Breakfast intake, habits and body composition in New Zealand European women

A thesis presented for the partial fulfilment of the requirements for the degree of

Master of Science

in

Nutrition and Dietetics

Massey University, Albany

New Zealand

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2017

Abstract

ABSTRACT

Background: The rise of obesity and related poor health outcomes is rampant in New Zealand. Dietary factors are key in the aetiology of obesity. One dietary factor with wide reaching implications on health and weight maintenance is breakfast consumption. Breakfast consumption has declined in New Zealand in recent years, and adverse health outcomes have risen concurrently. Breakfast consumption has been associated with lower BMI, improved appetite control, better diet quality, and more stable glycaemia.

Objective: The aim of this study was to describe and compare reported and observed breakfast consumption between obese and normal weight New Zealand European women aged 18-45 years, living in Auckland, New Zealand.

Methods: In a cross-sectional study, healthy women (n=75 normal BMI, n=82 obese BMI) completed a 5-day food record, an observed *ad libitum* buffet breakfast assessment and body composition measurements. Nutrient intake, food choices and behavioural aspects, including pace of eating and meal skipping data were obtained and analysed.

Results: More normal BMI women (n=69; 84.1%) than obese BMI women (n=56; 74.6%) consumed breakfast daily. Obese BMI women consumed significantly more energy at the observed breakfast (1915 ± 868 kJ) than at the recorded breakfast (1431 ± 690kJ, p<0.001); however neither BMI group met one third of estimated energy requirements at either breakfast occasion. Carbohydrate consumption was lower than recommended (AMDR: 45-65%) in both groups in the recorded breakfast (40.7% and 42.6%; normal BMI and obese BMI respectively), whereas total fat consumption was higher than recommended (AMDR: 20-35%) (36.5% and 35.9% respectively). Protein consumption was within AMDR recommendations (15-25%) for both groups in the recorded breakfast (16.3% and 17.5%) but not in the observed breakfast, (13.0% and 14.0%), obese BMI and normal BMI respectively. Foods with the greatest contribution to energy at the observed breakfast for obese BMI women were discretionary items (fats, cake and biscuits), compared with sweetened cereals, nuts and seeds for normal BMI women. Having a faster pace of eating and consuming foods with a higher energy density significantly increased the likelihood of falling into the obese BMI category (b=3.11, p=0.016; b=1.35, p=0.042 respectively).

Conclusions: Consuming a breakfast, particularly one that contains whole grains, fruits and low-fat dairy products, and minimising discretionary items could enable women to more closely meet dietary recommendations, and as a result, improve health outcomes.

Key words: breakfast, obesity, energy intake, appetite, pace of eating

Acknowledgements

Firstly, I would like to acknowledge the significant contribution made by the participants in the PROMISE study. The huge effort made at both visits to the research centre, and during at home data collection enabled this research to take place.

I would also like to thank my supervisors A/Prof Rozanne Kruger and Dr Marilize Richter for the invaluable advice and guidance provided throughout this process. Thank you so much for your availability and support, and for enabling me to see the manageable individual tasks that made up the whole. Thank you also to Prof Bernhard Breier, without whose vision and passion this project could never have eventuated.

Thank you to my colleagues on the PROMISE study, particularly Niamh Brennan, Nikki Renall, Jo Slater and Sophie Kindleysides. Your knowledge and effort made during data collection made this process enjoyable, and I learned an immense amount. Thank you also to Bronte Anscombe, who persevered through countless hours of data entry. Your energy and motivation enabled me to keep on track and inspired.

Without the support of my family and friends I couldn't have made it through these endless years of study. Thank you to those who proof read and offered constructive feedback; Judy your keen eye was so valued. Finally, to my husband Robbie, thank you for your encouragement and support over these years!

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List of Abbreviations

AMDR	Acceptable macronutrient distribution range
ANS	Adult Nutrition Survey
BIA	Bioelectrical Impedance Analysis
BMI	Body mass index (kg/m^2)
CCK	Cholecystokinin
CRP	C-reactive protein
CVD	Cardiovascular disease
EAR	Estimated Average Requirement
GLP-1	Glucagon like peptide 1
IL-6	Interleukin-6
NCD	Non communicable disease
NHANES	National Health and Nutrition Examination Survey
NHMRC	National Health and Medical Research Council
NRV	Nutrient Reference Values
NZ	New Zealand
PCOS	Polycystic ovarian syndrome
PYY	Peptide YY (or peptide tyrosine tyrosine)
RMR	Resting metabolic rate
USA	United States of America
T2DM	Type 2 diabetes mellitus
WC	Waist Circumference
WHO	World Health Organisation
WHR	Waist to hip ratio

Chapter 1 Introduction and Scope

1.1.1 Background

The global obesity epidemic is showing no signs of slowing down, despite significant public health efforts to address the problem (Swinburn *et al.*, 2011, Roberto *et al.*, 2015, The GBD 2015 Obesity Collaborators, 2017). Within New Zealand, where more than one third of the population is obese, the effects of obesity related disease are significant (Ministry of Health, 2017). Unbalanced energy intake and energy expenditure are widespread features in the Western obesogenic environment; a key component in the development of obesity (Swinburn *et al.*, 2011, Hanson and Gluckman, 2015). The relationship between the consumption of energy dense fast food combined with an excessively sedentary lifestyle, as well as the influence of genetic factors, sets the scene for chronic weight gain and ill health (Hu, 2004, Hanson and Gluckman, 2015). It has been well established that obesity has a significant role in the aetiology of chronic disease. Excess body fat has been implicated in the increased rate of all-cause mortality, cardiovascular disease, type 2 diabetes and certain cancers (Hu, 2004, Ryan, 2007, O'Rahilly, 2009, Huxley *et al.*, 2010).

Obesity can be defined as excess adipose tissue (Villareal *et al.*, 2005, Huxley *et al.*, 2010, Oliveros *et al.*, 2014). There are a number of methods employed in the diagnosis, each with related benefits and drawbacks. Calculation of the body mass index (BMI) is a common diagnostic method, as it is simple and has been widely validated (Huxley *et al.*, 2010, Romero-Corral *et al.*, 2010). Directly measuring body fat (and lean tissue) using dual x-ray absorptiometry (the preferred method) or bioelectrical impedance analysis are other common diagnostic tools (Oliveros *et al.*, 2014). Anthropometric measurements considering abdominal adiposity such as waist circumference, waist to hip ratio and waist to height ratio are also commonly used, owing to the significance of abdominal fatness in the risk of chronic disease (Cameron *et al.*, 2009, Huxley *et al.*, 2010, Oliveros *et al.*, 2014).

Obesity is universally detrimental to health; however the associated complications have a greater effect on women (Hu, 2004, Ryan, 2007). In particular, type 2 diabetes and coronary heart disease are significant contributors to mortality in women, and obesity increases the risk of these diseases (Hu, 2004, Hanson and Gluckman, 2015). Obesity also negatively effects reproductive health, with excess maternal adiposity being associated with complications in pregnancy, increased risk of miscarriage and congenital defects in offspring (Ryan, 2007, Eriksson *et al.*, 2014, Eriksson *et al.*, 2015). The effects of maternal adiposity are long standing, and the offspring of obese mothers are at an increased risk of obesity and cardiometabolic morbidity later in life (Eriksson *et al.*, 2015). Excessive gestational weight gain and post-partum weight retention have also been associated with increased obesity later in life, and therefore an increase in risk of chronic disease (Rooney and Schauberger, 2002, Gore *et al.*, 2003).

The aetiology of obesity is multifactorial, and encompasses aspects such as energy balance, environmental, genetic and behavioural factors (Swinburn *et al.*, 2011). Of cardinal importance are dietary factors, due to the inextricable link between food intake and energy balance. Dietary factors which contribute to excessive weight gain and subsequent obesity include energy intake in excess of requirements, excessive intake of discretionary foods high in fat and sugar, poor diet quality, skipping meals, and late-night eating (Swinburn *et al.*, 2004, Mendoza *et al.*, 2007, Swinburn *et al.*, 2011, Barr *et al.*, 2016). Breakfast is one meal which has received widespread attention due to its association with various health outcomes (Pereira *et al.*, 2011, Odegaard *et al.*, 2013, O'Neil *et al.*, 2014, Kant and Graubard, 2015, Barr *et al.*, 2016). Breakfast has been defined as “the first meal of the day, eaten before or at the start of daily activities, within two hours of waking, typically no later than 10 am, of an energy level between 20 and 35% of total daily energy needs” (Pereira *et al.,* 2011). The role of eating breakfast in the aetiology of obesity has been explored in relation to a number of contributing aspects. The breakfast meal provides an opportunity to consume a number of key nutrients that may be lacking at subsequent meals, particularly when breakfast cereal is consumed (Albertson *et al.*, 2008, Kant *et al.*, 2008, Deshmukh-Taskar, 2010). The breakfast meal also has a role in providing the opportunity to spread out food intake throughout the day, and is related to eating frequency - an aspect of dietary behaviour that is linked to weight maintenance and diet quality (Smith *et al.*, 2012, Murakami and Livingstone, 2016). Breakfast consumption has also been associated with improved body weight, reduced energy intake and improved satiety, as a result of the consumption of foods high in fibre and low in fat (Wyatt *et al.*, 2002, Song *et al.*, 2005, Clegg and Shafat, 2010, Rebello *et al.*, 2013). Conversely, skipping breakfast has been associated with excess weight gain, purportedly due to over-consuming energy at subsequent meals (Cho *et al.*, 2003, Kant and Graubard, 2015, Megson *et al.*, 2017). In addition to the over-consumption of energy, those who skip breakfast often consume a poorer quality diet with lower intake of micronutrients, suggesting high intake of discretionary, energy dense food (Pereira *et al.,* 2011).

The consumption of breakfast in Western countries such as the United States of America, Australia and New Zealand has declined in recent years, where approximately 25% of people frequently skip breakfast (Song *et al.*, 2005, Deshmukh-Taskar *et al.*, 2010, Ministry of Health, 2012, Levitsky, 2013). In New Zealand, the National Nutrition Survey 2008-9 showed that around 79% of women across all age groups and ethnicities consume breakfast every day (Ministry of Health, 2012). The present trend illustrates that breakfast consumption increases with age; only 44.5% of women between 15-18 years consume breakfast every day, whereas 96.9% of women aged 71+ years are regular breakfast consumers (Ministry of Health, 2012). The figures relating to adult women of the same age group as the present study population show that around 55% of women consume breakfast daily (Ministry of Health, 2012). This is concerning, as there are a multitude of health benefits associated with breakfast consumption, including weight maintenance, improved nutrient adequacy, more stable glycaemia, and improved satiety, that may be lost to those who skip breakfast (Cho *et al.*, 2003, Clegg and Shafat, 2010, Barr *et al.*, 2013, Odegaard *et al.*, 2013, Betts *et al.*, 2014). There are also many adverse effects of regular breakfast skipping, such as impaired fasting lipids, postprandial insulin sensitivity, and impaired glucose homeostasis (Farshchi *et al.*, 2005, Nas *et al.*, 2017). Breakfast consumers also often exhibit other healthy lifestyle behaviours, such as greater physical activity, less smoking and alcohol intake and lower fat eating patterns (Song *et al.*, 2005, Levitsky, 2013).

