↓
Fish (SSE[1]) (Note: EXPLORE includes Seafood)	≥2 SSE/ week[3]	3.39	3.57	69.5% ↑	78.5%↑	2.70	4.51	25.6% ↓	26.3% ↑

CVD = Cardiovascular disease; DHHS = Diabetes, Heart and Health Study; EAGNZA = Eating and Activity Guidelines for New Zealand Adults; EXPLORE = Examining the Predictors Linking Obesity Related Elements; NZHF = New Zealand Heart Foundation; SSE = Standard serving equivalents.

1. SSE of foods in each food group, as outlined in the Eating and Activity Guidelines for New Zealand Adults (MOH, 2015b)
2. The World Cancer Research fund and American Institute for Cancer Research found that eating over 500g (>5 SSE) of (cooked) red meat per week increases colorectal cancer risk (WCRF & AICR, 2011)
3. The NZHF recommend consuming ≥2 SSE of fish per week, particularly oily fish, to help reduce risk of CVD and stroke (Heart Foundation, 2015b)

A study on 90,659 premenopausal women (26 to 46 years old) had their diet assessed over 12 years and found women who consumed red meat over 5 times per week had a higher relative risk (RR) (RR=1.42) for oestrogen and progesterone receptor positive breast cancers compared with women who ate between 3 to 5 servings per week (RR=1.14) (Cho et al., 2006). Despite women in this study reporting lower red meat consumption, the diagnosis of breast cancer among Māori and Pacific women has been increasing throughout NZ (MOH, 2016c). Māori and Pacific women have a higher chance of dying from breast cancer than other NZ women, with a population attributable risk of 16% and 17%, respectively (Hayes, Richardson, & Frampton, 2013; MOH, 2016c). Unlike red meat, consumption of chicken was higher among Māori (↑ 214%) and Pacific women (↑67.1%) in the current study than women in the DHHS (Table 5.4). Perhaps a shift towards lower intake of red meat and greater intake of chicken has been influenced by perceived health benefits, environmental concerns, or recent media releases on the relationship between cancer and red meat intake (Gibson, Heath, Limbaga, Prosser, & Skeaff, 2001; Radio New Zealand, 2015; Richardson, 1994). Overall, Māori women (12.2 SSE) ate 1.02 SSE more meat per week than participants in the DHHS (11.2 SSE), whereas Pacific women (12.6 SSE) ate 1.54 SSE less meat than participants in the DHHS (14.1 SSE).

Māori women in the current study ate nearly double the amount of bread (↑ 87.6%) and half the milk (↓ 44.5%) of women in the DHHS (Table 5.5). Wholemeal bread can be high in DF (Sivakumaran et al., 2015), which may have contributed towards greater DF among women in the current study (30.4g) compared with DHHS women (26g) (Table 5.3). Despite consuming more milk, women in the DHHS (796mg) had a lower calcium intake than women in the current study (1119mg) (Table 5.3). This suggests women in the current study (0.328 SSE) obtained calcium from multiple other sources, such as cheese, which was eaten more frequently than women in the DHHS (0.286 SSE). Alternatively, the 220-item FFQ used in EXPLORE may have captured more sources of dietary calcium than the shorter, 142-item FFQ used in the DHHS (Metcalf et al., 2008).

Likewise, the current study assessed intake of takeaways whereas the DHHS did not. Māori women in this study (0.641 SSE) ate 85.6% less takeaways than those in the NZHS (1.19 SSE) (Table 5.5), equating to 4.49 and 8.33 SSE per week, respectively. Daily consumption of takeaways is a major health risk because they are usually high in fat, SFA and sodium (Jaworowska et al., 2013), which have all been related to increasing risk of CVD and obesity (Lachat, Nago, Verstraeten, Roberfroid, Van Camp, & Kolsteren, 2012; NICE, 2010; O'Keefe et al., 2008). However, these nutrients (fat, SFA and sodium) were not assessed in the NZHS

(MOH, 2015a). Instead, comparisons were made between the percentage of participants with adequate intake of fruit and vegetables (FAVs). A higher percentage of women from the current study consumed adequate SSE of fruit (≥2 SSE) and vegetables (≥3 SSE) than women from the NZHS, by 12.4% and 25.6%, respectively, perhaps resulting higher intakes of DF and micronutrients.

Table 5.5 presents dietary data from Māori and Pacific women in the women's EXPLORE study, NZHS (2014/15), NZANS (2008/09), DHHS (2008), and DPRF (2002). Where possible, comparisons were made between SSE of food groups.

Table 5.5 Daily intake of food groups among comparable New Zealand studies

Comparable food groups, per day	EXPLORE, 2015/16		NZHS, 2014/15		NZANS, 2008/09		DHHS, 2008	
	Māori (n=79)	**Pacific (n=75)**	**Māori (n=1913)**	**Pacific (n=518)**	**Māori (n=588)**	**Pacific (n=343)**	**Māori (n=562)**	**Pacific (n=508)**
Eggs (SSE[1])	0.547	0.539					0.418	0.477
Cheese (SSE[1])	0.328	0.252					0.286	0.128
Milk (SSE[1])	1.01	1.04					1.46	1.31
Bread (SSE[1])	1.67	2.36					0.89	1.01
Takeaways (SSE[1])	0.641	1.17			1.19	1.21		
Vegetables (SSE[1])	4.12	4.15			~2.67	~2.41	4.37	4.55
Fruit (SSE[1])	2.93	3.03			~1.92	~1.98	2.37	2.88
≥3 SSE vegetables[2] (% participants)	67.1	56.0	59.7	48.3	59.1	49.1	79.9	79.3
≥2 SSE fruit[2] (% participants)	60.8	54.6	48.4	61.1	56.9	62.2	42.0	44.5

DHHS = Diabetes, Heart and Health Study; EAGNZA = Eating and Activity Guidelines for New Zealand Adults; EXPLORE = Examining the Predictors Linking Obesity Related Elements; NZANS = New Zealand Adult Nutrition Survey; NZHS = New Zealand Health Survey; SSE = Standard serving equivalents

1. SSE of foods in each food group, as outlined in the Eating and Activity Guidelines for New Zealand Adults (EAGNZA) (MOH, 2015b)
2. Recommendations sourced from the EAGNZA (MOH, 2015b)

Pacific women in the current study (0.252 SSE) ate almost double the cheese (↑ 96.9%) consumed by women in the DHHS (0.128 SSE). Cheese is a good source of calcium but it can also be high in fat, particularly SFA (Sivakumaran et al., 2015). This may have contributed towards higher average intakes of calcium (40.6%), total fat (6.59%) and SFA (10.1%) among women in this study compared with women from the DHHS (Table 5.3). In contrast, carbohydrate consumption was 21.6% less than women in the DHHS, despite eating 1.35 SSE more bread per day than women in the DHHS (1.01 SSE). There must have been other sources of carbohydrate in the diets of DHHS women, such as vegetables. Likewise, 23.3% more DHHS women ate adequate SSE of vegetables (≥3 SSE) compared with women from the current study. The NZANS also presented a higher carbohydrate intake than women from the current study (↑ 5.9%), perhaps related to the higher percentage of women (7.6%) consuming adequate SSE of fruit (≥2 SSE) and a greater frequency of milk (↑ 26%), both of which of which are fairly high in carbohydrates (Sivakumaran et al., 2015).

5.6 Contribution of foods to energy intake, macronutrients, added sugar and sodium

Table 4.8 showed that the highest contributor of total EI among Māori women were takeaways (9.44%), yet for NZANS women the highest contributor of EI was bread (11%) (MOH, 2011a). Perhaps this could explain the higher intakes of total fat and SFA among women in the current study compared with women in the NZANS (Table 5.3). A multitude of factors may be responsible for higher takeaway consumption in the current study, such as the greater availability of takeaway outlets, frequency of stores which are open 24/7, free Wi-Fi (internet access), and clever use of advertisements (Brailsford, 2003; Maher, Wilson, & Signal, 2005; McDonald’s, 2017; Orfanos et al., 2007).

Additionally, there seems to be a positive association between the number of takeaway outlets and level of deprivation in that area (Fraser, Edwards, Cade, & Clarke, 2010). A recent NZ study found that takeaway outlets were especially accessible to school children in deprived areas of Auckland (Vandevijvere, Sushil, Exeter, & Swinburn, 2016). A high proportion of Māori and Pacific women reside in these more deprived areas, which could help explain why the prevalence of obesity is greatest among Māori and Pacific compared with non-Maori and non-Pacific women in NZ (MOH, 2012b, 2012c; SNZ & MPIA, 2011; White et al., 2008). Additionally, a greater proportion of advertisements are dedicated to ‘unhealthy’ food and many are NZ-specific, which may give the impression that takeaways and ‘unhealthy’ food are part of the NZ culture (Brailsford, 2003; Maher et al., 2005). High exposure to these ‘obesogenic’ environments have facilitated excessive energy intake and thus, weight gain (Giskes, van

Lenthe, Avendano-Pabon, & Brug, 2011). Such findings are in-line with a systematic review on the impact of environment on obesity, where obesogenic dietary behaviours (such as regular consumption of SSB) were consistently associated with living in a deprived area (Giskes et al., 2011).

Fruit and bread were the highest contributors of carbohydrate in both the EXPLORE study and the NZANS (Table 4.8 and Table 4.9). However, discretionary sweet snacks and takeaways were also within the top four. Participants from both EXPLORE and the NZANS had similar contributions of carbohydrate from 'Discretionary sweet snacks' (9.07%) and 'Sugar and sweets' (7%) groups, respectively. These food groups are likely to be high in added sugar, yet only the current study analysed food contribution towards added sugar, which was highest from SSB (15.2%).

In the current study, consumption of butter, margarine, oils and fats (BMOF) contributed most towards total fat (15.2%) and SFA (17.4%). In the NZANS, consumption of BMOF was not comparable with women in the current study because most were coupled with the foods to which they were added, rather than in a separate 'BMOF' group (MOH, 2011a). In contrast, the current study had questions within the FFQ relating to amounts, types and frequency of BMOF (Appendix 1). Therefore, BMOF could be included in a separate group for analysis, called "BMOF". Despite these differences in data collection, participants in the NZANS also had butter and margarine as their highest contributors of total fat (9%) and SFA (8%), but their results are likely underestimated.

Table 4.9 showed the highest contributor towards total EI among Pacific women were takeaways (13.4%), whereas bread (11%) was the highest contributor of EI in NZANS participants (MOH, 2011a). Higher EI from takeaways and lower EI from bread may have contributed to their higher intake of total fat, higher SFA, and lower carbohydrate (14% ↓) than women in the NZANS (Table 5.3).

Takeaways were also the highest contributors of protein (13.4%), total fat (17.7%) and sodium (19.6%) among Pacific women in the current study. In comparison, NZANS participants consumed most of their protein from bread (11%) and their fat from butter and margarine (9%). Overall, women in this study had takeaways feature within the top three foods across all macronutrients, except for added sugar, where SSB (17.3%) featured as the top 'food'. Numerous studies found a clear association between intake of SSB with excess EI and consequent gain in body weight (Vartanian, Schwartz, & Brownell, 2007), yet women in this study had a lower average BMI (31.9 kg/m^2) than women in the NZANS (33 kg/m^2). Therefore, other factors may be contributing to disparity in body composition.

Although takeaways (17.7%) contributed the most towards total fat, the highest contributors of SFA were butter, margarine, oils and fats (18.8%). Similarly, the highest contributors of fat (9%) and SFA (8%) in the NZANS were butter and margarine. Nonetheless, food contributions towards EI and macronutrients are not necessarily reflective of consumption among Māori and Pacific women in the NZANS because results were an average of all participants in the study, both males and females. Therefore, results cannot be accurately compared with those of Māori and Pacific women in the women's EXPLORE study.

Between 2004/05, 644 female supermarket customers, with a mean age of 38 years, had their purchases analysed from electronic supermarket sales data (Hamilton, Mhurchu, & Priest, 2007). The highest-selling supermarket products were white bread, full-fat milk, SSB, and butter. Despite differing methodologies for data collection (objective versus subjective), these foods aligned with the top-20 foods consumed by Māori and Pacific women in the current study (Table 4.7), suggesting the continuity of a similar dietary pattern. Additionally, the main source of total fat and saturated fat for women in Hamilton et al.'s (2007) study were butter and margarine (~20% of EI), which was similar for Māori and Pacific women in the current study (~15-19% of EI) (Table 4.8 and Table 4.9). However, their main source of energy and protein was from bread (12%) (Hamilton et al., 2007), whereas the main source of energy for Māori (9.44%) and Pacific women (13.4%) in this study were takeaways, and the main sources of protein were poultry (13.5%) and takeaways (13.4%), respectively (Table 4.8 and Table 4.9). The differing results may be highlighting trends in time because women from the 2008/09 NZANS also consumed their main sources of energy (11%) and protein (11%) from bread (MOH, 2011a).

5.7 Dietary intake of women in higher versus lower body fat percentage groups

There were no statistically significant differences in EI and macronutrients between Māori women in obese and non-obese BMI or BF percentage groups, respectively (Table 4.10). Higher EI is usually associated with a greater BF percentage, especially if EI is in excess of requirements (Peters, Wyatt, Donahoo, & Hill, 2002; Vadiveloo et al., 2015). These results suggest Māori women may have misreported EI because EI is likely to have been in excess of requirements since 64.6% of women were either overweight or obese (Table 5.1).

Dissimilarly, Pacific women with BF ≥35% (n=47 (62.7%)) consumed more energy (42.1% ↑), protein (37.3% ↑), total fat (42.4% ↑), carbohydrate (47.0% ↑), and added sugars (41.8% ↑) than women with BF <35% (Table 4.11). Studies have found that dietary fat is converted to BF more efficiently than other macronutrients (National Research Council, 1989) and has the highest energy density of all the macronutrients (9 kcal per gram) (National Research Council, 1989; Zou et al., 2007). Therefore, high-fat diets may cause greater weight gain than those which are lower in fat. However, total EI has shown a stronger effect on BMI than the ratio of macronutrients (Austin, Ogden, & Hill, 2011; National Research Council, 1989; Van Dam & Seidell, 2007). Furthermore, there was no significant difference in percentage EI of macronutrients, despite differences in BF percentage.

Māori women in the higher BF percentage group (≥35%) had significantly more takeaways (42.7% ↑), whereas those in the lower BF percentage group (<35%) consumed significantly more eggs (68.9% ↑); legumes, nuts and seeds (69.7% ↑); milk (72.5% ↑). The latter three food groups are part of the Eating and Activity Guidelines for New Zealand Adults (EAGNZA), whereas takeaways are not (MOH, 2015b). This suggests that Māori women with a lower BF percentage are more likely to have diets consistent with national guidelines. However, the most common type of milk was whole or standard (0.446 SSE) (Table 4.6), which is not consistent with guidelines. The EAGNZA suggest opting for low- and reduced-fat milk over the whole or standard varieties because they are lower in SFA (MOH, 2015b; Sivakumaran et al., 2015). Similarly, Vadiveloo et al. (2015) found that a large variety of healthful food (quantified using the US Healthy Food Diversity index) was inversely associated with most adiposity indicators, such as BMI and BF percentage. Wilson et al. (2013) identified dietary patterns that met nutritional requirements and were within the budget of people on as low as NZ$ 3.17 per day, proving the feasibility of eating healthy, inexpensive meals.

Pacific women in the higher BF percentage group (≥35%) had significantly more food than those in the lower BF percentage group (<35%), especially discretionary breads, cereals and starchy foods (↑ 210%) (Table 4.13). Discretionary breads, cereals and starchy foods included iced buns, croissants, paraoa parai (fry bread), and chocolate based cereals (Appendix 3). These foods were defined as 'discretionary' because they are generally higher in energy, fat, SFA, added sugar and sodium than regular breads, cereals and starchy foods and therefore not recommended as part of a healthy diet (MOH, 2015b; Sivakumaran et al., 2015). Opposite to the results found in Māori women, Pacific women with a higher BF percentage consumed greater amounts of food from groups in the EAGNZA. These foods included bread (grain foods), red meat (meat products and alternatives) and starchy foods (grain foods) (Table 4.4). Foods within these groups can provide a variety of essential nutrients, especially if wholemeal bread, brown rice (starchy food) and lean red meat are consumed over the refined and high-fat versions, respectively. It seems as though general over-consumption, as well as food choice, played part in contributing towards excessive EI (>8800 KJ). Similarly, Metcalf et al. (1998 and 2008) found Pacific women had larger portion sizing (more SSE) and frequency of certain foods than women of other ethnicities, thus contributing to their greater energy intake and obesity (Metcalf, Scragg, Tukuitonga, & Dryson, 1998; Metcalf et al., 2008).

It was expected for those with a higher BF percentage to consume takeaways and SSB more regularly because they are generally energy-dense and nutrient-poor foods, such as pizza and fries (Jaworowska et al., 2013; Sivakumaran et al., 2015). The NZANS found that Māori and Pacific women were more likely to consume these foods (11.2 % and 13.2% respectively) over three times per week than women of other ethnicities (MOH, 2012a, 2012b, 2012c). Similarly, the number of Māori (29.1%) and Pacific women (31.7%) consuming soft drinks and energy drinks over three times per week was double the number of NZ European and Others (15.7%) (MOH, 2012a). These foods put them at increased risk of obesity and/or exacerbate pre-existing metabolic conditions (Misra & Khurana, 2008). Nonetheless, Māori (4.5 SSE) and Pacific women (8.2 SSE) in the current study reported consuming fewer takeaways, per week, than those in the NZANS (~8.4 SSE) (Table 5.5). Perhaps a lower frequency of takeaways contributed to the lower percentage of obesity among Māori (19.8% ↓) and Pacific women (6.8% ↓) in this study (Table 5.1). However, we cannot be certain whether the NZANS definition of takeaways was the same as with EXPLORE and therefore we may not be comparing like-with-like.

6.0 Conclusions

6.1 Summary

The purpose of this study was to assess the dietary intake and body composition of Māori and Pacific cohorts of women recruited in the women's EXPLORE study, and to investigate the relationship between dietary intake and BF. Studies in NZ most comparable to this study were the 2008 DHHS, 2008/09 NZANS, and the 2014/15 NZHS. However, the current study further compared dietary data from women in higher (≥35%) versus lower (<35%) BF percentage groups, to investigate differences in food consumed from different food groups, EI and macronutrient intakes and distributions. Obese (BF ≥35%) Pacific women consumed significantly more energy-dense bread and starchy foods, fats, discretionary breads, discretionary sweet snacks, savoury (and sweet) sauces, spreads and flavourings (Table 4.13). Their high energy and nutrient intakes further support these findings (Table 4.11). This data suggest Pacific women had a higher BF percentage because of general over-consumption, especially of discretionary breads, cereals and starchy foods (210%). Obese (BF ≥35%) Māori women consumed significantly more takeaways, whereas non-obese women consumed significantly more eggs, legumes, nuts, seeds and milk (Table 4.12).