In Western societies, the breakfast meal traditionally encompasses foods high in carbohydrate and high in fibre, such as oats and cereals, bread, fruit, and dairy products (Cho *et al.*, 2003, Chowdhury *et al.*, 2015). These foods confer a number of health benefits, and are linked to improved satiety, glycaemia, lipidaemia, weight maintenance and reduced cardiometabolic disease (McKeown *et al.*, 2002, Albertson *et al.*, 2008, Chowdhury *et al.*, 2015). Regular breakfast consumers have been shown to have a more favourable diet quality, with reduced intake of energy, saturated fat and added sugars (Deshmukh-Taskar, 2010, Barr *et al.*, 2013, O'Neil *et al.*, 2014). Additionally, regular breakfast consumers have been observed to consume more whole grains, and foods from diverse food groups (O'Neil *et al.*, 2010).

It is widely acknowledged that obesity is an important driver of chronic disease, particularly cardiometabolic disease (Cameron *et al.*, 2009, The GBD 2015 Obesity Collaborators, 2017). There are key metabolic alterations evident in the aetiology of cardiometabolic disease: alterations in fat oxidation, post prandial insulin response and glucose disposal, inflammation, and altered lipid profiles (Nas *et al.*, 2017). These have been observed in relation to irregular breakfast patterns (Nas *et al.*, 2017). It has also been observed in large cohort studies that breakfast consumers generally have a lower BMI than those who regularly skip breakfast (Wyatt *et al.*, 2002, Cho *et al.*, 2003). The relationship between weight control and breakfast consumption is multifactorial, with a number of elements involved, including appetite and satiety, energy intake and expenditure (Pereira *et al.*, 2011, Rebello *et al.*, 2013, Betts *et al.*, 2014). It has been observed regularly that appetite control is a key component in weight management; appetite is a strong driver towards the consumption of food irrespective of energy requirements (Rebello *et al.*, 2013).

Infrequent eating (for example skipping breakfast) has been linked to inferior control of appetite and consequently an increased desire to eat (Clegg and Shafat, 2010, Pereira *et al.*, 2011). Reduced diet-induced thermogenesis, and thus reduced energy expenditure, has additionally been associated with infrequent meals (Farshchi *et al.*, 2005, Neumann *et al.*, 2016). Infrequent meal consumption also influences the hormonal control of appetite via mechanisms such as the release of orexigenic hormones in response to a meal, with metabolic changes observed such as elevated insulin after a test lunch meal following morning fasting (Chowdhury *et al.*, 2015). The composition of meals, in particular foods rich in fibre and carbohydrate such as oats, influence appetite hormone concentrations, the glycaemic response, and satiety, as a result of bulking effects, stomach distension and the stimulation of satiety signals (Rebello *et al.*, 2013). Satiety is another key component related to weight control, energy intake and expenditure (Rebello *et al.*, 2013). Breakfast consumption is particularly satiating and has been linked to reduced food intake throughout the remainder of the day (Rebello *et al.*, 2013).

1.1.2 Purpose of the Study

Within New Zealand, the patterns of an uncontrollable obesity epidemic and decreased breakfast consumption mimic what has been observed globally (Lal *et al.*, 2012, Vandevijvere *et al.*, 2015, Ministry of Health, 2017). Obesity in New Zealand has consistently risen in the last decade; from 26.5% to 32.2% (Ministry of Health, 2017). Thirty-two percent of New Zealand European women are obese, which equates to approximately 440000 - a substantial proportion of the population. Additionally, the burden of non-communicable disease in New Zealand is large, with cancer, diabetes and cardiovascular disease accounting for 89% of total deaths in New Zealand (World Health Organisation, 2014). The adverse effects particularly impacting women confirms the importance of novel practical interventions that can halt the rapid rise in obesity and related outcomes.

Given the increased risk of adverse health outcomes associated with obesity, it is important to discover whether there are differences in food choices and eating habits between obese and normal BMI people. As breakfast consumption has been associated with the reduced risk of many of these diseases, it is beneficial to assess self-reported breakfast consumption in terms of nutritional content as well as food choice, in these groups. Additionally, to further explore breakfast eating practices, an observed breakfast allows determination of whether food choices are different between groups when presented with a buffet meal.

This study seeks first to describe the breakfast eating practices of obese versus normal weight New Zealand European women aged between 18 and 45 years, and second to characterise factors associated with breakfast consumption. This will inform recommendations which may serve to support the development of novel research areas and practical strategies with recommendations relating to breakfast consumption. These strategies may assist in reaching the common goal of reducing obesity and contributing to widespread improvements in the health of New Zealand women and their offspring.

1.2 Aims and Objectives

The aim of this study is to describe and compare reported and observed breakfast consumption between obese and normal weight New Zealand European women, aged 18-45 years, living in Auckland, New Zealand.

1.2.1 Objectives

- To describe reported and observed breakfast consumption between normal weight and obese women.
- To compare differences between reported and observed breakfast consumption within each body composition group.
- To describe and compare recorded versus observed nutrient consumption between each body composition group.
- To describe and compare reported versus observed food choices between each body composition group.
- To describe and compare reported and observed eating behaviours (meal skipping, meal timing, and rate or pace of eating) between each body composition group.
- To determine the factors that increase the likelihood of being obese.

1.2.2 Hypothesis

It is hypothesised that obese women will consume less energy at breakfast due to increased rates of skipping breakfast, with a greater contribution to energy from saturated fat and discretionary foods at breakfast than normal weight New Zealand women. A secondary hypothesis is that obese women will omit breakfast more frequently and have a faster pace of eating than normal weight women.

1.3 Structure of the Thesis

This thesis consists of four chapters. The first chapter provides an introduction to concepts described in the study, and introduces the purpose of the study. Chapter two is a narrative literature review, highlighting the health effects of obesity and the link between breakfast consumption and various health outcomes. This chapter was prepared in accordance with the guidelines for submission to Nutrition Reviews. Key words were identified, including obesity, breakfast, diabetes, cardiovascular disease, diet quality, appetite, satiety, insulin, metabolic syndrome. Databases were searched, including discover, web of science and google scholar. The third chapter is the research study manuscript, providing an abstract and introduction, describing methodology used, and presenting and discussing results and conclusions. This manuscript was prepared according to the guidelines for submission to Asia Pacific Journal of Clinical Nutrition. Chapter four provides a summary of the research, including conclusions, strengths and limitations of the study, and recommendations for further research. Appendix A contains supplementary results. Appendix B contains procedures for food record data entry. Appendix C contains foods provided at the observed breakfast and corresponding FoodWorks foods. Appendix D contains assumptions for entering food record data. Appendix E contains food groups used. Appendicies F and G contain author guidelines for the narrative review and research manuscript respectively. Referencing has been completed according to the Harvard referencing style throughout. Tables have been presented within the text, rather than after the references for both articles for ease of reading. Lines were not numbered, for ease of reading.

1.4 Researchers' Contributions to the Study

Table 1.1 Researchers' Contributions to the Study

Researchers	Contributions to the Study
Elizabeth Cullen	Assisted in planning and implementation of the breakfast study, co-ordinated research assistants, food record data entry and checking. Data and statistical analysis, interpretation of results, author of the thesis.
A/ Prof Rozanne Kruger	Main supervisor. Concept and research design of the PROMISE study, ethical application. Designed and conceptualised the breakfast study, supervised the execution of the breakfast study, data entry and analysis, interpretation of results, revision and approval of the thesis.
Dr Marilize Richter	Co-supervisor. Advisor on the breakfast study, supervised the data entry and analysis, advisor for statistical analysis, interpretation of results, revision and approval of the thesis.
Prof Bernhard Breier	Lead investigator, PROMISE study Concept and research design of the PROMISE study, ethical application.
Nikki Renall and Jo Slater	Dietary review interviews, checking of food records, planning and implementation of the PROMISE study.
Bronte Anscombe	Food record data entry and checking, assisted with breakfast study planning and implementation.
Niamh Brennan, Moana Manukia, Sherina Holland, Owen Mugridge, Sophie Kindleysides	Planning, screening, recruitment and execution of the PROMISE study: phlebotomy, anthropometry, body composition, taste testing, questionnaires, food record education, faecal sample collection instructions.
Ashleigh Jackson, Shivon Singh, Amelia Franklin, Alexandra Thomson, Anishka Ram, Sunna Jacobsen, Beatrice Drury, Laura Mickleson	Data entry: food record, BIA, sleep, video observation, assistance with breakfast study implementation.

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Chapter 2 Literature Review

Prepared according to the author guidelines for Nutrition Reviews

Narrative Review of the Role of Breakfast in Obesity and Chronic Disease in Women

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2.1 Introduction

Obesity is a substantial health crisis, rapidly increasing globally. Within the New Zealand environment, the rate of obesity has steadily increased from 26.5% to 32.2% in the last 10 years (Ministry of Health, 2017). The proportion of obese women (33.8%) is slightly greater than that of men (30.5%) (Ministry of Health, 2017). The prevalence of obesity is much higher proportionally in Maori women (51.5%) and Pacific women (73.4%); however, 32.2% of New Zealand European women are obese, which equals approximately 440000 people (a sizeable number) (Ministry of Health, 2017). The burden of non-communicable disease, which obesity predisposes, is also pronounced, with cancer and cardiometabolic disease accounting for 89% of the total deaths in New Zealand (World Health Organisation, 2014). Breakfast consumption has been proposed to play a key role in the prevention of excess body fatness, as well as cardiometabolic disease prevention and management (McKeown *et al.* 2002, Deshmukh-Taskar, 2010, Barr *et al.*, 2013, Chowdhury *et al.,* 2015). Various mechanisms, including improved diet quality, greater satiety, reduced energy intake, greater intake of nutrients including dietary fibre and micronutrients are proposed to be related to the improved health outcomes evident with the consumption of breakfast (McKeown *et al.* 2002, Deshmukh-Taskar, 2010, Barr *et al.*, 2013, Chowdhury *et al.,* 2015). Due to the broad nature of the content in this review, limited interventional data available, as well as it not being reflective of our study population (free living humans), it was decided to complete a narrative literature review rather than a systematic review, to incorporate both interventional studies and large population based observational studies. This narrative review aims to investigate the literature related to breakfast consumption and health outcomes, and to provide recommendations for the ideal composition of breakfast in order to support future public health recommendations. Topics covered include the prevalence and aetiology of obesity, elements and composition of breakfast, diet quality, and the relationship between these topics and breakfast consumption as well as appetite, satiety and energy balance, and finally the role of breakfast consumption and the aetiology and management of chronic disease. Databases searched included discover, web of science and google scholar, using search terms: obesity, breakfast, diabetes, cardiovascular disease, diet quality, appetite, satiety, insulin and metabolic syndrome.

2.2 Obesity

Obesity is a major global health crisis and is rapidly increasing, despite significant efforts to reverse the trend (Swinburn *et al.*, 2011, Roberto *et al.*, 2015, The GBD 2015 Obesity Collaborators, 2017). The prevalence of obesity has doubled in 70 countries in the last 35 years and has continuously increased in most other countries (Roberto *et al.*, 2015, The GBD 2015 Obesity Collaborators, 2017). Despite marked efforts to halt this rapid increase, no country has managed to reverse the epidemic (McLean, 2014, Roberto *et al.*, 2015, Vandevijvere *et al.*, 2015). As previously mentioned, obesity within New Zealand is a growing problem, with a significant economic impact. Between NZ$60million and NZ$98million in both annual health care costs and lost productivity can be attributed to obesity-related disease (Lal *et al.*, 2012). This, in combination with the large proportion of obese people within the population, points towards the necessity for urgent efforts to reduce obesity in New Zealand (Lal *et al.*, 2012).