6.2 Study objectives

Objective	How the objective was met
To investigate body composition, particularly BMI and BF percentage, of young Māori and Pacific women recruited in the women's EXPLORE study.	Height and weight were measured using the International standards for anthropometric assessment protocol (Marfell-Jones et al., 2006). BMI was calculated using kg/m^2. BF percentage was measured using air displacement plethysmography (BodPod). Participants were categorised into different BMI and BF percentage groups, as shown in Table 4.1. Most Māori women (35.4%) had an overweight BMI (25.0-29.9 kg/m^2), while most Pacific women (54.7%) had an obese BMI (≥30.0 kg/m^2). There was a low presence of Māori (10.1%) and Pacific women (2.7%) in the "Hidden fat" group and instead, most Māori (55.7%) and Pacific women (77.3%) were in the "Apparent Fat" group. Furthermore, significant positive correlations were found between the BMI and BF percentage of both Māori (r=0.857) and Pacific women (r=0.871), suggesting that BMI is a good indicator of BF percentage in these populations.
To investigate dietary intakes (macronutrients, micronutrients, and food groups) of young Māori and Pacific women recruited in the women's EXPLORE study, and to compare these with NZ guidelines.	Dietary intake was collected using a validated, 220-item, self-administered, semi-quantitative FFQ (See Appendix 1), assessing dietary intake over the previous month. Food intake was converted to daily and weekly equivalents, for analysis. Questionnaire data was processed in FoodWorks 8, which allowed extraction of foods, food groups, macronutrients, micronutrients, DF and added sugars (FoodWorks Professional, 2016). Both groups of women consumed inadequate carbohydrate, excess total fat and excess SFA. Sodium exceeded the UL in 58.2% of Māori women and 73.3% of Pacific

Objective	How the objective was met
	women. Over 65% of Māori and Pacific women had inadequate intakes of manganese and iodine. Takeaways contributed the most towards total sodium intake (16.3% and 19.6%, respectively). As well as sodium, takeaways were the top contributor of total EI (13.4%), protein (13.4%) and fat (17.7%) in Pacific women.
To explore relationships between dietary intake and body fat percentage (high versus low groups [BF ≥35% / <35% respectively]).	Dietary intakes of obese and non-obese Māori and Pacific women were compared to investigate differences in consumption of energy, macronutrients and food groups. These food groups were disaggregated versions of the four basic groups included in the Eating and Activity Guidelines for New Zealand Adults. Additionally, food groups such as takeaways and discretionary products were also included in the analyses. Findings revealed that Māori women with BF ≥35% consumed more takeaways, while Pacific women with BF ≥35% consumed more discretionary breads, cereals and starchy foods (e.g. iced buns and paraoa parai (fry bread)) than those with BF <35%. Māori women with BF <35% consumed more eggs, legumes, nuts and seeds, and milk.

6.2.1 Recommendations to improve dietary intake of Māori and Pacific women

- Reduce the amount of butter, margarine, oils and fats used in food preparation and cooking because they contributed the most towards total fat and/ or SFA intake among Māori and Pacific women, respectively. Instead, opt for fats/ oils that are lower in SFA and higher in unsaturated fat, such as PUFA/ MUFA margarine and olive oil. Other sources of healthy fats include avocados, nuts and seeds.
- Māori women could opt for low-fat/skim milk over full-fat milk because this was one of the top four contributors towards their intake of energy, fat and SFA.
- Opt for oily fish (e.g. salmon, mackerel, sardines and tuna) over discretionary meat and meat alternatives (e.g. salami, luncheon and ham) because oily fish provides a rich source of omega-3 PUFAs, which were inadequate among the women in this study, especially Pacific women. Aim for ≥2 SSE per week, either canned or fresh.
- Increase SSE of complex carbohydrates, such as those found in legumes and wholegrain breads and cereals. Choose these instead of discretionary sweet snacks and discretionary breads, cereals and starchy foods. Wholegrain breads and cereals will provide DF and manganese, which were inadequate among the women in this study.
- Replace SSB with water, tea, or coffee because these are lower in sugars, caffeine and carbonation. Overall, drink more fluids every day because they will aid hydration, digestion, satiation and comfortable elimination of stools. Aim for about 8 SSE (250ml each) of low-calorie fluids such as water, tea, and coffee (using skim/ trim milk).

- Aim to consume at least 2 SSE of fruit (including at least one vitamin C rich fruit (e.g. citrus fruit, kiwifruit, papaya) and one fibrous fruit (e.g. apple, orange, pear, mango)) and 3 SSE of vegetables per day (including at least one leafy green vegetable (e.g. broccoli, spinach, brussels sprouts) and one orange-/red-coloured vegetable (e.g. kumara, carrots, red capsicums) and one white-/light-coloured vegetable (e.g. cauliflower, mushroom, onion)). Leafy green vegetables will provide DF, manganese, folate and beta-carotene, which were inadequate among the women in this study. The orange-/red-coloured fruit and vegetables provide beta-carotene and potassium.
- Explore ways to increase skills in making healthy, low-cost meals rather than buying takeaways. It has been proven that eating healthily is affordable in NZ (Mhurchu & Ogra, 2007; Wilson et al., 2013). Cooking at home more, instead of buying takeaways, would be beneficial to health because takeaways were a high contributor of total fat, SFA and sodium, which were all consumed in excess. Limit takeaway foods in a stepwise approach initially, with a final recommendation of limiting takeaways to once-per-week, or as an occasional treat.

6.3 Strengths and limitations

6.3.1 Strengths

There were a high number of controlled variables. Requirements included participants who were post-menarcheal, pre-menopausal, and not pregnant or lactating. These criteria helped minimise the possibility of major hormonal effects on body composition, which could have confused the effect of diet. Other controlled factors were the intention to lose/gain weight, and if participants had been diagnosed with chronic disease or illness, especially illness of metabolic consequence (e.g. type 2 diabetes mellitus).

Another strength was the variation in dietary data. Each participant completed a 220-item, self-administered, semi-quantitative FFQ , which was validated for nutrient intake and included ethnic-specific foods such as taro and paraoa parai (fry bread). The FFQ data was analysed for EI, macronutrients, micronutrients, food groups, and specific food groups, to explore the relationship with BMI and BF percentage. BF fat percentage was measured using Air Displacement Plethysmography, which is the gold standard method for body composition assessment.

Furthermore, mis-reporters and major over-/ under-reporters were identified using a variation of different techniques, as discussed in section 3.6.2 of the methods. Having thorough exclusion criteria may have significantly reduced the data but made it more reliable.

6.3.2 Limitations

Despite these strengths, the study had several limitations. The main limitation is the cross-sectional design, which is prone to non-response bias (participants who consented to take part in the study may differ significantly from those who did not take part) and difficultly inferring any associations or causality because diet and body composition were measured simultaneously. Results may be different if another time-frame was used. Furthermore, collection of dietary data was retrospective, using a FFQ. Retrospective dietary data includes an element of recall bias and FFQs are not suitable for measuring absolute intake of food and nutrients, and they often result in over-reporting of fruit and vegetables (Cade et al., 2002). Rather, FFQs are best for identifying participants according to high, moderate and low intakes.

Additionally, the volunteer samples were relatively small, consisting of 79 Māori women and 75 Pacific women (after applying exclusion criteria), due to difficulties in recruiting a larger sample size. In comparison, the DHHS, NZANS and NZHS had >562 Māori women and >343 Pacific women (Metcalf et al., 2008; MOH, 2011b, 2015a). Moreover, there was no consideration of where participants reside in Auckland and any data on social background. The World Health Organization explains that those in low- and middle-income areas have a higher likelihood of exposure to inadequate nutrition than those in high-income areas (WHO, 2016b). People with lower incomes have shown more adverse dietary intake patterns, evidenced by lower consumption of DF, milk, vegetables and fruit (Metcalf et al., 2014). Similarly, some areas in Auckland have high rates of deprivation and could therefore have affected food choice. Those living in more deprived areas of Auckland are less likely to own a car, have kitchen facilities, sufficient income or employment (Salmond et al., 2013), thus creating barriers to accessing or purchasing healthy food. A high proportion of Māori and Pacific women reside in these areas and could therefore explain why the prevalence of obesity in NZ is greatest among women of Māori and Pacific ethnicity (SNZ & MPIA, 2011; White et al., 2008).

Dietary supplements were not integrated with results. Various vitamin and mineral supplements may have contributed significantly to total intake of nutrients (Lachat et al., 2016), especially if the participant was planning to conceive; requirements for folate in pregnancy are almost double and therefore easier to achieve through taking supplements. The only supplements included in analysis were energy-providing protein supplements, such as protein bars/ powders/ shakes.

Some foods were entered into FoodWorks 8 (dietary assessment software) as a single entry, made-up of multiple food groups. Most of these foods were found in the takeaways group, thus, takeaways were not included in analysis regarding the four food groups in the Eating and Activity Guidelines for New Zealand Adults. More time was needed to disaggregate the takeaway meals into their separate components. For instance, a cheese sandwich would have contributed 2 SSE of ‘Grain foods’ (bread) and 1 SSE of ‘Milk products and alternatives’ (cheese), while an Indian takeaway would have contributed 2 SSE of ‘Grain Foods’ (rice and naan bread) and 1 SSE of ‘Meat and meat alternatives’ (chicken).

The New Zealand Heart Foundation (NZHF) guidelines consider one serve of butter, margarine, oil and fat as 1 teaspoon (5g) (Heart Foundation, 2015a), whereas Australian dietary guidelines (ADG) suggest one serve of butter/ margarine as 1 Tablespoon (20g) and one serve of oil as 10mls (AGDH, 2015) (Appendix 2). The NZHF guidelines are for people at risk of CVD (Heart Foundation, 2015a), whereas ADG are for the general population of Australians (AGDH, 2015). Māori and Pacific women in this study were free from CVD, thus, ADG were more appropriate for assessing their SSE of butter, margarine, oils and fats than the NZHF guidelines. However, NZHF guidelines may have been more beneficial in specifying serves of particular types of foods. For instance, one serve of fish is 100g in the Eating and Activity Guidelines for New Zealand Adults (EAGNZA), whereas one serve of fish is 150g (oily fish) or 200g (white fish) with the NZHF (Heart Foundation, 2015a). This study has highlighted the need for recommendations outlining SSE of discretionary foods in NZ and the need for consistency among serving sizes of food in different dietary resources: the EAGNZA and NZHF guidelines (Heart Foundation, 2015a).

Additionally, SSE of rice and pasta was based on serving sizes in the EAGNZA. One cup of rice or pasta is supposed to be equivalent to one slice of bread (MOH, 2015b). However, analysis in FoodWorks 8 revealed both the weight and carbohydrate content in a cup of rice/ pasta is significantly higher than a slice of bread. Therefore, it may have been appropriate to half the serving size of rice and pasta, to better reflect another grain food e.g. 1 slice of bread. Likewise, the Australian dietary guidelines were adjusted in 2013 so that their standard serve of grain foods, such as rice, were reduced from 1 cup to ½ cup (AGDH, 2015). These discrepancies highlight the need to revise serving size advice in the EAGNZA.

‘Added sugars’ were the sum of glucose and sucrose intakes. However, this does not necessarily mean the sugars were added to food, they could have been inherent. Nonetheless, our definition of added sugars has excluded natural sugars, such as lactose (inherent in milk and other dairy products) and fructose (found in fruit). In comparison, the WHO defines free sugars as the "monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates" (WHO, 2015). We have taken some of these aspects into account by highlighting the SSE of SSB, which included fruit drinks, flavoured water, carbonated or fizzy drinks, cordial (fruit juice concentrate), powdered drinks, energy drinks, and sports drinks (Appendix 3).

Finally, participant sodium intake is unlikely to be accurate because it is notoriously difficult to assess the varied sources of sodium, such salt added at the table and levels found in tap water (Bentley, 2006; McLean, 2014; Thomson et al., 2008).

6.4 Recommendations for future research

- Recruit a larger population of participants in order to achieve results which are more representative of the groups (Māori and Pacific women in NZ);
- Consider deprivation scores and what effect these would have on dietary intake;
- Incorporate dietary supplements into micronutrient counts, to increase the accuracy of micronutrient data;
- Include more detailed questions regarding takeaways, so they can be integrated into the SSE towards different food groups of the Eating and Activity Guidelines for New Zealand Adults (EAGNZA);
- Investigate the relationship between WC and diet because WC is a better indicator of health than total BF percentage.

Finally, there is an urgent need to revise serving size advice in the EAGNZA because there are no recommendations outlining SSE of discretionary foods in NZ. Additionally, there are discrepancies among serving sizes of food (e.g. grain foods and types of fish) in different dietary resources: the EAGNZA and New Zealand Heart Foundation guidelines.

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Appendices

Appendix 1 Food frequency questionnaire used in EXPLORE

Begins next page:

EXPLORE Food Frequency Questionnaire

1. Please read carefully before you begin:

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 correct, but don't spend too much time on each food.
• Answer EVERY question; the asterisk symbol (*) at the beginning of each question means that you must answer before moving onto the next question.

This will help us to get the most accurate information about your usual food intake.

Please answer by ticking the box which best describes HOW OFTEN you ate or drank a particular food or drink in the LAST MONTH and HOW MUCH you would usually have.

For example:

1. EXAMPLE: How often do you usually have sugar? (Please do not fill out)

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Sugar - 1 tsp	○	○	○	○	○	○	○	○	○

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 four or more times per day = '4+ x / day'.

Adjust your portion size and frequency of intake to suit your eating habits.

2. EXAMPLE: How often do you usually eat bread? (Please do not fill out)

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Bread - 1 slice	○	○	○	○	○	○	○	○	○

If every day you have two slices of toast for breakfast, and you have a sandwich for lunch three times per week, you would choose two - three times per day = '2-3x / day'.

Adjust your portion size and frequency of intake to suit your eating habits.

EXPLORE Food Frequency Questionnaire

2. EXPLORE Study Food Frequency Questionnaire

***1. Please enter your study ID (if you are unsure or don't know please ask the researcher)**

EXPLORE Food Frequency Questionnaire

3. Eating Pattern

***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 and 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
- ○ None of the above

Other (please state)

EXPLORE Food Frequency Questionnaire

4. Dairy

***1. Do you use milk? (e.g. fresh, UHT, powdered)**

- Yes
- No

2. What type(s) of milk do you have most often? (You can choose up to 3 options, but please only choose the ones you usually have)

- Not applicable
- Full cream milk (purple top)
- Standard milk (blue top)
- Skim milk (light blue top)
- Trim milk (green top)
- Super trim milk (light green top)
- 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 one only)**
(A 'serving' = 250 mL or 1 cup/glass)
e.g. 5 cups of coffee/tea using 50 mL of milk + ½ cup of milk on cereal = 1 ½ servings per day

- Not applicable
- Less than 1 serving
- 1-2 servings
- 3-4 servings
- 5 or more servings

EXPLORE Food Frequency Questionnaire

*4. How often do you usually have milk?

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Flavoured milk (milkshake, iced coffee, Primo, Nesquik) - 250 mL/ 1 cup	○	○	○	○	○	○	○	○	○
Milk as a drink - 250 mL / 1 cup	○	○	○	○	○	○	○	○	○
Milk on breakfast cereals or porridge - 125 mL/ 1/2 cup	○	○	○	○	○	○	○	○	○
Milk added to water-based hot drinks (coffee, tea) - 50 mL / 1/5 cup	○	○	○	○	○	○	○	○	○
Milk-based hot drinks (Latte, Milo) - 250 mL / 1 cup	○	○	○	○	○	○	○	○	○

*5. How often do you usually eat cheese?

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day	4+ x / day
Cheddar (tasty, mild, colby) - 2 heaped Tbsp / matchbox cube	○	○	○	○	○	○	○	○	○	○
Edam, Gouda, Swiss - 2 heaped Tbsp / matchbox cube	○	○	○	○	○	○	○	○	○	○
Feta, Mozarella, Camembert - 1 heaped Tbsp / 1 med wedge	○	○	○	○	○	○	○	○	○	○
Brie, blue and other specialty cheese - 1 heaped Tbsp / 1 med wedge	○	○	○	○	○	○	○	○	○	○
Processed cheese slices - 1 slice	○	○	○	○	○	○	○	○	○	○
Cream cheese - 2 heaped Tbsp	○	○	○	○	○	○	○	○	○	○
Cottage or ricotta cheese - 2 heaped Tbsp	○	○	○	○	○	○	○	○	○	○

*6. How often do you usually eat these dairy based foods?

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Ice cream - 2 scoops	○	○	○	○	○	○	○	○	○
Custard or dairy food - 1 pottle / ½ cup	○	○	○	○	○	○	○	○	○
Yoghurt, plain or flavour - 1 pottle / ½ cup	○	○	○	○	○	○	○	○	○
Milk puddings (semolina, instant) - ½ cup	○	○	○	○	○	○	○	○	○
Fermented or evaporated milk (buttermilk) - ½ cup	○	○	○	○	○	○	○	○	○

EXPLORE Food Frequency Questionnaire

5. Bread

***1. Do you eat bread?**

- ○ No
- ○ Yes

2. What type(s) of bread, rolls or toast do you eat most often? (You can choose up to 3 options, but please only choose the ones you usually have)

- ☐ Not applicable
- ☐ White
- ☐ White – high fibre
- ☐ Wholemeal or wheat meal
- ☐ Wholegrain

Other (please state)

***3. What type of bread slice do you usually have? (Please choose one only)**

- ○ Not applicable
- ○ Sandwich slice
- ○ Toast slice
- ○ Mixture of both sandwich and toast slices

***4. On average, how many servings of bread do eat per day? (Please choose one only)**
(A 'serving' = 1 slice of bread or 1 small roll)

- ○ Not applicable
- ○ Less than 1 serving
- ○ 1–2 servings
- ○ 3–4 servings
- ○ 5–6 servings
- ○ 7 or more servings

EXPLORE Food Frequency Questionnaire

*5. How often do you usually eat these bread based foods?

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Plain white bread - 1 slice	○	○	○	○	○	○	○	○	○
High fibre white bread - 1 slice	○	○	○	○	○	○	○	○	○
Wholemeal or wheat meal - 1 slice	○	○	○	○	○	○	○	○	○
Wholegrain bread - 1 slice	○	○	○	○	○	○	○	○	○
Fruit bread or fruit bun - 1 slice	○	○	○	○	○	○	○	○	○
Wrap - 1 medium	○	○	○	○	○	○	○	○	○
Focaccia, bagel, pita, panini or other speciality breads - 1 medium	○	○	○	○	○	○	○	○	○
Paraoa Parai (fry bread) - 1 slice	○	○	○	○	○	○	○	○	○
Rewena bread - 1 slice	○	○	○	○	○	○	○	○	○
Doughboys or Maori bread - 1 slice	○	○	○	○	○	○	○	○	○

*6. How often do you usually eat these other bread based foods?

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Crumpet or muffin split - 1 crumpet / 1 whole muffin split	○	○	○	○	○	○	○	○	○
Scone - 1 medium	○	○	○	○	○	○	○	○	○
Bran muffin or savoury muffin - 1 medium	○	○	○	○	○	○	○	○	○
Croissant - 1 medium	○	○	○	○	○	○	○	○	○
Waffle, pancakes or pikelets - 1 medium / 2 small	○	○	○	○	○	○	○	○	○
Iced buns - 1 medium	○	○	○	○	○	○	○	○	○
Crackers (cream crackers, cruskits, corn / rice crackers, vitawheat) - 2 medium	○	○	○	○	○	○	○	○	○

*7. Do you have butter, margarine or spreads on bread or crackers?