Obesity can be defined as excess adiposity, as a result of the excessive accumulation and storage of fat (Huxley *et al.*, 2010, Oliveros *et al.*, 2014). This occurs due to the complex interplay between genetic and behavioural factors (Swinburn *et al.*, 2011). Of current concern is the obesogenic environment prevalent in Western countries, where cultural and socioeconomic factors, including increased sedentary behaviour and easy access to energy dense food, exacerbate the discrepancy between intake and expenditure (Hu, 2004). A hallmark feature of the Western lifestyle is diets high in fat, sugar and salt, excessive alcohol consumption and lack of physical activity - factors recognised as important drivers of the imbalance (Hanson and Gluckman, 2015).

It has been well established that obesity is associated with a substantial increase in the risk of developing non-communicable diseases (NCDs), particularly cardiovascular disease, type 2 diabetes (T2DM), and many cancers (O'Rahilly, 2009, Huxley *et al.*, 2010, Eriksson *et al.*, 2014, Hanson and Gluckman, 2015). NCDs present a major challenge to public health as they are essentially incurable, and account for 63% of deaths globally (Hanson and Gluckman, 2015). They are also associated with increased all-cause mortality (Hu, 2004, Rush *et al.*, 2007). It was proposed by the GBD Collaborators that the provision of evidenced based health interventions to reduce the risk of obesity related disease are vital for improving global health outcomes (The GBD 2015 Obesity Collaborators, 2017).

2.2.1 Women and Obesity

Although obesity is universally detrimental to health, the associated risks affect men and women unequally; women are at a greater risk for the development of obesity and associated complications (Hu, 2004, Ryan, 2007). Increased abdominal obesity in women has been linked to increased risk for Type 2 Diabetes Mellitus (T2DM), and women with diabetes have a greater risk of developing coronary heart disease than men (Hu, 2004). Women also experience more severe dyslipidaemia than men (Hu, 2004). Obesity is strongly related to polycystic ovarian syndrome (PCOS), although it is unclear whether the effect is causative (Hu, 2004). Obesity is also linked to many cancers, including postmenopausal breast cancer and cancers of the colon, endometrium and kidney (Hu, 2004). Obesity not only effects metabolic health, but also negatively impacts psychosocial and reproductive health (Ryan, 2007). The number of women gaining weight as they enter adulthood is rising. Large cohort studies in Australia and the United States report an average weight gain of between 6 and 11kg between the ages 20-30 (Hutchesson *et al.*, 2013). This is concerning, as obesity and unbalanced nutrition during pregnancy have been associated with both short and long term adverse effects in offspring (Ryan, 2007, Eriksson *et al.*, 2014, Eriksson *et al.*, 2015, Shin and Song, 2015,).

Maternal adiposity has been positively associated with increased birth weight and body fat percentage of offspring later in life, further influencing obesity related health outcomes (Eriksson *et al.*, 2015). Furthermore, maternal obesity and the resulting adverse metabolic status of the mother have been associated with cardiometabolic morbidity in offspring. These are linked to biological and epigenetic changes (Ryan, 2007, Eriksson *et al.*, 2014, Eriksson *et al.*, 2015, Hanson and Gluckman, 2015). Additionally, it has been suggested that raised maternal glucose, insulin and free fatty acids due to over nutrition creates an adverse intrauterine environment, which induces long-term disadvantageous metabolic effects on offspring (Eriksson *et al.*, 2015, Hanson and Gluckman, 2015).

2.3 Meal Patterns

While the aetiology of obesity can be related to genetic, environmental, socioeconomic and behavioural factors, it cannot be ignored that dietary intake, particularly dietary patterns, play a major role. An individual's dietary pattern consists of various meals or eating occasions throughout the day, which are influenced by a number of aspects. A meal is commonly understood to be "an act or the time of eating a portion of food to satisfy appetite" (Anon, 2017). In fact, the definition of a meal has wide ranging implications taking into consideration cultural factors such as eating with others, religious celebrations, whether the meal was eaten at a table or "on the run" (Leech *et al.*, 2015b).

There are various definitions of a meal within the scientific literature, many of which stem from its colloquial use (Gatenby, 1997, Leech *et al.*, 2015, Leech *et al.*, 2016). One way in which a meal has been defined is using periods of time; for example the largest eating occasion between 6 and 10am, 12 and 3pm and 6 and 9pm as breakfast, lunch and dinner (Leech *et al.*, 2015). The definition of an eating occasion has been suggested to contain a minimum energy content of 210kJ (Gibney and Wolever, 2007).

Another way of defining a meal is via participant self-identification measures, through time of day or via allocated responses using a list of meal labels such as breakfast, brunch, lunch and so on (Leech *et al.*, 2015).

Research in the field of nutrition has traditionally focussed on the study of nutrients rather than foods as a whole (Leech *et al.*, 2015). Although this is imperative in order to determine biological effects and interactions, it is a reductionist approach. Humans eat foods in various combinations as meals and snacks, which make up an overall dietary pattern, leading to the joint effect of food and nutrient consumption (Mesas, 2012, Leech *et al.*, 2015). Within Western countries such as New Zealand, the general dietary pattern is customarily three meals (breakfast, lunch and dinner) often with the addition of mid-morning or mid-afternoon snacks (Stote *et al.*, 2007, Leech *et al.*, 2015).

One meal, that has received attention in the field of nutrition regarding the relationship between diet and disease is breakfast. Breakfast consumption has been linked to obesity as a result of a number of mechanisms encompassing diet quality, nutrient intake, satiety, and energy balance (Wyatt *et al.*, 2002, Song *et al.*, 2005, Barr *et al.*, 2013, O'Neil *et al.*, 2014b). The consumption of breakfast has traditionally been encouraged for good health, with more recent scientific evidence pointing to advantageous health consequences such as weight management and reduced cardiometabolic disease risk (Farshchi, 2005a, Farshchi *et al.*, 2005, , Deshmukh-Taskar, 2010, Odegaard *et al.*, 2013, Betts *et al.*, 2014).

2.4 Breakfast: Elements and Importance

The meal of breakfast is important when considering the causes of obesity and obesity-related disease. Breakfast, traditionally the first meal consumed after rising has often been referred to as “the most important meal of the day” (Maki *et al.*, 2016). Consuming breakfast regularly has been associated with many positive health outcomes, such as improved weight maintenance, reduced cardiometabolic disease, and improved diet quality and nutrient intake - so much so that it has been considered a marker of a healthy lifestyle (Wyatt *et al.*, 2002, O'Neil *et al.*, 2014a, Maki *et al.*, 2016, Leidy *et al.*, 2016).

2.4.1 Definition of Breakfast

There is a traditional understanding of what defines breakfast, derived from the literal meaning of 'breaking the fast'; however there is no clear definition within the scientific community (O'Neil *et al.*, 2014a). In the literature, breakfast has been defined as "the first meal of the day, eaten before or at the start of daily activities, within two hours of waking, typically no later than 10am, of an energy level between 20-35% of total daily energy needs" (Pereira *et al.*, 2011). Breakfast has also been defined in terms of size, with one study using the definition "the largest eating occasion occurring between 0600 and 1000" (Clegg and Shafat, 2010). A group of Spanish researchers proposed a definition, that included the consumption of foods from a number of food groups, namely dairy, cereals, fruit and healthy fats (Monteagudo *et al.*, 2012). A review by O'Neil et al (2014) proposed a definition encompassing a number of definitions in the literature: "the first meal of the day that breaks the fast after the longest period of sleep and consumed within 2-3 hours of waking, comprising at least one food group" (O'Neil *et al.*, 2014a). The definition of breakfast when used in large scale studies often strays from a rigorous definition. Many researchers use a participant self- reported method of identity. This is evident in large population based studies such as the National Health and Nutrition Examination Survey (NHANES) in the United States and the New Zealand Adult Nutrition Survey (2008/9) (Cho *et al.*, 2003, Deshmukh-Taskar, 2010, Ministry of Health, 2012, Kant and Graubard, 2015).

Worldwide, the regular consumption of breakfast has declined over recent years, with 19-28% of people living in Western societies frequently skipping breakfast (Timlin and Pereira, 2007, Levitsky, 2013, Chowdhury *et al.*, 2015). There are a number of contributing factors to breakfast skipping. One reason for omitting breakfast is the reduced frequency of meals eaten by families together in the home, as a result of busy schedules (Farshchi, 2005). Another is the common belief that meal omission may assist weight control as a result of reduced total energy intake (Wyatt *et al.*, 2002, Farshchi, 2005a, Levitsky, 2013, Clayton and James, 2016). In contrast, consuming breakfast has been associated with reduced BMI in many studies (Cho *et al.*, 2003, Song *et al.*, 2005, O'Neil *et al.*, 2014b, Barr *et al.*, 2016, Megson *et al.*, 2017).

In the New Zealand context, as illustrated in the 2008/9 New Zealand Adult Nutrition Survey, between 8 and 10% of New Zealand European women aged 19-50 do not eat breakfast every day (9.5% women aged 19-30 years, 8.3% women aged 31-50 years). Approximately half of New Zealand European women aged 19-30 years old reported not consistently having breakfast every day, whilst 50.2% of women aged 19-30 years and 69.8% of women aged 31-50 years reported eating something for breakfast on every day of the week (Ministry of Health, 2012).

2.4.2 Composition of Breakfast

The composition of the breakfast meal plays a key role in the associated health benefits. Foods commonly included at breakfast encompass the core food groups: breads and cereals, dairy products and fruit, providing all macronutrients (carbohydrate, protein and fat), as well as fibre and a range of micronutrients (Smith *et al.*, 2012). Other foods often present at breakfast include another source of protein such as meat and eggs (Cho *et al.*, 2003). The ideal composition of breakfast is one that aligns with this: foods from more than one food group (ideally more than three), rich in carbohydrate, protein, fat and fibre, whilst being micronutrient dense (O'Neil *et al.*, 2014b). This is similar to a more recent proposal by Clayton and James, who suggested that breakfast should contain milk or milk derived products, cereals (preferably whole grain) as well as fresh fruit (or natural fruit juice), with no added sugar, providing protein, fat, carbohydrate, fibre and micronutrients (Clayton and James, 2016). This constitutes a meal containing grains, fruit and vegetables with reduced fat dairy, providing a range of macronutrients and micronutrients such as protein, carbohydrate, dietary fibre and calcium (Deshmukh-Taskar, 2010, O'Neil *et al.*, 2014b, Clayton and James, 2016).

The consumption of whole grains, cereals and fibre via foods such as cereal and quick breads (muffins, banana bread) has been associated with a lower BMI, as has the consumption of fruit (Cho *et al.*, 2003). Including these foods rather than skipping breakfast or eating meat or eggs has been associated with reduced body weight (Cho *et al.*, 2003). The intake of whole grains has also been associated with improved insulin sensitivity (McKeown *et al.*, 2002). Diets rich in rapidly available carbohydrate such as those high in refined sugar have been linked to increased risk for T2DM; minimising these foods at breakfast by including greater amounts of protein, whole grains, cereal, and unsaturated fats may lead to favourable metabolic outcomes (Salmeron *et al.*, 1997, McKeown *et al.*, 2002, Willett *et al.*, 2002). The combination of these foods, which contain fat and protein (an important macronutrient with important satiety properties as well as an alternate energy source), and fibre (to slow the absorption of carbohydrate), act to reduce the glycaemic load. This consequently reduces the glycaemic and insulinaemic response to the meal, and reduces demand on pancreatic beta cells (Salmeron *et al.*, 1997, Willett *et al.*, 2002, Barclay *et al.*, 2008). In fact, consuming ready to eat cereals at breakfast (with milk to provide protein and fat) has been related to a desirable macronutrient profile, in turn associated with the prevention of obesity (Song *et al.*, 2005, Deshmukh-Taskar, 2010).

Breakfast cereals such as oats, barley and rye contribute significantly to dietary fibre intake (Barr *et al.*, 2013, O'Neil *et al.*, 2014b). It has been well established that dietary fibre confers a number of health benefits, with advantages evident in the prevention and management of cardiovascular disease and diabetes, weight reduction and the prevention of colon cancer (Kochar, 2007, Shulze, 2007, Slavin, 2013). The soluble fibre present in oats has been associated with benefits in cholesterol control and glycaemia - two key contributors to cardiometabolic disease (Brown *et al.*, 1999). Dietary fibre also reduces the intestinal absorption of carbohydrate, further reducing glycaemic response (Willett *et al.*, 2002, Slavin, 2013).

2.4.3 Diet Quality

Diet quality is another term whose definition is often ambiguous. Diet quality traditionally considers the overall composition of the diet and is often used in exploring the relationship between diet and disease (Kant, 1996). An early definition proposed (in the review) by Kant (1996) described diet quality as the overall quality of an individual's food intake, which may be measured by adherence to dietary guidelines (Kant, 1996, Alkerwi, 2014). Approaches discussed Kant's review included diet quality relating nutrients, food groups or both in combination (Kant, 1996). The approach to defining diet quality that is most strongly predictive of risk of disease considered both nutrients and food groups (Kant, 1996).

More recently, Kant et al (2008) described diet quality as relating the percentage energy contribution from dietary total and saturated fat, in combination with the consumption of foods from all food groups, with micronutrients and dietary fibre (Kant *et al.*, 2008). This approach was critiqued in a more recent review by Alkerwi (2014), where a number of broader definitions were explored (Alkerwi, 2014). Concepts such as hygiene, food safety, sensory qualities and social dimensions were investigated (Alkerwi, 2014). These factors, although a key part of the wider concept of diet quality are not the main focus of the definition commonly used in dietary quality indices (Alkerwi, 2014). Health assessment, disease risk, nutritional adequacy and adherence to dietary guidelines are key factors in determining diet quality when the main goal is improving public health outcomes (Alkerwi, 2014).

It is also possible to consider diet quality in terms of percentage energy contribution from macronutrients, such as the Acceptable Macronutrient Distribution Range (AMDR) (NHMRC, 2005). The AMDR is a useful method of determining nutritional adequacy of the diet due to consuming adequate intakes of nutrients and optimising general health outcomes (NHMRC, 2005). It has been consistently established that those who consume breakfast have an improved diet quality, as they consume fewer kilojoules, but more fibre and micronutrients (Levitsky, 2013, Odegaard *et al.*, 2013, Barr *et al.*, 2016). Furthermore, overall diet quality is generally improved in those who follow a regular meal pattern where breakfast is consumed (Levitsky, 2013).

2.4.4 Breakfast and Diet Quality

Consuming breakfast has been associated with higher intakes of a number of key nutrients that are protective against chronic disease development (Wyatt *et al.*, 2002, Alkerwi, 2014). These nutrients include fibre, calcium, antioxidants, riboflavin, zinc, folate, magnesium and iron (Pereira *et al.*, 2011, Betts *et al.*, 2014, O'Neil *et al.*, 2014b, Clayton and James, 2016). Breakfast eaters also consume on a daily basis less energy, added sugar, saturated fat, cholesterol and sodium, all factors implicated in the development of cardiometabolic diseases (Wyatt *et al.*, 2002, O'Neil *et al.*, 2014b). Those who consume breakfast also have improved daily nutrient intakes, food group selection (particularly grains and cereals, lower fat milk, whole fruit), dietary adequacy and diet quality (O'Neil *et al.*, 2014b, Clayton and James, 2016). Futhermore, it has been observed that skipping breakfast has been linked to poorer diet quality, lower micronutrient and the lowest Healthy Eating Index score (Pereira *et al.*, 2011). The consumption of whole grains and cereals, foods which are commonly included at breakfast has been associated with reduced total and saturated fat intake, in turn reducing serum cholesterol (McKeown *et al.*, 2002, Wyatt *et al.*, 2002).

Consuming key nutrients prevalent in a typical Western breakfast dietary pattern and minimising the consumption of nutrients to limit, contributes to improved diet quality and the reduction of chronic disease (O'Neil *et al.*, 2014b). Additionally, those who consume breakfast regularly often exhibit healthy lifestyle behaviours such as improved exercise habits, less consumption of alcohol, saturated fat and added sugars, and greater interest in the maintenance of weight (Levitsky, 2013, Betts *et al.*, 2014).

2.4.5 Breakfast and Healthy Lifestyle Behaviours

As well as breakfast consumption being associated with improved diet quality and the reduced risk of many NCDs, having breakfast regularly has also been linked to behaviours consistent with an overall healthy lifestyle (Levitsky, 2013, Mekary *et al.*, 2013, Odegaard *et al.*, 2013, Betts *et al.*, 2014, Clayton and James, 2016). Improved exercise habits and increased physical activity is one facet of healthy lifestyle behaviours, exhibited by regular breakfast consumers (Levitsky, 2013, Odegaard *et al.*, 2013, Betts *et al.*, 2014, Clayton and James, 2016). Furthermore, breakfast eaters are generally more likely to be non-smokers, and consume less fat and alcohol (Song *et al.*, 2005, Mekary *et al.*, 2013, Odegaard *et al.*, 2013, Betts *et al.*, 2014). Another consideration which may lead to improved health in breakfast eaters, is the reduced consumption of fast food and snacks, as well as the increased focus on maintaining and controlling weight (Song *et al.*, 2005, Levitsky, 2013, Odegaard *et al.*, 2013, Clayton and James, 2016). As described earlier, interventions aimed at enhancing weight control is an area of public health interest. It has been demonstrated that breakfast consumption plays a key role in influencing a number of factors associated with the control of weight, such as energy intake and expenditure, appetite control and satiety. Breakfast consumption or indeed its omission has been associated with these elements (Pereira *et al.*, 2011).

Another behavioural factor that is key to the control of energy intake and weight status is the speed or pace at which meals and snacks are consumed. It has been demonstrated that fast eating is associated with elevated BMI (Maruyama *et al.*, 2008, Leong *et al.*, 2011). In a nationally representative cross-sectional study of New Zealand women, it was observed that higher BMI and faster eating were associated (Leong *et al.*, 2011). Eating slowly has additionally been associated with improved satiety and reduced energy intake in a randomised study of 30 women in the United States of America (Andrade *et al.*, 2008). When a mixed macronutrient meal (orange juice, milk and cereal) was consumed slowly, energy intake was reduced and satiety was improved compared with when participants ate as fast as possible (Andrade *et al.*, 2008). It has been found that enhanced satiety and reduced appetite are elements key in the moderation of energy intake and thus in the maintenance of body weight (Clegg and Shafat, 2010, Gibbons *et al.*, 2014). It has also been demonstrated that normal eating speed provides benefits in terms of maintaining optimal ghrelin and blood glucose levels, suggesting an impact on satiety, appetite and metabolic control (Andrade *et al.*, 2008, Leong *et al.*, 2011).

2.5 Consumption of Breakfast, and Factors Associated with Weight Control

2.5.1 Appetite

Appetite is generally understood to be the feeling of hunger and an indicator of an imminent eating occasion. In the literature, appetite has been defined as the subjective sensation of hunger, thus influencing the desire to eat (Rebello *et al.*, 2013, Clayton and James, 2016). Appetite is considered to be the main driver of the decision to consume food, rather than an actual need for energy (Rebello *et al.*, 2013). The implication of this is that it is easy to over consume energy and consequently gain weight. Appetite is thus a key factor significant in the control of body weight (Gibbons *et al.*, 2014).

Appetite can be measured either subjectively or empirically. Subjective markers of appetite are commonly measured using a visual analogue scale, where hunger and fullness can be indicated (Clayton and James, 2016). The objective analysis of appetite includes the measurement of peripheral appetite hormone concentrations. These include ghrelin, peptide tyrosine tyrosine (PYY), glucagon-like-peptide-1 (GLP-1), cholecystokinin (CCK), leptin, and gastric inhibitory peptide (GIP) (Pereira *et al.*, 2011, Clayton and James, 2016). Appetite hormones can either promote eating (orexigenic) or signal satiety (anorexigenic) (Blundell *et al.*, 2001).

Consuming a regular breakfast has been shown to moderate appetite, thus reducing hunger later in the day (Wyatt *et al.*, 2002, Pereira *et al.*, 2011). Appetite control has also been associated with eating frequency, with reduced eating frequency (defined as fewer than three eating occasions a day) linked with disadvantageous implications for appetite control (Pereira *et al.*, 2011). Furthermore, skipping breakfast has been associated with increased appetite later in the day (Levitsky, 2013O, 'Neil *et al.*, 2014a), whilst daily breakfast has been shown to improve appetite control (Pereira *et al.*, 2011).

The mechanisms involved in the control of appetite induced by frequency of eating involve hormonal responses, with ghrelin concentrations elevated on days where breakfast was omitted in both interventional and observational studies (Clayton and James, 2016, Nas *et al.*, 2017). Additionally, the anorexigenic hormones GLP-1 and PYY have been shown to be greater after the consumption of breakfast compared with when breakfast is omitted (Clayton and James, 2016). Subjective measures of appetite have also shown to be elevated as a result of skipping breakfast (Levitsky, 2013).

The consumption of increased energy dense snacks has also been observed in response to the omission of breakfast (Clayton and James, 2016). This is in contrast to results from a randomised controlled trial, where, although breakfast was omitted and metabolic and hormonal responses occurred (increased PYY and leptin), the expected increase in ghrelin was not observed in the afternoon (Chowdhury *et al.*, 2015). As well as the frequency and timing of eating affecting appetite, the composition of meals and particular types of foods consumed has an impact on peripheral appetite hormone concentrations. It has been observed that food components such as whole grains and fibre, fruit, and low fat dairy are key contributors to improved appetite control (Pereira *et al.*, 2011). These foods, fibre rich and high in carbohydrate, are often part of a breakfast meal and have beneficial effects on satiety. This is related to blunted glycaemic response as a result of appetite regulating hormonal factors, as well as the fermentation of fibre and its metabolites in the colon (Lattimer and Haub, 2010).

2.5.2 Satiety

Satiety is another key factor in maintaining a balance between energy intake and expenditure, and thus has implications in the control of weight (Rebello *et al.*, 2013). The term satiety relates to postprandial subjective feelings of reduced hunger, increased fullness and the lack of motivation to eat (Rebello *et al.*, 2013). The overall macronutrient composition of foods has an effect on satiety through various mechanisms (Westerterp-Plantenga *et al.*, 1999, Timlin and Pereira, 2007, Rebello *et al.*, 2013). Protein has been identified as the most satiating macronutrient, due to elevated amino acid concentrations and anorexigenic hormones indicating satiety, leading to reduced food intake (Westerterp-Plantenga, 2009). In a study where participants consumed isocaloric meals with manipulated macronutrient content, it was shown that satiety and fullness was greater where high protein and high carbohydrate was consumed as opposed to high fat (Westerterp-Plantenga *et al.*, 1999). The suggested mechanism for this result is related to increased metabolic rate as a result of diet induced thermogenesis, leading to reduced oxygen availability, which is perceived as a reduction in the possibility to eat, therefore enhancing satiety (Westerterp-Plantenga *et al.*, 1999). The satiating power of protein was also demonstrated in a recent study where breakfast was either skipped, or a high protein breakfast was consumed (Gwin and Leidy, 2017). Although having a small sample size (n=13), the study showed results consistent with previous research; appetite control was greater, and energy intake reduced in association with the consumption of a high protein breakfast (Gwin and Leidy, 2017).