○ No

○ Yes

EXPLORE Food Frequency Questionnaire

8. What type(s) do you have most often? (You can choose up to 3 options, but please only choose the ones you usually have)

- ☐ Not applicable
- ☐ 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 day? (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

- ○ Not applicable
- ○ Less than 1 serving
- ○ 1–2 servings
- ○ 3–4 servings
- ○ 5–6 servings
- ○ 7 or more servings

EXPLORE Food Frequency Questionnaire

6. Breakfast Cereals and Porridge

***1. Do you usually eat breakfast cereal and/or porridge?**

- ○ No
- ○ Yes

2. What breakfast cereal(s) do you eat most often? (You can choose up to 3 options, but please only choose the ones you usually have)

- ☐ Not applicable
- ☐ 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)

***3. 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

- ○ Not applicable
- ○ Less than 4 servings
- ○ 4–6 servings
- ○ 7–9 servings
- ○ 10–12 servings
- ○ 13–15 servings
- ○ 16 or more servings

EXPLORE Food Frequency Questionnaire

***4. How often do you usually eat porridge or these cereal foods?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / 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 (All Bran, Bran Flakes) - ½ cup	○	○	○	○	○	○	○	○	○
Bran based cereals (Sultana Bran, Sultana Bran Extra) - ½ cup	○	○	○	○	○	○	○	○	○
Light and fruity cereals (Special K, Light and Tasty) - ½ cup	○	○	○	○	○	○	○	○	○
Chocolate based cereals (Milo cereal, Coco Pops) - ½ cup	○	○	○	○	○	○	○	○	○
Sweetened cereals (Nutrigrain, Fruit Loops, Honey Puffs, Frosties) - ½ cup	○	○	○	○	○	○	○	○	○
Breakfast drinks (Up and Go) - Small carton / 250 mL	○	○	○	○	○	○	○	○	○

EXPLORE Food Frequency Questionnaire

7. Starchy Foods

***1. Do you eat any type of starchy foods such as rice, pasta, noodles and couscous?**

- No
- Yes

***2. On average, how many servings of starchy foods such as rice, pasta, noodles and couscous do you eat per week? (Please choose one only)**
(A 'serving' = 1 cup cooked rice / pasta)
e.g. 1 cup of rice + ½ cup of pasta included in a lasagne pasta dish + 1 cup of spaghetti = 2.5 servings

- Not applicable
- Less than 4 servings
- 4–6 servings
- 7–9 servings
- 10–12 servings
- 13–15 servings
- 16 or more servings

***3. How often do you usually eat these starchy foods?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Rice, white - 1 cup									
Rice, brown or wild - 1 cup									
Pasta, white or wholegrain (spaghetti, vermicelli) - 1 cup									
Canned spaghetti (Watties) - 1 cup									
Instant noodles (2 minute noodles) - 1 packet									
Egg and rice noodles (hokkien noodles, udon) - 1 cup									
Other grain (quinoa, couscous, bulgar wheat) - 1 cup									

EXPLORE Food Frequency Questionnaire

8. Meat

***1. Do you eat beef, mutton, hogget, lamb, or pork**

- No
- Yes

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

- Not applicable
- Always
- Often
- Occasionally
- Never cut the fat off meat

***3. On average, how many servings of meat e.g. beef, mutton, hogget, lamb or pork do you eat per week? (Please choose one only)**
(A 'serving' = palm size or ½ a cup of meat without bone)
e.g. ½ cup of savoury mince + 2 small lamb chops = 2 servings

- Not applicable
- Less than 1 serving
- 1-3 servings
- 4-6 servings
- 7 or more servings

***4. How often do you usually eat meat?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Beef mince dishes (rissoles, meatloaf, hamburger pattie) - 1 slice / patty / ½ cup									
Beef or veal mixed dishes (casserole, stir-fry) - ½ cup									
Beef or veal (roast, chop, steak, schnitzel, corned beef) - palm size / ½ cup									
Lamb, hogget or mutton mixed dishes (stews, casserole, stir-fry) - ½ cup									
Lamb, hogget or mutton (roast, chops, steak) - palm size / ½ cup									
Pork (roast, chop, steak) - palm size / ½ cup									
Canned corned beef - 1 medium slice									

EXPLORE Food Frequency Questionnaire

***5. How often do you usually eat these other meats?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Sausage, frankfurter or saveloy - 1 sausage / frankfurter/ 2 saveloys	○	○	○	○	○	○	○	○	○
Bacon - 2 rashers	○	○	○	○	○	○	○	○	○
Ham - 1 medium slice	○	○	○	○	○	○	○	○	○
Luncheon meats or brawn - 1 slice	○	○	○	○	○	○	○	○	○
Salami or chorizo - 1 slice / cube	○	○	○	○	○	○	○	○	○
Offal (liver, kidneys, pate) - palm size / ½ cup	○	○	○	○	○	○	○	○	○
Venison/game - palm size / ½ cup	○	○	○	○	○	○	○	○	○

EXPLORE Food Frequency Questionnaire

9. Poultry

***1. Do you eat poultry e.g. chicken, turkey or duck?**

- No
- Yes

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

- Not applicable
- Always
- Often
- Occasionally
- Never remove the skin from chicken

***3. On average, how many servings of chicken do you eat per week? (Please choose one only)**
(A 'serving' = palm size of chicken or ½ cup)
e.g. 1 chicken breast + 2 chicken drumsticks + 1 chicken thigh = 4 servings per week

- Not applicable
- Less than1 serving
- 1-3 servings
- 4-6 servings
- 7 or more servings

***4. How often do you usually eat poultry?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Chicken legs or wings - palm size / ½ cup / 1 unit (wing, drumstick)									
Chicken breast - palm size / ½ cup / ½ breast									
Chicken mixed dishes (casserole, stir-fry) - palm size / ½ cup									
Crumbed chicken (nuggets, patties, schnitzel) - 1 medium / 4 nuggets									
Turkey or quail - palm size / ½ cup									
Mutton bird or duck - palm size / ½ cup									

EXPLORE Food Frequency Questionnaire

10. Fish and Seafood

***1. Do you eat any type of fish or seafood?**

- No
- Yes

***2. On average, how many servings of fish and seafood (all types; fresh, frozen, tinned) do you eat per week? (Please choose one only)**
(A 'serving' = 80 - 120g or palm size or small tin (85g))
e.g. 1 fish fillet and 1 small tin of tuna = 2 servings per week.

- Not applicable
- Less than 1 serving
- 1-3 servings
- 4-6 servings
- 7 or more servings

3. How do you normally cook / eat fish? (You can choose up to 3 options, but please only choose the ones you usually have)

- Not applicable
- Raw / I don't cook it
- Oven baked / Grilled
- Deep fried
- Shallow fry
- Micro waved
- Steamed
- Poached
- Smoked

EXPLORE Food Frequency Questionnaire

*4. How often do you usually eat seafood?

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Canned Salmon - 1 small can (85-95g)	○	○	○	○	○	○	○	○	○
Canned Tuna - 1 small can (85-95g)	○	○	○	○	○	○	○	○	○
Canned Mackerel, sardines, anchovies, herring - 1 small can (85-95g)	○	○	○	○	○	○	○	○	○
Frozen crumbed fish (patties, fillets, cakes, fingers, nuggets) - 1 medium / 4 nuggets	○	○	○	○	○	○	○	○	○
Snapper, Tarakihi, Hoki, Cod, Flounder - palm size / ½ cup	○	○	○	○	○	○	○	○	○
Gurnard, Kahawai or Trevally - palm size / ½ cup	○	○	○	○	○	○	○	○	○
Lemon fish or Shark - palm size / ½ cup	○	○	○	○	○	○	○	○	○
Tuna - palm size / ½ cup	○	○	○	○	○	○	○	○	○
Salmon, trout or eel - palm size / ½ cup	○	○	○	○	○	○	○	○	○

*5. How often do you usually eat seafood?

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Shrimp, prawn, lobster or crayfish - ½ cup	○	○	○	○	○	○	○	○	○
Crab or surumi - ½ cup	○	○	○	○	○	○	○	○	○
Scallops, mussels, oysters, paua or clams - ½ cup	○	○	○	○	○	○	○	○	○
Pipi or cockle - ½ cup	○	○	○	○	○	○	○	○	○
Kina - ½ cup	○	○	○	○	○	○	○	○	○
Whitebait - ¼ cup	○	○	○	○	○	○	○	○	○
Roe - ¼ cup	○	○	○	○	○	○	○	○	○
Squid, octopus, calamari, cuttlefish - ½ cup	○	○	○	○	○	○	○	○	○

EXPLORE Food Frequency Questionnaire

11. Fats and Oils

***1. Do you cook meat, chicken, fish, eggs and/or vegetables with fat or oil?**

- No
- Yes

2. What type(s) do you use most often? (You can choose up to 3 options, but please only choose the ones you usually have)

- Not applicable
- Butter (all varieties)
- Margarines (all varieties)
- Cooking oils (all varieties)
- Lard, Dripping, Coconut oil, Ghee (clarified butter)
- Cooking spray

Other (please state)

***3. 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)

- Not applicable
- Less than 1 serving
- 1 serving
- 2 servings
- 3 servings
- 4 servings
- 5 or more servings

***4. On average, how many servings of fat or oil do you use to cook per week? (Please choose one only)**

- Not applicable
- Less than 1 serving
- 1-3 servings
- 4-7 servings
- 8-10 servings
- 11-14 servings
- 15 or more servings

EXPLORE Food Frequency Questionnaire

12. Eggs

***1. Do you eat eggs?**

- No
- Yes

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

- Not applicable
- Less than 1 egg
- 1 egg
- 2 eggs
- 3 eggs
- 4 eggs
- 5 or more eggs

***3. How often do you usually eat eggs?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Whole eggs (hard-boiled, poached, fried, mashed, omelette, scrambled) - 1 egg	○	○	○	○	○	○	○	○	○
Mixed egg dish (quiche, frittata, other baked egg) - 1 slice	○	○	○	○	○	○	○	○	○

EXPLORE Food Frequency Questionnaire

13. Legumes

***1. Do you eat legumes e.g. chickpeas/dried peas, soybeans, dried/canned beans, baked beans, lentils or Dahl?**

- No
- Yes

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

- Not applicable
- Less than 1 serving
- 1 serving
- 2 servings
- 3 servings
- 4-5 servings
- 6-7 servings
- 8 or more servings

***3. How often do you usually eat these legumes?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Soybeans - ½ cup									
Tofu - ½ cup									
Dahl - ½ cup									
Canned or dried legumes, beans (baked beans, chickpeas, lentils, peas, beans) - ½ cup									
Hummus - 2 Tbsp									