Carbohydrate consumption has also been associated with satiety, particularly in relation to dietary fibre (Lattimer and Haub, 2010, Rebello *et al.*, 2013). The consumption of soluble dietary fibre delays gastric emptying, leads to the distension of the stomach and stimulates satiety signals (Lattimer and Haub, 2010, Rebello *et al.*, 2013). Dietary fibre is also fermented in the large intestine, leading to the production of short chain fatty acids which positively influence satiety (Lattimer and Haub, 2010). Short chain fatty acids affect insulin sensitivity and the regulation of satiety after entering the portal circulation (Lattimer and Haub, 2010). In addition, carbohydrate consumption affects the release of the satiety hormone CCK (Lattimer and Haub, 2010).

As well as protein and carbohydrate, fat affects satiety and satiation, most notably due to the influence on gastric emptying. It has been demonstrated that although fat empties from the stomach more slowly, high fat meals have a hyperphagic effect. This has been observed in a single blinded crossover study (n=9), where participants consumed three meals: a high fat breakfast, a low fat breakfast (isoenergetic) and a low fat breakfast (equal mass to the high fat breakfast) (Clegg and Shafat, 2010). The high fat breakfast contained 60g fat, 13g protein and 49g carbohydrate, whereas the low fat breakfasts contained 25g fat and 22g (isoenergetic) and 21g fat and 14g protein (equal mass) (Clegg and Shafat, 2010). *Ad libitum* meal consumption post high fat breakfast was higher in energy, fat and protein compared with after a low fat breakfast (Clegg and Shafat, 2010).

The type of food consumed at breakfast also affects feelings of satiety. It has been observed that oatmeal is more satiating than bread, eggs or croissants (Holt *et al.*, 1995). However, a randomised controlled trial indicated that consuming a breakfast with similar energy and mass consisting of eggs (with toast) as opposed to a bagel (with cream cheese & yoghurt) lead to a reduction in total energy consumed at lunch among obese participants (Vander Wal *et al.*, 2005). This was confirmed in a randomised controlled study by Neumann et al., who illustrated that the consumption of an isocaloric breakfast meal higher in protein lead to increased satiety throughout the day, as well as reduced energy intake at lunch (Neumann *et al.*, 2016).

Consuming, as opposed to skipping breakfast has been associated with increased satiety, with a reduction in cravings after meals observed (Neumann *et al.*, 2016). Other factors associated with enhanced satiety and breakfast consumption include time of day and proportion of energy intake (de Castro, 2004), food types and their glycaemic load, as well as nutrients consumed (Pereira *et al.*, 2011, Rebello *et al.*, 2013, Park *et al.*, 2015, Nas *et al.*, 2017). The consumption of food in the morning has been shown to be particularly satiating, and can result in a reduced total amount of food consumed during the day (de Castro, 2004). In a study where an *ad libitum* lunch was consumed after the omission or consumption of breakfast, breakfast omission lead to a greater intake of energy at lunch (Chowdhury *et al.*, 2015). The satiety hormones PYY and leptin were elevated in response to breakfast consumption rather than omission, and remained higher throughout the day (Chowdhury *et al.*, 2015).

2.5.3 Energy Balance

Energy balance refers to the equilibrium between energy intake and energy expenditure necessary to maintain consistency of body weight (Westerterp-Plantenga *et al.*, 1999). Previously discussed appetite and satiety signals are key regulatory factors implicated in the maintenance of energy balance; however there are other factors which also have an effect. Diet-induced thermogenesis (DIT) or the thermic effect of food is the main nutrition related factor that impacts energy expenditure, and thus contributes to energy balance. Diet-induced thermogenesis refers to the energy required to break down food into components useable by the body (Binns *et al.*, 2015). Diurnal variations are evident in DIT, with greater effects in the morning as opposed to later in the day (Morris *et al.*, 2015). The effect of this is that food consumed later in the day requires less energy to break down, and thus may contribute to positive energy balance and increased risk of weight gain (Binns *et al.*, 2015, Morris *et al.*, 2015). It has also been established that the macronutrient composition of a meal has a substantial impact on DIT, where protein elicits the greatest response (Smeets *et al.*, 2008). This is as a result of the increased energy cost associated with intestinal absorption, hepatic metabolism, protein synthesis, nitrogenous end products and gluconeogenesis (Westerterp-Plantenga, 2009, Binns *et al.*, 2015).

The timing and regularity of eating is another significant factor in energy expenditure, with infrequent meals leading to lower postprandial energy expenditure as a result of decreased DIT, elevated insulin resistance and elevated fasting lipid profiles (Farshchi *et al.*, 2005). This was noted in subjects exposed to irregular meal frequency in one randomised controlled trial (Farshchi et al., 2005). Increased energy intake was observed in this group, consequently leading to positive energy balance and risk of weight gain (Farshchi *et al.*, 2005). It has also been demonstrated that increased meal frequency induces changes in metabolism, leading to blunted postprandial glycaemic and insulinaemic responses, improved insulin sensitivity and reduced between meal hypoglycaemia (Bellisle *et al.*, 1997, Farshchi *et al.*, 2005, Odegaard *et al.*, 2013). This is associated with reduced appetite and consequently reduced energy intake (Bellisle *et al.*, 1997, Farshchi *et al.*, 2005, Odegaard *et al.*, 2013).

Breakfast skipping is of importance when considering the effects of meal frequency on energy balance, as it is becoming an increasingly common behaviour in Western countries, including New Zealand (Farshchi, 2005a, Ministry of Health, 2012). A number of conflicting results have been reported in the literature comparing breakfast omission with consumption, with differences noted in energy intake and energy expenditure. It has been suggested that skipping breakfast may lead to the compensatory increase in energy consumption at the next meal; however energy omitted at breakfast is not completely made up over a 24 hour period, indicating that those who skip breakfast may consume greater amounts of energy at lunch, but not enough to increase in weight (Chowdhury *et al.*, 2015). This is similar to the findings in a randomised controlled trial, where greater energy intake and physical activity thermogenesis was associated with breakfast consumption, although no metabolic adaptation occurred (Betts *et* al., 2014). This suggests that although energy intake was greater, the increased physical activity was too, therefore the excess energy intake would not be stored, and thus would have no influence on weight stability (Betts *et al.*, 2014). Additionally, in a large cross-sectional study of participants who had maintained long term weight loss (on average participants had lost 32kg and maintained it for 6 years), there was no difference in daily energy intake between those who consumed and those who omitted breakfast (Wyatt *et al.*, 2002). These studies suggest that varying energy intake at breakfast does not have a direct effect on body weight.

In some studies, skipping breakfast has been associated with increased energy intake and reduced energy expenditure as well as reduced postprandial insulin sensitivity (Farshchi, 2005a, Betts *et al.*, 2014, Chowdhury *et al.*, 2015). In a small intervention study (n=10), energy intake was lower on days where breakfast was consumed, although, energy expenditure was the same (Farshchi, 2005a). This is in contrast to a more recent study, where energy expenditure was greater on days where breakfast was skipped (Nas *et al.*, 2017). Energy expenditure was lower than energy intake on both breakfast and dinner skipping days (Nas *et al.*, 2017). It has been suggested that the reasons for elevated energy expenditure as a result of meal skipping is due to prolonged fasting leading to a state of physiological stress, which in turn leads to increased adrenergic activity and lipolysis and increased energy expenditure (Jensen *et al.*, 1987).

2.6 Breakfast Consumption and the Risk of Chronic Disease

It has been shown previously that skipping breakfast is associated with an increased prevalence of elevated BMI and adiposity, as well as NCDs associated with obesity such as T2DM and CVD. (Odegaard *et al.*, 2013, Neumann *et al.*, 2016). **Table 2.1** presents various studies that investigated the association between breakfast consumption in adults and health outcomes related to the risk of chronic disease. These studies show that those who consume breakfast have a more favourable diet quality, more stable glycaemia, reduced insulin, and the reduced risk of a number of metabolic conditions.

Table 2.1 Studies Investigating Breakfast Consumption and Factors Effecting Health

Reference	Study methodology and population	Aim	Outcome of study: Breakfast and health benefits
Barr (2013) Canada	Canadian Community Health Survey, 24hr recall and health questionnaire n=19,913 adults	To assess the association between breakfast intake and nutrient adequacy	Breakfast consumers, and ready to eat cereal consumers had significantly higher intakes of fibre and several vitamins and minerals than breakfast non-consumers
Betts (2014) England	Randomised controlled trial, adults aged 21-60. Men: n=12, Women: n=21	To examine causal links between breakfast habits and energy balance	Daily breakfast linked with higher physical activity thermogenesis. Breakfast maintained more stable afternoon and evening glycaemia than fasting
Chowdhury (2015)	RCT, BMI 15-25kg/m2, 48hr weighed food record prior to lab visit. Breakfast provided or breakfast skipped. Hourly blood samples, ad libitum lunch provided. Subjective appetite assessed n=14 (men) n=21 (women)	To examine acute energy intake, metabolic and hormonal responses to an ad libitum lunch following extended fasting compared with high carbohydrate breakfast	Extended fasting lead to incomplete energy compensation at the ad libitum lunch, altered metabolic and hormonal responses but no greater appetite during the afternoon. Breakfast consumption increased some satiety hormones in the afternoon however abolished suppression of ghrelin
Clegg (2010) Ireland	Randomised, single blinded cross over study Consumption of either high fat breakfast, low fat equal energy to high fat or low fat equal mass to high fat breakfast Male volunteers, 25.5 ± 1.6 years, 79.1 ± 6.4 kg n=9	To assess the gastric emptying of lunch and whether it was different following 3 breakfasts with differing energy, mass and macronutrient content	Mass and energy content of food regulates subsequent appetite and feeding. A single high fat meal demonstrated a hyperphagic effect
Deshmukh-Taskar (2013) USA	NHANES, 24hr recall, adults (20-39 years) n=2615	To assess the impact of breakfast skipping and breakfast type on energy and nutrient intake, nutrient adequacy and diet quality	Healthy Eating Index scores were greater in ready to eat cereal consumers than in breakfast skippers or other breakfast consumers. Ready to eat breakfast consumers had higher intake of fruit, whole grain, dairy carbohydrate, total sugar, dietary fibre and several micronutrients than other breakfast consumers
Farshchi (2005) United Kingdom	Randomised crossover trial, two 14 day interventions, eating or omitting breakfast (2 week washout period). Overweight and obese women, n=10	To determine whether regular meal frequency affected energy intake, energy expenditure or circulating insulin, glucose and lipid concentrations	Regular meal frequency has beneficial effects on fasting lipid and postprandial insulin profiles and thermogenesis

Reference	Study methodology and population	Aim	Outcome of study: Breakfast and health benefits
Farshchi, (2005) United Kingdom	Randomised crossover trial, two 14 day interventions, eating or omitting breakfast (2 week washout period). Normal weight women, n=10	To determine whether eating or omitting breakfast affects energy intake, energy expenditure, circulating insulin, glucose, lipid concentrations	Omitting breakfast impaired fasting lipid and post prandial insulin sensitivity and could lead to weight gain if the observed higher energy intake was sustained
Levitsky (2013) USA	Two studies: Study 1: Randomised crossover design, normal BMI adults. Either no breakfast, high carbohydrate breakfast or high fibre breakfast followed by a test meal n=24 Study 2: Two groups: breakfast/no breakfast then food intake recorded at three subsequent time periods n=18	To examine the effects of consuming breakfast on subsequent energy intake	Skipping breakfast did not lead to overconsumption at lunch or at other eating occasions during the day
Nas (2017) Germany	RCT, 3 isocaloric interventions, breakfast skipping, dinner skipping separated by conventional 3-meal day n=17	To investigate whether the timing of meal skipping impacts the risk of obesity and type 2 diabetes by affecting circadian regulation of energy balance, glucose metabolism, postprandial inflammatory responses	Meal skipping lead to increased energy expenditure. Higher postprandial insulin concentrations and increased fat oxidation where breakfast was skipped suggests metabolic inflexibility which may lead to impaired glucose homeostasis
Neumann (2016) USA	Randomised controlled study, with three groups: breakfast skipping, carbohydrate or protein groups for eight days. Female, habitual breakfast skippers n=8 per group	To determine whether the macronutrient composition of breakfast improved thermic effect of feeding and appetite (after 1 week adaptation)	Increase in thermic effect of feeding with protein compared with carbohydrate breakfast
Odegaard (2013) USA	Analysis of participants from the community-based Coronary Artery Risk Development in Young Adults Diet assessed by interviewer-administered diet history questionnaire n=3598	To examine breakfast intake frequency with incidence of metabolic conditions	Daily breakfast intake was strongly associated with the reduced risk of a number of metabolic conditions

Reference	Study methodology and population	Aim	Outcome of study: Breakfast and health benefits
Pereira (2011) USA	Two pilot experimental studies (adults and children). Overweight adults, aged 20-40 years received one of four breakfast meals or water. Blood samples taken every 30 minutes n=9	To study the acute effects of breakfast frequency and composition on glycaemia, perceived appetite and energy.	Breakfast frequency and quality may be related to appetite control and blood sugar control.
Rebello (2013) USA	Randomised crossover trial, adults >18. Overnight fast followed by consumption of either oatmeal or a ready to eat cereal (isocaloric). Appetite and satiety measured throughout n=48	To compare the satiety impact of oatmeal with ready to eat cereal.	Oatmeal improved appetite control and increased satiety.

USA: United States of America. NHANES: National Health and Nutrition Examination Survey. BMI: Body mass index (kg/m^2).

Weight gain or increased adiposity occurs as a result of positive energy balance over an extended time period (Swinburn *et al.*, 2004, Chowdhury *et al.*, 2015, The GBD 2015 Obesity Collaborators, 2017). The consumption of breakfast has been associated with improved weight control, although this is not a consistent finding amongst studies (Albertson *et al.*, 2008, Betts *et al.*, 2014, Barr *et al.*, 2016). Table 2.2 outlines a number of studies relating breakfast consumption and body composition outcomes. These studies generally show that breakfast consumption is related to the maintenance of weight, and prevention of high BMI.

The relationship between breakfast consumption, its composition, and BMI, has been studied widely and reported on in a number of large population based studies. In the Canadian Community Health Survey, consuming ready to eat cereal for breakfast was associated with lower BMI in women (Barr *et al.*, 2016). This is similar to what has been shown in a United States NHANES study: breakfasts containing ready to eat cereal, cooked cereal and quick breads were associated with lower BMI, compared with either skipping breakfast or consuming meat or eggs (Cho *et al.*, 2003). In a more recent NHANES study, grains, ready to eat cereal, 100% juice, lower fat milk, fruit and cooked cereal included at breakfast was associated with lower BMI than skipping breakfast (O'Neil *et al.*, 2014b). Ready to eat cereal consumption was also associated with lower BMI in young adults compared with either omitting breakfast or consuming other foods (Deshmukh-Taskar, 2010).

Results associated with the consumption of breakfast are not consistent; using data from NHANES (1999-2004), BMI was lower in women who consumed breakfast but not in men (Kant *et al.*, 2008). In a 6-week intervention study, there were no differences in body mass or adiposity following either breakfast consumption or omission (Betts *et al.*, 2014). In a longer intervention study (16 weeks) where weight loss was the main outcome, neither the consumption of breakfast or its omission had an effect on weight loss (Dhurandhar *et al.*, 2014).

Table 2.2 Studies Investigating Breakfast Consumption and Weight or Body Composition Outcomes

Reference	Study Methodology and population	Aim	Outcome of study: breakfast and weight / BMI
Barr (2013) Canada	Canadian Community Health Survey, 24hr recall and health questionnaire n=12,377 adults	To assess whether breakfast consumption and type of breakfast consumed was associated with BMI	BMI significantly lower among ready to eat cereal breakfast consumers than other breakfast consumers but not significantly different to breakfast non-consumers
Cho (2003) USA	NHANES, 24hr recall, adults ≥ 19 years n=16,452	To investigate the relationship between breakfast type, energy intake and BMI	Ready to eat cereal, cooked cereal or quick breads for breakfast as opposed to breakfast skippers and meat or egg eaters. Meat and egg eaters had the highest daily energy intake and one of the highest BMIs
Dhurandar (2014) USA	RCT, 16 weeks, 3 parallel arm, overweight and obese adults 20-65years n=309	To determine the effectiveness of recommendation to eat or skip breakfast on weight loss in adults trying to lose weight	No discernible effect on weight loss in free-living adults trying to lose weight
Kant (2008) USA	NHANES, combined dietary data from three surveys, adults ≥20years n=12,316	To examine the association between energy density of breakfast foods, with the energy density of non-breakfast foods with diet quality and BMI	With increasing energy density of breakfast, non-breakfast energy density and fat intake increased, but micronutrient intake declined. Energy density of breakfast was associated with diet quality, overall diet energy density and body weight
Megson (2017) USA	BMI >25, 3 month weight loss intervention, Either wellness campaign only, the addition of internet weight loss programme or the addition of group meetings n=230	To examine the effects of breakfast eating and eating frequency on BMI and weight loss outcomes in adults enrolled in obesity treatment programmes	Increasing breakfast consumption while simultaneously reducing or keeping eating frequency constant may improve weight loss outcomes
O'Neil (2014) USA	NHANES, 24 hour recall, adults >19 years n=18,988	To compare the nutrient intake, diet quality and adiposity measures in breakfast skippers and breakfast eaters with different breakfast patterns	Breakfast consumption, particularly grains, cereals, lower-fat milk, whole fruit/100% juice was associated with dietary and weight advantages in comparison to skipping breakfast
Song (2005) USA	NHNANES, 24 hour recall, adults >19years n=4218	To assess whether breakfast consumption and BMI are associated	Consumption of ready to eat cereal predicted weight status in women but not men.
Wyatt (2002)	Cross sectional study, demographic, weight history and breakfast consumption questionnaires. n=2959 (participants must have lost at least 13.6kg and maintained for at least 1 year)	To examine breakfast consumption in subjects maintaining weight loss	Breakfast consumption was a common characteristic in weight loss maintainers

USA: United States of America. NHANES: National Health and Nutrition Examination Survey. BMI: Body mass index (kg/m^2).

Cardiometabolic diseases, particularly CVD and T2DM are inextricably linked, and have been associated with obesity. Key features of CVD risk include elevated serum total and LDL cholesterol, and for T2DM elevated glycaemia and reduced insulin sensitivity. The consumption of breakfast has been associated with reduced risk of cardiometabolic diseases, not only as a result of reduced risk of obesity but due to a number of metabolic factors such as decreased abdominal obesity, metabolic syndrome and hypertension (Odegaard *et al.*, 2013).

Nocturnal lifestyles, breakfast skipping and a delayed eating pattern can lead to increased 24hr glycaemia and impaired insulin response to glucose (Nas *et al.*, 2017). This is associated with an increased risk of obesity and T2DM (Nas *et al.*, 2017). In a randomised controlled trial that compared skipping breakfast with skipping dinner, researchers found an increase in fat oxidation (higher peaks and lower troughs of insulin), glucose and insulin concentrations (Nas *et al.*, 2017). Irregular meal frequency has also been linked to insulin resistance and altered fasting lipid profiles (Farshchi, 2005a). Increased postprandial insulin concentrations and an increase in fat oxidation has been shown in response to skipping breakfast, with the suggestion that impaired glucose homeostasis may occur in the long term (Nas *et al.*, 2017). Chowdhury and colleagues illustrated that after omitting breakfast, insulin concentrations were elevated in the afternoon, compared with consumption of breakfast (Chowdhury *et al.*, 2015). Regularly skipping breakfast may elicit adaptations that impair glucose disposal; in a randomised controlled trial (n=33) over 6 weeks, glycaemia was more stable in the afternoon and evening after breakfast consumption (Betts *et al.*, 2014). Impaired glucose disposal and insulin resistance leads to increased pancreatic beta cell demand and increased risk for T2DM, whereas altered fasting lipid profiles are implicated in CVD development (Turner *et al.*, 1998, Willett *et al.*, 2002).

2.7 Summary

This review describes obesity and its aetiology, and the associations between the consumption of breakfast and various health outcomes, including the reduction of obesity and cardiometabolic disease risk with breakfast consumption. There are clear benefits in many facets of health associated with breakfast consumption, ranging from improved diet quality and lifestyle behaviours to reduced risk of obesity and excess body fat, as a result of mechanisms such as satiety, hormonal and glycaemic responses. The ideal composition of breakfast includes foods such as protein containing foods, whole grain and cereals, fruit, and low fat dairy. As well as improvements in obesity, breakfast consumption has wide ranging beneficial effects on cardiovascular and metabolic health, significant contributors to the burden of disease in New Zealand. As the eating habits and patterns of women of reproductive age have an impact not only on themselves but for offspring as well, it is vital to study this population group in order to direct public health efforts in a manner which can offer the greatest benefit. Women are susceptible to obesity and its adverse effects more than men, and New Zealand European women make up a large proportion of the population in New Zealand; thus it is important to conduct research to describe the differences in breakfast habits in this population group. This will enable the provision of recommendations about breakfast consumption that are tailored to this population group, which may serve to enhance health outcomes for New Zealand European women.

2.7.2 Acknowledgements

This research was supported by funding from the Health Research Council of New Zealand.

2.7.3 Conflicts of interest

None.

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Chapter 3 Research Study Manuscript

Prepared according to author guidelines for submission to Asia Pacific Journal of Clinical Nutrition

Describing breakfast intake and breakfast habits in New Zealand European women

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ABSTRACT

Background: The rise of obesity and related poor health outcomes is rampant in New Zealand. Dietary factors are key in the aetiology of obesity. One dietary factor with wide reaching implications on health and weight maintenance is breakfast consumption. Breakfast consumption has declined in New Zealand in recent years, and adverse health outcomes have risen concurrently. Breakfast consumption has been associated with lower BMI, improved appetite control, better diet quality, and more stable glycaemia.

Objective: The aim of this study was to describe and compare reported and observed breakfast consumption between obese and normal weight New Zealand European women aged 18-45 years, living in Auckland, New Zealand.

Methods: In a cross-sectional study, healthy women (n=75 normal BMI, n=82 obese BMI) completed a 5-day food record, an observed *ad libitum* buffet breakfast assessment and body composition measurements. Nutrient intake, food choices and behavioural aspects, including pace of eating and meal skipping data were obtained and analysed.