EXPLORE Food Frequency Questionnaire

14. Vegetables

***1. Do you eat vegetables?**

- No
- Yes

***2. On average, how many servings of vegetables (fresh, frozen, canned) do you eat per day? Do NOT include vegetable juices. (Please choose one only)**
(A 'serving' = 1 medium potato / kumara or ½ cup cooked vegetables or 1/2 cup of lettuce)
e.g. 2 medium potatoes + ½ cup of peas = 3 servings

- Not applicable
- Less than 1 serving
- 1 serving
- 2 servings
- 3 servings
- 4 or more servings

***3. How often do you usually eat these vegetables?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Potato (boiled, mashed, baked, roasted) - 1 medium / ½ cup									
Pumpkin (boiled, mashed, baked, roasted) - ½ cup									
Kumara (boiled, mashed, baked, roasted) - 1 medium / ½ cup									
Mixed frozen vegetables - ½ cup									
Green beans - ½ cup									
Silver beet, spinach - ½ cup									
Carrots - 1 medium / ½ cup									
Sweet corn - 1 medium cob / ½ cup									
Mushrooms - ½ cup									
Tomatoes - 1 medium / ½ cup									
Beetroot - 1 medium / ½ cup									
Taro, cassava or breadfruit - 1 medium / ½ cup									

EXPLORE Food Frequency Questionnaire

***4. How often do you usually eat these vegetables?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Green bananas (plantain) - 1 medium / ½ cup	○	○	○	○	○	○	○	○	○
Sprouts (alfalfa, mung) - ½ cup	○	○	○	○	○	○	○	○	○
Pacific Island yams - 1 medium / ½ cup	○	○	○	○	○	○	○	○	○
Turnips, swedes, parsnip or yams - 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, cucumber - ½ cup	○	○	○	○	○	○	○	○	○
Capsicum (peppers) - ½ medium / ¼ cup	○	○	○	○	○	○	○	○	○
Avocado - ¼ avocado	○	○	○	○	○	○	○	○	○
Lettuce greens (mesculin, cos, iceberg) - ½ cup	○	○	○	○	○	○	○	○	○
Other green leafy vegetables (whitloof, watercress, taro leaves, puha) - ½ cup	○	○	○	○	○	○	○	○	○

EXPLORE Food Frequency Questionnaire

15. Fruit

***1. Do you eat fruit?**

- No
- Yes

***2. On average, how many servings of fruit (fresh, frozen, canned or stewed) do you eat per day? Do NOT include fruit juice. (Please choose one only)**
(A 'serving' = 1 medium or 2 small pieces of fruit or 1/2 cup of chopped fruit)
e.g. 1 apple + 2 small apricots = 2 servings)

- Not applicable
- Less than one serving
- 1 serving
- 2 servings
- 3 or more servings

***3. How often do you usually eat these fruits?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Apple - 1 medium / ½ cup									
Pear - 1 medium / ½ cup									
Banana - 1 medium / ½ cup									
Orange, mandarin, tangelo, grapefruit - 1 medium / 2 small									
Peach, nectarine, plum or apricot - 1 medium / ½ cup / 2 small									
Mango, paw-paw or persimmons / ½ cup									
Pineapple - ½ cup									
Grapes - ½ cup / 8-10 grapes									
Strawberries, other berries, cherries - ½ cup									
Melon (watermelon, rockmelon) - ½ cup									
Kiwifruit - 1 medium / 2 small									
Feijoas - 1 medium / 2 small									
Tamarillos - 1 medium / ½ cup									
Sultanas, raisins or currants - 1 small box									
Other dried fruit (apricots, prunes, dates) - 4 pieces									

EXPLORE Food Frequency Questionnaire

16. Drinks

***1. On average, how many drinks do you have per day? (Please choose one only) (A 'serving' = 250 mL or one cup/glass)**

- Less than 1 serving
- 1-3 servings
- 4-5 servings
- 6-8 servings
- 9-10 servings
- 11 or more servings

***2. How often do you usually have these drinks?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Instant soup (Cup of soup) - 250 mL / 1 cup									
Fruit juice (Just Juice, Fresh-up, Charlie's, Rio Gold) - 250 mL / 1 cup/glass									
Fruit drink (Choice, Rio Splice) - 250 mL / 1 cup/glass									
Vegetable juice (tomato juice, V8 juice) - 250 mL / 1 cup/glass									
Iced Tea (Lipton ice tea) - 250 mL / 1 cup/glass									
Cordial or Powdered drinks (Thriftee, Raro, Vita-fresh) - 250 mL / 1 cup/glass									
Low-calorie cordial - 250 mL / 1 cup/glass									
Energy drinks small-medium can (V, Red Bull) - 250-350 mL									
Energy drinks large can (Monster, Mother, Demon, large V) - 450-550 mL									
Sugar-free Energy drinks (sugar-free V, Monster, Red Bull) - 1 small can									
Diet soft/fizzy/carbonated drink (diet sprite) - 250 mL / 1 cup/glass									
Soft/fizzy/carbonated drinks (Coke, Sprite) - 250 mL / 1 cup/glass									
Sport's drinks (Gatorade, Powerade) - 1 bottle									
Flavoured water (Mizone, H2Go flavoured) - 1 bottle									
Water (unflavoured mineral water, soda water, tap water) - 250 mL / 1 cup/glass									

EXPLORE Food Frequency Questionnaire

***3. How often do you usually have these drinks?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Coffee instant or brewed with or without milk (Nescafe, expresso) - 1 cup	○	○	○	○	○	○	○	○	○
Specialty coffees (flat white, cappuccino, lattes) - 1 small cup	○	○	○	○	○	○	○	○	○
Coffee decaffeinated or substitute (Inka) - 1 cup	○	○	○	○	○	○	○	○	○
Hot chocolate drinks (drinking chocolate, hot chocolate, Koko) - 1 cup	○	○	○	○	○	○	○	○	○
Milo - 1 tsp	○	○	○	○	○	○	○	○	○
Tea (English breakfast tea, Earl Grey) - 1 cup	○	○	○	○	○	○	○	○	○
Herbal tea or Green tea - 1 cup	○	○	○	○	○	○	○	○	○
Soy drinks - 1 cup	○	○	○	○	○	○	○	○	○

***4. How often do you usually have these alcoholic drinks?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Beer – low alcohol - 1 can or bottle	○	○	○	○	○	○	○	○	○
Beer – ordinary - 1 can or bottle	○	○	○	○	○	○	○	○	○
Red wine - 1 small glass	○	○	○	○	○	○	○	○	○
White wine, champagne, sparkling wine - 1 small glass	○	○	○	○	○	○	○	○	○
Wine cooler - 1 small glass / bottle	○	○	○	○	○	○	○	○	○
Sparkling grape juice - 1 glass / cup	○	○	○	○	○	○	○	○	○
Sherry or port - 100 mL	○	○	○	○	○	○	○	○	○
Spirits, liqueurs - 1 shot or 30 mL	○	○	○	○	○	○	○	○	○
RTD (KGB, Vodka Cruiser, Woodstock bourbon) - 1 bottle / can	○	○	○	○	○	○	○	○	○
Cider - 1 glass / cup / bottle	○	○	○	○	○	○	○	○	○
Kava - 1 glass / cup	○	○	○	○	○	○	○	○	○

EXPLORE Food Frequency Questionnaire

17. Dressings and Sauces

***1. How often do you usually have these dressings or sauces?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Butter (all varieties) - 1 tsp	○	○	○	○	○	○	○	○	○
Margarine (all varieties) - 1 tsp	○	○	○	○	○	○	○	○	○
Oil (all varieties) - 1 tsp	○	○	○	○	○	○	○	○	○
Cream or sour cream - 1 Tbsp	○	○	○	○	○	○	○	○	○
Mayonnaise or creamy dressings (aioli, tartae sauce) - 1 Tbsp	○	○	○	○	○	○	○	○	○
Low fat/calorie dressing (reduced fat mayonnaise) - 1 Tbsp	○	○	○	○	○	○	○	○	○
Salad dressing (french, italian) - 1 Tbsp	○	○	○	○	○	○	○	○	○
Sauces (tomato, BBQ, sweet chilli, mint) - 1 Tbsp	○	○	○	○	○	○	○	○	○
Mustard - 1 Tbsp	○	○	○	○	○	○	○	○	○
Soy sauce - 1 Tbsp	○	○	○	○	○	○	○	○	○
Chutney or relish - 1 Tbsp	○	○	○	○	○	○	○	○	○
Gravy homemade - ¼ cup	○	○	○	○	○	○	○	○	○
Instant Gravy (e.g. Maggi) - ¼ cup	○	○	○	○	○	○	○	○	○
White sauce/cheese sauce - ¼ cup	○	○	○	○	○	○	○	○	○

EXPLORE Food Frequency Questionnaire

18. Miscellaneous - Cakes, Biscuits and Puddings

***1. How often do you usually eat these baked products?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Cakes, loaves, sweet muffins - 1 slice / 1 muffin	○	○	○	○	○	○	○	○	○
Sweet pies or pastries, tarts, doughnuts - 1 medium	○	○	○	○	○	○	○	○	○
Other puddings or desserts - not including milk-based puddings (sticky date pudding, pavlova) - ½ cup	○	○	○	○	○	○	○	○	○
Plain biscuits, cookies (Round wine, Ginger nut) - 2 biscuits	○	○	○	○	○	○	○	○	○
Fancy biscuits (chocolate, cream) - 2 biscuits	○	○	○	○	○	○	○	○	○

EXPLORE Food Frequency Questionnaire

19. Miscellaneous

*1. How often do you usually eat these other foods?

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Jelly - ½ cup									
Ice blocks - 1 ice block									
Lollies - 2 lollies									
Chocolate - including chocolate bars (Moro bars) - 1 small bar									
Sugar added to food and drinks - 1 level tsp									
Jam, honey, marmalade or syrup - 1 level tsp									
Vegemite or marmite - 1 level tsp									
Peanut butter or other nut spreads - 1 level Tbsp									
Brazil nuts or walnuts - 2									
Peanuts - 10									
Other nuts (almonds, cashew, pistachio, macadamia) - 10									
Seeds (pumpkin, sunflower)									
Muesli bars - 1 bar									
Coconut cream - ¼ cup									
Coconut milk - ¼ cup									
Lite coconut milk - ¼ cup									
Potato crisps, corn chips, Twisties - ½ cup / handful									

*2. Do you use salt in cooking?

- Never
- Rarely
- Sometimes
- Usually
- Always

*3. Do you use salt at the table?

- Never
- Rarely
- Sometimes
- Usually
- Always

EXPLORE Food Frequency Questionnaire

20. Miscellaneous - Takeaways

***1. On average, how often do you eat takeaways per week? (Please choose one only)**

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

***2. How often do you usually eat these takeaway foods?**

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Meat pie, sausage roll, other savouries - 1 pie / 2 small sausage rolls or savouries									
Hot potato chips, 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 (KFC, Country fried chicken) - 1 medium piece									
Bread based (Kebab, sandwiches, wraps, Pita Pit, Subway) - 1 medium									

EXPLORE Food Frequency Questionnaire

21. Other

***1. Are there any other foods or drinks that you can think of that you have on a regular basis that was not covered by this questionnaire?**

- No
- Yes

EXPLORE Food Frequency Questionnaire

22. Other

1. Please list these foods and drinks including; the serving size, and how many times per week you eat or drink these items (e.g. Pizza, 4 slices, one time per week)

Appendix 2 Decisions regarding standard serving equivalents (SSE)

Food	SSE	Justification
2 minute noodles	320g	This equates to roughly one cup of noodles and is the size of a standard packet serve.
Bagel/crumpet/scone/muffin	1 whole	Using the Australian dietary guidelines ADG[1] for plain cake/small cake-type muffin because they are similar in size and composition*.
Beer	330ml	As outlined in the MOH guidelines[4].
Bread	1 slice	As outlined in the EAGNZA[2].
Bread rolls/buns	1 bread roll	As outlined in the EAGNZA[2].
Butter/ margarine	2 Tbsp. (20g)	As outlined in the ADG[1].
Cereals (other)	0.5 cup	Using the EAGNZA[2] for muesli and porridge.
Cereals (Weetbix)	2 biscuits	As outlined in the EAGNZA[2].
Cheese	6 Tbsp. (40g)	As outlined in the EAGNZA[2].
Cheese (processed)	2 slices (40g)	Using the EAGNZA[2] for cheese.
Chicken drumsticks	2 drumsticks	As outlined in the EAGNZA[2].
Chicken nuggets	4 pieces	Using the ADG[1] for processed meats because 4 pieces is similar to 2 slices of other processed meats*.
Cider	330ml	As outlined in the MOH guidelines[4].
Coconut cream	2 Tbsp. (40g)	Using the ADG[1] for cream because they have similar compositions*.
Coconut milk	0.25 cup (~60ml)	Lower in fat than coconut cream*, thus a greater allowance.
Cracker	4 crackers (27g)	Using the ADG[1] for salty crackers or crisps (30g)*.
Cream	2 Tbsp. (40g)	As outlined in the ADG[1].
Cream cheese	2 Tbsp.	Using the ADG[1] for cream because it's higher in fat than most regular cheese*.
Dried fruit	30g	As outlined in the ADG[1].
Drinks (any type) and watery soup.	250ml	As outlined in the EAGNZA[2], a standard serve of fluid.
Egg	1 egg	As outlined in the EAGNZA[2].
Fish	100g or one medium fillet	As outlined in the EAGNZA[2].
Fruit	1 medium-sized piece	As outlined in the EAGNZA[2].
Ham/luncheon/salami/corned beef/bacon	2 slices/rashers	As outlined in the ADG[1].
Hot potato chips, kumara chips, French fries, wedges	12 Chips (60g)	As outlined in the ADG[1].
Jam/honey	~2 Tbsp. (60g)	As outlined in the ADG[1].
Leafy vegetables (e.g. lettuce, spinach and watercress)	1 cup	Serve size used in the NZANS 2008/09, making results comparable with dietary results of Māori and Pacific women in the EXPLORE study.
Legumes (e.g. baked beans and	0.75 cup	As outlined in the EAGNZA[2].

chickpeas)		
Māori bread	1 piece	These are approximately half the size of a slice of bread but are fried, thus high in energy*.
Meat (most types)	100g	As outlined in the EAGNZA[2].
Nuts and seeds	30g	As outlined in the EAGNZA[2].
Oil	10ml	As outlined in the ADG[1].
Pasta	1 cup	As outlined in the EAGNZA[2].
Peanut butter	30g	As outlined in the ADG[1].
Quinoa	1 cup	Using the EAGNZA[2] for rice*.
Rice	1 cup	As outlined in the EAGNZA[2].
Sausages	1.5 sausages	As outlined in the ADG[1].
Seafood (e.g. prawns, crab, pipi)	0.5 cup (~100g)	Using the EAGNZA[2] for fish*.
Spaghetti/noodles	1 cup	Using the EAGNZA[2] for pasta.
Spirits	30ml	As outlined in the MOH guidelines[4].
Stewed beef kidney	0.75 cup	Using the EAGNZA[2] for mince or casseroles.
Sugar	1 tsp. (4g)	Chelsea sugar serve, in-line with FSANZ[3].
Sushi	8 pieces	St Pierre's Sushi serve, in-line with FSANZ[4].
Tortilla/pancake	1 medium tortilla/pancake	Using the EAGNZA[2] for bread because tortillas and pancakes are similar in size and composition to one slice of bread*.
Vegetables (most types)	0.5 cup	As outlined in the EAGNZA[2].
Wine	100ml	As outlined in the MOH guidelines[4].

* = Foods were compared using the NZ food composition tables (Sivakumaran et al., 2015); ADG = Australian Dietary Guidelines; EAGNZA = Eating and Activity Guidelines for New Zealand Adults; FSANZ = Food Standards Authority New Zealand; MOH = Ministry of Health; SSE = Standard serving equivalents

1. SSE for discretionary food is limited in NZ, so the Australian dietary guidelines (ADG) were used (AGDH, 2015)
2. Most SSE for foods were outlined in the Eating and Activity Guidelines for New Zealand Adults (MOH, 2015b)
3. FSANZ provide the guidelines for a standard serve of sugar, which is also displayed on the back of various packets of sugar e.g. Chelsea sugar
4. Alcohol intake guidelines (MOH, 2016a)

Appendix 3 Food groups

Food groups in analysis	Food, as listed in the FFQ
Milk	Full cream milk (purple top)/ Standard milk (blue top)/ Skim milk (light blue top)/ Trim milk (green top)/ Super trim milk (light green top)/ Calcium enriched milk (yellow top) e.g. Xtra, Calci/ 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/ Evaporated milk.
Cheese	Brie, blue and other specialty cheese/ Cheddar (Tasty, Mild, Colby)/ Cottage or ricotta cheese/ Cream cheese/ Edam, Gouda, Swiss/ Feta, Mozarella, Camembert/ Processed cheese slices.
Dairy-based foods	Yoghurt, plain or flavour.
Discretionary dairy products	Custard or dairy food/ Ice cream/ Milk puddings (semolina, instant)/ Breakfast drinks (Up and Go)/ Flavoured milk e.g. milkshake, iced coffee, Primo, Nesquik/ Cream or sour cream.
Bread	Focaccia, bagel, pita, panini or other speciality breads/ Fruit bread or fruit bun/ Wholegrain bread/ High fibre white bread/ Plain white bread/ Wholemeal or wheat meal/ Crackers (cream crackers, cruskits, corn / rice crackers, vitawheat)/ Crumpet or muffin split/ Bran muffin or savoury muffin/ Waffle, pancakes or pikelets/ Scone/ Wrap.
Cereal	Bran cereals (All Bran, Bran Flakes)/ Cornflakes or rice bubbles/ Light and fruity cereals (Special K, Light and Tasty)/ Muesli (all varieties)/ Porridge, rolled oats, oat bran, oat meal/ Bran based cereals (Sultana Bran, Sultana Bran Extra)/ Weetbix (all varieties).
Starchy foods	Egg and rice noodles (hokkien noodles, udon)/ Pasta, white or wholegrain (spaghetti, vermicelli)/ Other grain (quinoa, couscous, bulgar wheat)/ Rice, brown or wild/ Rice, white.
Discretionary breads, cereals and starchy foods	Iced buns/ Croissant/ Paraoa Parai (fry bread)/ Doughboys or Māori bread/ Chocolate based cereals (Milo cereal, Coco Pops)/ Sweetened cereals (Nutrigrain, Fruit Loops, Honey Puffs, Frosties)/ Instant noodles (2 minute noodles)/ Canned spaghetti (Watties).
Red meat[1]	Beef or veal (roast, chop, steak, schnitzel, corned beef)/ Offal (liver, kidneys, pate)/ Beef or veal mixed dishes (casserole, stirfry)/ Ham/ Lamb, hogget or mutton (roast, chops, steak)/ Lamb, hogget or mutton mixed dishes (stews, casserole, stirfry)/ Pork (roast, chop, steak)/ Venison/game.
Poultry	Chicken mixed dishes (casserole, stirfry)/ Chicken breast/ Chicken legs or wings/ Mutton bird or duck/ Turkey or quail.
Fish and	Canned Salmon/ Canned Tuna/ Canned Mackerel, sardines, anchovies,