Results: More normal BMI women (n=69; 84.1%) than obese BMI women (n=56; 74.6%) consumed breakfast daily. Obese BMI women consumed significantly more energy at the observed breakfast (1915 ± 868 kJ) than at the recorded breakfast (1431 ± 690kJ, $p<0.001$); however neither BMI group met one third of estimated energy requirements at either breakfast occasion. Carbohydrate consumption was lower than recommended (AMDR: 45-65%) in both groups in the recorded breakfast (40.7% and 42.6%; normal BMI and obese BMI respectively), whereas total fat consumption was higher than recommended (AMDR: 20-35%) (36.5% and 35.9% respectively). Protein consumption was within AMDR recommendations (15-25%) for both groups in the recorded breakfast (16.3% and 17.5%) but not in the observed breakfast, (13.0% and 14.0%), obese BMI and normal BMI respectively. Foods with the greatest contribution to energy at the observed breakfast for obese BMI women were discretionary items (fats, cake and biscuits), compared with sweetened cereals, nuts and seeds for normal BMI women. Having a faster pace of eating and consuming foods with a higher energy density significantly increased the likelihood of falling into the obese BMI category ($b=3.11$, $p=0.016$; $b=1.35$, $p=0.042$ respectively).

Conclusions: Consuming a breakfast, particularly one that contains whole grains, fruits and low-fat dairy products, and minimising discretionary items could enable women to more closely meet dietary recommendations, and as a result, improve health outcomes.

Key words: breakfast, obesity, energy intake, appetite, pace of eating

3.1 Introduction

Obesity and associated adverse health outcomes are continually increasing worldwide, despite significant efforts towards prevention (Swinburn *et al.*, 2011, Roberto *et al.*, 2015, The GBD 2015 Obesity Collaborators, 2017). Within New Zealand, the prevalence of obesity is currently 32% - a 5% increase over the last decade (Ministry of Health, 2017). A substantial number (32.2%) of New Zealand European women are obese (Ministry of Health, 2017). Obesity is a well-known contributor towards an increased risk of a number of chronic diseases, particularly cardiovascular disease, type 2 diabetes (T2DM) and certain cancers (Dulloo *et al.*, 2010, The GBD 2015 Obesity Collaborators, 2017). The adverse health effects of obesity impact women more significantly than men (Hu, 2004, Ryan, 2007), particularly having a negative effect on women's reproductive health (Eriksson *et al.,* 2014, Shin and Song, 2015). Maternal adiposity has also been associated with negative health outcomes in offspring in both the short and long term (Eriksson *et al.*, 2014, Shin and Song, 2015).

There are many factors associated with the aetiology of obesity (The GBD 2015 Obesity Collaborators, 2017). Dietary aspects receive significant attention due to the inextricable link between energy intake and energy expenditure. One dietary factor that has been identified as favourably influencing obesity prevention and weight management is the breakfast meal. Breakfast consumption has been associated with a number of advantageous health outcomes, encompassing nutritional, metabolic and functional (Albertson *et al.*, 2008, Levitsky, 2013, Barr *et al.*, 2016). Regular breakfast consumption has been linked to lower BMI as a result of a number of elements, including those related to appetite and satiety, energy balance and diet quality (Farshchi *et al.*, 2005, O'Neil *et al.*, 2010, Pereira *et al.*, 2011, O'Neil *et al.*, 2014). Additionally, skipping breakfast has been associated with excess weight gain, due to possible overconsumption of energy at subsequent meals (Megson *et al.*, 2017).

The composition of the breakfast meal plays a key role in the positive effects on weight management (and associated health benefits) that are connected with breakfast consumption. Fibre rich high carbohydrate foods such as breads, cereals and fruit have been associated with lower BMI and improved insulin sensitivity (Cho *et al.*, 2003, Chowdhury *et al.*, 2015). Additionally, ready to eat cereal consumption has been linked with the prevention of obesity due to having a favourable macronutrient profile (Song *et al.*, 2005). These foods have also been associated with the prevention and management of cardiovascular disease, diabetes, colon cancer and weight reduction (Kochar, 2007, Shulze, 2007, Slavin, 2013). Conversely, foods rich in rapidly available carbohydrate such as those high in refined sugars have been linked to an increased risk of type 2 diabetes (T2DM) (Pereira *et al.*, 2011).

Breakfast consumption has been associated with improved diet quality, where fibre and micronutrient intake, in conjunction with lower energy intake is evident (Barr *et al.*, 2016, Levitsky, 2013, Odegaard *et al.*, 2013). Reduced total and saturated fat intake has been observed in regular breakfast eaters, particularly where whole grains and cereals are consumed (McKeown *et al.*, 2002, Wyatt *et al.*, 2002). These are key dietary components instrumental in the prevention of cardiovascular disease, a significant contributor to mortality in New Zealand (World Health Organisation, 2014).

Breakfast consumption has declined in recent years, particularly in Western countries (Song et al., 2005, Deshmukh-Taskar et al., 2010, Levitsky, 2013). In New Zealand, between 8 and 10% of New Zealand European women aged 19-50 years skip breakfast every day, whilst approximately half reported eating breakfast every day of the week (Ministry of Health, 2012). Given the significant negative health outcomes associated with obesity, it is vital that research is undertaken to better understand dietary differences between obese and normal populations. Understanding the differences in food choices, nutrient intake, and meal behaviour between populations of normal BMI and obese BMI will pave the way for recommendations that would be made to improve health outcomes. Comparing between observed and recorded intakes allows the confirmation of self-reported data by reviewing food choices and eating behaviour without the bias of under-reporting. Additionally, providing a buffet breakfast with appropriate breakfast food choices provides the opportunity to observe whether participants in this study choose an adequate breakfast when it is offered.

This study seeks to firstly describe and compare the breakfast eating practices (reported and observed) of obese versus normal weight New Zealand European women, between the ages of 18 and 45, and secondly to characterise factors associated with breakfast consumption. The outcomes of this study may inform future lifestyle interventions, and provide evidence towards targeted dietary advice focussing on breakfast consumption, in order to halt the increase of obesity evident in New Zealand and thus positively affect health outcomes.

3.2 Materials and Methods

The present study was undertaken as a sub-study of the PROMISE study (Predictors linking Obesity and gut Microbiome), a single-centre, cross-sectional study conducted at the Human Nutrition Research Unit, Massey University, Auckland. The PROMISE study aimed to recruit 272 women of NZ European and Pasifika ethnicity: 68 in each BMI category (normal and obese). The aim of the PROMISE study was to investigate the role of gut microbiome complexity and functionality and associated predictors in different body fat profiles (for example dietary intake, eating behaviour, taste perception, markers of metabolic health, sleep and physical activity). Ethical approval for the study was obtained from the Health and Disability Ethics Committee, Southern Region, Ethics Reference 16/STH/32. Information sheets were provided, and written informed consent was obtained from all participants. Women were recruited from the general population in Auckland, New Zealand over a 14-month period from July 2016 to September 2017.

Inclusion criteria for this sub study were: being female aged 18-45 years, NZ European Ethnicity, BMI 18.5-24.9kg/m^2 and BMI ≥30kg/m^2, generally healthy, no chronic health conditions, no previous bariatric surgery, not pregnant, not breastfeeding for less than six months, not allergic to milk, no severe dietary restrictions or avoidances. For inclusion in the sub-study, participants had to attend the breakfast provided following blood sampling (to obtain observed data), complete the 5-day food record (to obtain recorded breakfast data) and complete the body composition procedures.

Participants were involved in the data collection phase over a 3-week period, and visited the Human Nutrition Unit at Massey University twice. Points of data collection and procedures are outlined in **figure 3.1**.

For the purposes of this sub-study, data required for analysis included demographic, body composition (weight, height, BMI, waist circumference, hip circumference, body fat percentage, lean muscle percentage), recorded and observed breakfast intake data, and breakfast eating behavioural data (obtained from the diet record review and from observation).

3.2.1 Body Composition Assessments

Anthropometric measurements were obtained (height, weight and circumferences) using a stadiometer and Lufkin tape using International Society for the Advancement of Kinanthropometry (ISAK) protocols (Marfell-Jones *et al.*, 2006) for all measurements (NHLBI Obesity Education Initiative Expert Panel on the Identification Evaluation and Treatment of Overweight and Obesity in Adults, 1998). Body composition profiles (fat and lean mass) were obtained using Bioelectrical Impedance Analysis (BIA) (Inbody 230, Biospace Co. Ltd, Seoul) (Ling et al, 2011). Body mass index was calculated as weight in kilograms divided by height in meters squared (kg/m^2). Waist to hip ratio was calculated as waist circumference (cm) divided by hip circumference (cm). Waist to height ratio was calculated as waist circumference (cm) divided by height (cm). Body fat percentage and muscle percentage were obtained from the BIA measurement.

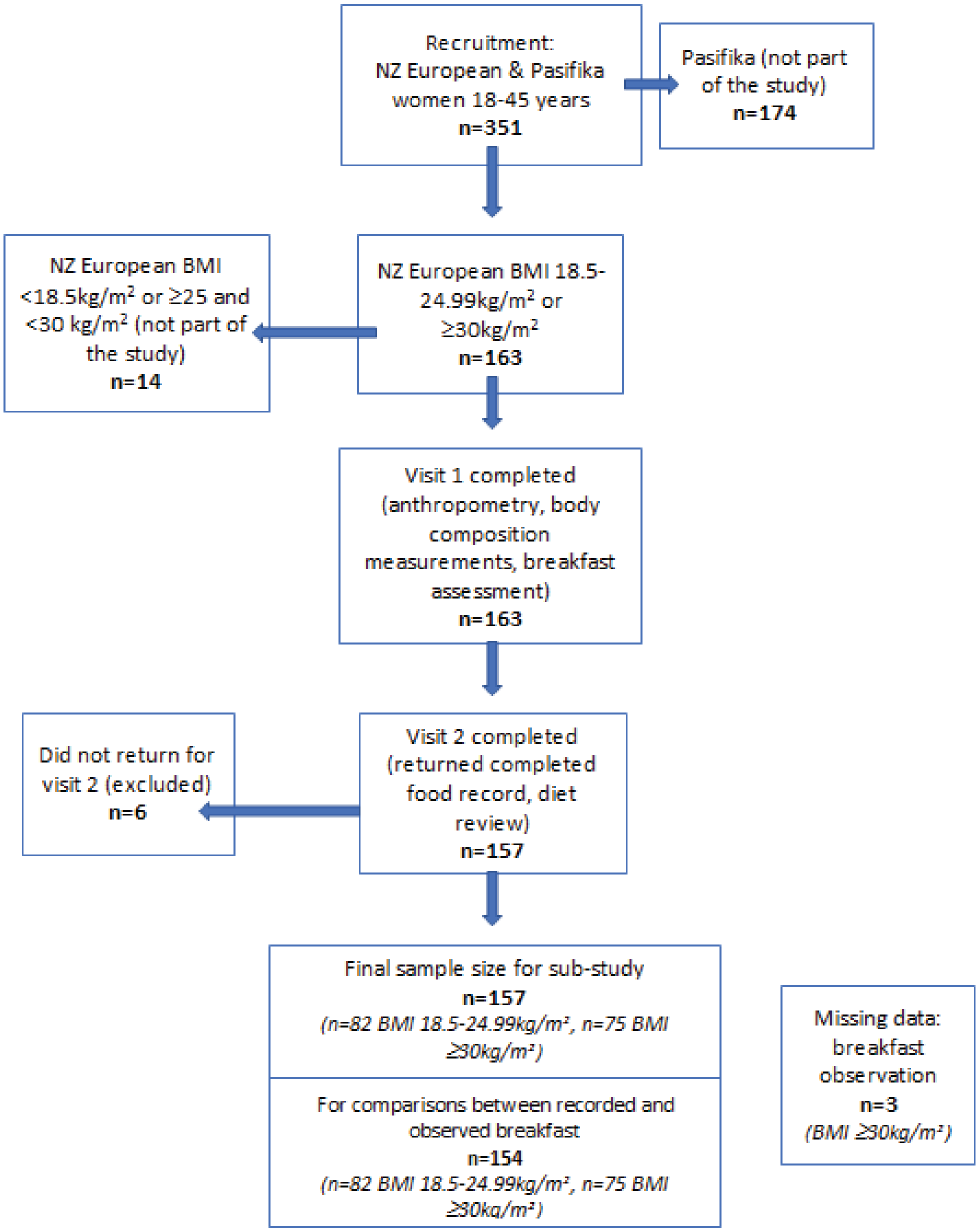

Figure 3.1 Procedures and Points of Data Collection

3.2.2 Breakfast Eating: Food Record Procedures

For the purposes of obtaining usual breakfast food and nutrient intake, women were allocated five non-consecutive days in which to complete an estimated food record at home between two data collection days. For the larger study, all food intake was required to be recorded; however for the sub-study, only breakfast data was required. Breakfast was defined as the first meal of the day, consumed between 6 and 10 am or within 2 hours of waking (Pereira *et al.*, 2011). Breakfast was considered to be food consumed at one eating occasion, within a period of 30 minutes, which did not include snacks. Days were pre-allocated to ensure all days of the week were well represented in the final sample. Participants were required to watch an explanatory video, followed by detailed verbal and written instructions on how to complete the estimated food record. Written information included a pictorial guide in a supplementary booklet, with codes to assist in correctly identifying portions consumed. Participants were also encouraged to collect and bring in any food packaging to visit two. Research staff (New Zealand Registered Dietitians (NZRDs)) subsequently reviewed the 5-day food record during visit two, to further clarify dietary intake using probing questions. The NZRDs were able to identify portion sizes from the code allocated by participants, and match it to the correct weight in grams of the appropriate food using the supplementary booklet. Only those with valid food record data (at least three days of food record) were included in subsequent analysis.