Seafood	herring/ Frozen crumbed fish (patties, fillets, cakes, fingers, nuggets)/ Snapper, Tarakihi, Hoki, Cod, Flounder/ Lemon fish or Shark/ Tuna/ Salmon, trout or eel/ Shrimp, prawn, lobster or crayfish/ Scallops, mussels, oysters, paua or clams/ Pipi or cockle/ Whitebait/ Kina/ Squid, octopus, calamari, cuttlefish.
Eggs	Whole eggs (hardboiled, poached, fried, mashed, omelette, scrambled)/ Mixed egg dish (quiche, frittata, other baked egg).
Legumes, nuts and seeds	Soybeans/ Tofu/ Dahl/ Canned or dried legumes, beans (baked beans, chickpeas, lentils, peas, beans)/ Hummus/ Peanut butter or other nut spreads/ Brazil nuts or walnuts/ Peanuts/ Other nuts (almonds, cashew, pistachio, macadamia)/ Seeds (pumpkin, sunflower).
Discretionary meat and meat-alternatives[2]	Canned corned beef/ Sausage, frankfurter or saveloy/ Bacon/ Luncheon meats or brawn Salami or chorizo/ Crumbed chicken (nuggets, patties, schnitzel)/ Crab or surumi/ Beef mince dishes (rissoles, meatloaf, hamburger pattie).
Starchy vegetables[3]	Potato (boiled, mashed, baked, roasted)/ Kumara (boiled, mashed, baked, roasted)/ Taro, cassava or breadfruit/ Green bananas (plantain)/ Pacific Island yams.
Vegetables (other)	Pumpkin (boiled, mashed, baked, roasted)/ Mixed frozen vegetables/ Green beans/ Silver beet, spinach/ Carrots/ Sweet corn/ Mushrooms/ Tomatoes/ Beetroot/ Sprouts (alfalfa, mung) / Turnips, swedes, parsnip or yams/ Onions, celery or leeks/ Cauliflower, broccoli or broccoflower/ Brussel sprouts, cabbage, red cabbage or kale/ Courgette/zucchini, marrow, eggplant, squash, kamo kamo, asparagus, cucumber/ Capsicum (peppers) / Lettuce greens (mesculin, cos, iceberg) / Other green leafy vegetables (whitloof, watercress, taro leaves, puha).
Fruit	Avocado/ Apple/ Pear/ Banana/ Orange, mandarin, tangelo, grapefruit/ Peach, nectarine, plum or apricot/ Mango, pawpaw or persimmons/ Pineapple/ Grapes/ Strawberries, other berries, cherries/ Melon (watermelon, rockmelon)/ Kiwifruit/ Feijoas/ Tamarillos/ Sultanas, raisins or currants/ Other dried fruit (apricots, prunes, dates).
Drinks	Instant soup (Cup of soup)/ Vegetable juice (tomato juice, V8 juice)/ Water (unflavoured mineral water, soda water, tap water)/ Coffee instant or brewed with or without milk (Nescafe, expresso)/ Specialty coffees (flat white, cappuccino, lattes)/ Coffee decaffeinated or substitute (Inka)/ Tea (English breakfast tea, Earl Grey)/ Herbal tea or Green tea.
SSB[4]	Fruit juice (Just Juice, Freshup, Charlie’s, Rio Gold)/ Fruit drink (Choice, Rio Splice)/ Iced Tea (Lipton ice tea)/ Cordial or Powdered drinks (Thriftee, Raro, Vitafresh)/ Low-calorie cordial/ Energy drinks small-medium can (V, Red Bull)/ Sugar-free Energy drinks (sugar-free V, Monster, Red Bull), small can/ Soft/fizzy/carbonated drinks (Coke, Sprite)/ Sport's drinks (Gatorade, Powerade)/ Flavoured water (Mizone, H2Go flavoured)/ Hot chocolate drinks (drinking chocolate, hot chocolate, Koko)/ Milo/ Sparkling grape juice.
Alcohol	Beer – low alcohol/ Beer – ordinary/ Red wine/ White wine, champagne, sparkling wine/ Wine cooler/ Sherry or port/ Spirits, liqueurs/ Cider.
Takeaways	Meat pie, sausage roll, other savouries/ Hot potato chips, kumara chips,

	french fries, wedges/ Chinese/ Indian/ Thai/ Pizza/ Burgers/ Battered fish/ Fried chicken (KFC, Country fried chicken)/ Bread based (Kebab, sandwiches, wraps, Pita Pit, Subway)/ Sushi.
Discretionary savoury snacks	Potato crisps, corn chips, Twisties.
Discretionary sweet snacks	Cakes, loaves, sweet muffins/ Sweet pies or pastries, tarts, doughnuts/ Other puddings or desserts not including milk-based puddings (sticky date pudding, pavlova)/ Plain biscuits, cookies (Round wine, Ginger nut)/ Fancy biscuits (chocolate, cream)/ Jelly/ Ice blocks/ Lollies/ Chocolate including chocolate bars (Moro bars)/ Muesli bars.
Butter, margarine, oils and fats	Butter (all varieties)/Margarines (all varieties)/ Cooking oils (all varieties)/ Lard, Dripping, Coconut oil, Ghee (clarified butter)/ Cooking spray/ Coconut cream/ Coconut milk/ 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.
Sauces, spreads and flavourings (savoury)	Mayonnaise or creamy dressings (aioli, tartae sauce)/ Low fat/calorie dressing (reduced fat mayonnaise)/ Salad dressing (french, italian)/ Mustard/ Soy sauce/ Gravy homemade/ Instant Gravy (e.g. Maggi)/ White sauce/cheese sauce/ Vegemite or marmite.
Sauces, spreads and flavourings (sweet)	Sauces (tomato, BBQ, sweet chilli, mint)/ Chutney or relish/ Sugar added to food and drinks/ Jam, honey, marmalade or syrup.
Supplements providing energy	Protein powder/ Protein shake/ Protein bar.

1. Red meat includes beef, lamb, mutton, goat, venison and pork. Having a separate group for red meat allows comparison with NZANS participants (MOH, 2011a)
2. Meat and Meat-alternatives describe the protein foods for non-vegetarians and vegetarians, respectively. These include legumes, nuts, seeds, fish and other seafood, eggs, poultry and red meat
3. Starchy vegetables contain some vitamins, minerals and fibre, but are usually higher in energy than other vegetables. They will often have a high glycaemic index. Kumara, potatoes, taro, yams and green bananas (green plantains) are classed as starchy vegetables in the Eating and Activity Guidelines for New Zealand Adults (EAGNZA) (MOH, 2015b)

The EAGNZA define SSB as fruit drinks, flavoured water, carbonated or fizzy drinks, cordial, powdered drinks, energy drinks, and sports drinks (MOH, 2015b)

Appendix 4 Assumptions followed when entering FFQ data

Drinks

Specialty coffee = Coffee, expresso, brewed AND Milk, cow, standard 3.3% fat, fluid, Auckland, November, Anchor. I combined these two entries because there are other types of coffee included in the analysis which are not separated into their milk/coffee components.

Drinks – alcoholic

RTD = Spirit, 70 proof AND Soft drink, lemonade.

Meals – Takeaways

Indian curry = Curry, butter chicken, indian, takeaway AND Rice, basmati, cooked, indian restaurant AND Bread, naan, indian restaurant. I combined these three entries because there are other types of takeaways included in the analysis which are not separated into their components/ingredients.

Hot potato chips, kumara chips, french fries, wedges = Potato,frzn wedges,canola oil,baked

Hot potato chips, kumara chips, french fries, wedges = Potato,fries,independant shops,straight cut (2009)

Milk

Purple full cream milk = Milk,whole,3.3% fat,Akl,Nov,Anchor + cream

Blue milk or Lacto free whole milk = Milk,whole,3.3% fat,Akl,Nov,Anchor

Light blue milk or Lacto free skim milk = Milk,lite,1.5% fat,Akl,Nov,Anchor

Green trim milk = Milk,trim,0.5% fat,Akl,Nov,Anchor

Yellow milk = Milk,High Calcium,0.1% fat,Nov,Anchor&Meadow fresh

Light green super trim milk = Milk,Super,Xtra,Ultra trim,0.3% fat,Nov,Anchor&MF

Standard soy milk or almond milk = Soy drink,So Good

Standard soy milk or almond milk = Soy drink,So Good Essential,Sanitarium

Light soy milk = Soy drink,So Good Lite

Not applicable = Milk, whole, 3.3% fat, Akl, Nov, Anchor

Blue milk or Lacto free whole milk = Milk,fluid,whole

Orange milk = Milk,2% fat,Anchor,"Mega milk",Fortified

Oils

Butter = Butter, salted

Coconut oil = Oil, coconut

Margarines (all varieties) = Margarine, Mono, 70% fat, Olivio Bertolli Classico

Cooking oils (all varieties) = Oil, composite

Lard, dripping, coconut oil, ghee (clarified butter) = Lard

Cooking spray = Oil, Composite

Not applicable = Oil, composite

Spreads

Butter = Butter, salted

Butter = Butter,cultured

Monounsaturated fat margarine e.g. olive, rice bran, canola oil = Margarine, Mono, 70% fat, Olivio Bertolli Classico

Monounsaturated fat margarine e.g. olive, rice bran, canola oil = Margarine spread,Mono canola,70% fat

Monounsaturated fat margarine e.g. olive, rice bran, canola oil = Margarine,Mono olive bld,75% fat,Olivani

Monounsaturated fat margarine e.g. olive, rice bran, canola oil = Olive oil

Polyunsaturated fat margarine e.g. sunflower oil spreads = Margarine, Poly, 60% fat, Sunrise

Light monounsaturated fat margarine e.g. Olivio Spread Light = Margarine, Mono, 55% fat, Olivani Lite

Light monounsaturated fat margarine e.g. Olivio Spread Light = Margarine,Mono,55% fat,Olivio Bertolli Light

Light polyunsaturated fat margarine e.g. Flora Spread Light = Margarine, Poly,50% fat, Flora Light

Light polyunsaturated fat margarine e.g. Flora Spread Light = Margarine,Poly,60% fat,Sunrise

Plant sterol enriched margarine e.g. Pro Active, Logical spreads = Spread, Rice bran oil, Alfa one

Light plant sterol enriched margarine e.g. Pro Active spread light = Spread, Rice bran oil, Light, Alfa one

Butter and margarine blend e.g. Country soft, butter lea = Dairy blend, Butter Canola

Not applicable = Margarine, Mono, 70% fat, Olivio Bertolli Classico

<u>Supplements providing energy</u>

Protein bar = Protein bar

Protein powder = Protein powder

Protein shake = Protein shake