3.2.3 Breakfast Eating: Observation Procedures

Participants arrived at visit one in the fasted state for a blood sample (not reported). Following blood sampling and taste testing of quinine, glucose and cream samples (not reported), participants were invited to eat breakfast. They could choose breakfast from a buffet in a communal dining room area, with instructions to take as much food as desired but to sit down to consume the breakfast meal at the dining table, prior to continuing with data collection. Foods provided at the buffet were pre-portioned, and were pre-selected using guidance from the Ministry of Health, with both 'healthy' and 'unhealthy' options available from all food groups, as well as a number of discretionary items (Ministry of Health, 2015). Foods included items commonly present at a

Western breakfast, such as cereal, bread, dairy, fruit, nuts, as well as beverages such as tea coffee and juice (refer to Appendix C for the complete list). Food choices and plate waste were recorded by covert camera surveillance and discrete observation by a researcher. The researcher noted food choices and plate waste where possible.

3.2.4 Dietary Data Analysis

To analyse nutrient and food intake, dietary data was entered into FoodWorks 8 (2015, Xyris Software (Australia) Pty Ltd, Queensland, Australia). For nutrient analysis, the New Zealand Food Composition Database (NZ FOODfiles 2014) was used preferentially, with Australian databases used secondarily where food was absent from the New Zealand database. NUTTAB 2010 (released by Food Standards Australia New Zealand (FSANZ)) was the first preference, followed by AusFoods 2015 (developed by Xyris software, expanded from AusNut 2013 (from FSANZ)) and finally AusBrands 2015 (nutrient data from product packaging, with many foods linked to an appropriate food in AusFoods). Recipes for foods that were not present in the database and for home cooked meals were entered into FoodWorks, considering the number of serves provided using the aforementioned databases. Where there was no suitable choice, a "new food" was created, such as gluten free weet-bix overriding the nutrients present in weet-bix to correctly match the nutrition information panel for gluten free weet-bix. Conversion factors were applied for meat (70%) and fish (80%) to ensure cooked weights were analysed (Bognar, 2002). Where necessary, assumptions were made (Appendix D). Weekly meetings were held with four NZRDs to discuss data entry, to ensure necessary assumptions were appropriate. Further questions were clarified by follow-up email to participants (such as brand of pasta).

Complete food records were entered in the first instance. Subsequently the breakfast meal was extracted into another document. The definition for breakfast used was "between 6 and 10 am or within 2 hours of waking" (Pereira *et al.*, 2011). Wake times where breakfast was consumed after 10 am were taken from the sleep diary (not reported) completed by participants to determine whether breakfast was consumed or skipped according to the aforementioned definition. Where sleep diaries were not completed, and breakfast was later than 10 am, breakfast was considered skipped. Where only water was consumed, breakfast was also considered skipped.

Breakfast observation dietary data was also entered into FoodWorks 8 for nutrient analysis, using the pre-determined list of foods and portions that were available at the breakfast buffet (Appendix C). Foods were entered as either 1/4, 1/3, 1/2, 2/3, or 3/4 of a portion and thus corresponding weight (grams) was recorded, according to what was consumed. Where it wasn't possible to observe at the breakfast assessment or to visualise on the recording what choice was made, the most common food choice was used, based on other participants' food choices. Where it wasn't possible to accurately quantify milk used in drinks or cereal, assumptions were made using a food quantities manual (Langenhoven, 1991). Dietary data was entered and checked by two MSc Nutrition and Dietetics students and a research intern. To ensure accuracy, all FoodWorks data was checked by one MSc student, and a small sample was re-checked by two NZRD PhD students.

To assess behavioural aspects of breakfast consumption during the dietary review, participants were asked to self-assess whether they considered themselves to be slow, medium or fast eaters. Where participants could not self-identify, probing questions were asked such as whether women finished first when eating with a group. In order to compare self-reported pace of eating with observed, the recorded breakfast observation was reviewed, and participants classified as being slow, medium or fast eaters according to benchmarked participants, including consideration of behaviours exhibited during eating such as talking, refilling the spoon whilst chewing, or reading a magazine. Participants were also asked whether they ever skipped meals in the dietary review. This was compared against observed meal skipping behaviour as demonstrated during the 5-day food record.

For the purposes of setting a parameter to enable the comparison of nutrient intake at breakfast to daily nutrient recommendations, one third of the appropriate Nutrient Reference Value was used. New Zealand is a Western country where three meals a day are typically consumed, and breakfast is one of those meals (Stote *et al.*, 2007, Leech *et al.*, 2017). Furthermore, various studies have recommended that nutrient intake at breakfast consist of around one third of intake (Soanes *et al.*, 2001, Anderson *et al.,* 2016). Nutrient intake at breakfast in this study was therefore compared against one third of the appropriate Nutrient Reference Value: estimated average requirement (EAR) in the first instance, with adequate intake (AI) where EAR was not possible to set (NHMRC, 2005). For comparison between energy intake and estimated energy requirements (EER), energy intake at breakfast was compared against participant's EER using both the BIA EER value and the Oxford equation value. To calculate the greatest contribution of particular food types to energy density at each breakfast occasion, foods were grouped according to previously determined food groups (Appendix E). Energy density was calculated as kilojoules per gram of food, and food groups were ranked according to greatest energy density.

3.2.5 Statistical Analysis

Statistical analysis was conducted using SPSS 24 for Windows (SPSS Inc, Chicago IL). The central limit theorem was applied and all data was treated as normally distributed. Normality was assessed visually using a histogram, box plot, de-trended plot and the Q-Q normality plot. Descriptive statistics were reported as mean and standard deviation. Categorical variables were reported as numbers, frequencies and percentages. All tests were two-tailed, and statistical significance was set at $p<0.05$ for all analyses.

To enable comparison between one single observed breakfast event and recorded breakfast intake over 4-5 days, total food record data was divided by the total days of food record completion for each participant. All comparisons between observed and recorded intake were treated in this manner. Differences between both the recorded intake and observed intake in obese BMI and normal BMI individuals were examined by the paired-samples t-test. For comparison between recorded and observed breakfast consumption, the three participants with missing data for the observed breakfast were excluded, leaving a sample size n=154 for these analyses. Differences between recorded and observed breakfast intakes were examined by the independent samples t-test for both BMI groups. To explore which variables predicted obesity, binary logistic regression was performed. The dependent variable was BMI groups (normal and obese BMI). Variables entered were age, energy density, number of days breakfast skipped and self-identified pace of eating using the enter method.

3.3 Results

3.3.1 Participant Characteristics

A total of 157 New Zealand European women were eligible for inclusion in the study. Of these, 75 (47.8%) were classified according to BMI as being in the obese BMI (BMI ≥30kg/m^2) versus 82 (52.2%) in the normal BMI group (BMI 24.99kg/m^2), (**Table 3.1**). The obese BMI women were older than those with normal BMI (33.4 ± 6.9 and 29.9 ± 6.5 years respectively, p<0.001). Disaggregated anthropometric and body composition categories are also presented in **Table 3.1.** Half (n=41; 50.0%) of the normal BMI women had normal body fat percentages ranging between 22.1% and 29.9%, whilst most of the obese BMI women (n=59; 78.7%) had body fat percentages greater than 40% - well outside the obese range of >30% (Oliveros *et al.*, 2014). Most of the obese BMI women (n=70; 93.3%) had a high (>88cm) waist circumference (WC) compared with normal WC (<80cm) for normal BMI women (n=77; 93.9%). More normal BMI than obese BMI women consumed breakfast every day of food record (n=69; 84.1% versus n=56; 74.6% respectively). More obese BMI women (n=19; 25.3%) skipped breakfast on at least one day of their food record than normal BMI women (n=13; 15.8%). More normal BMI women had breakfast between 6am and 10am every day (n=48; 58.5%) than obese BMI women (n=34; 45.3%)

Table 3.1 Participant Demographic, Anthropometric and Breakfast Consumption Characteristics

		n=157						
		Obese BMI ≥30kg/m² (n=75)			Normal BMI 18.5-24.9kg/m² (n=82)			
Characteristic	Reference Range	Mean ±SD	Minimum	Maximum	Mean ±SD	Minimum	Maximum	p-value*
Age (years)		33.4 ± 6.9	20.0	45.0	29.9 ± 6.5	18.0	42.0	<0.001
Weight (kg)		96.3 ± 11.5	75.6	126.4	61.9 ± 5.4	48.3	74.7	<0.001
BMI (kg/m²)		34.3 ± 3	30.0	42.3	22.2 ± 1.4	18.9	25.0	<0.001
EER (BIA)		2463 (±225)			2204 (±168)			<0.001
EER (Oxford)†		2743 (±249)			2148 (±119)			<0.001
Muscle mass (kg)		29.9 ± 3.8	21.4	40.3	25.3 ± 2.8	20.3	33.1	<0.001
Fat mass (kg)		42.7 ± 7.8	27.5	60.6	15.9 ± 3.9	7.9	23.5	<0.001
Body fat percentage		44.2 ± 4.5	34.8	54.3	25.5 ± 5.4	13.4	37.8	<0.001
WC (cm)		99.5 ± 9.1	81.5	124.4	72.7 ± 4.9	58.4	85.7	<0.001
Waist to hip ratio		0.8 ± 0.1	0.6	1.0	0.7 ± 0	0.6	0.9	<0.001
Waist to height ratio		0.6 ± 0.1	0.5	0.8	0.4 ± 0	0.4	0.5	<0.001

Characteristic	Interpretation	n(%)	n(%)
Food record 4 days		3(4.00)	1(1.22)
Food record 5 days		72(96.0)	81(98.7)
Breakfast 5 days‡		56(74.6)	69(84.1)
Breakfast 6-10am 5 days‡		34(45.3)	48(58.5)
Skipped BF > 1 day‡		19(25.3)	13(15.8)

Characteristic	Interpretation		Obese BMI ≥30kg/m^2 (n=75) n(%)	Normal BMI 18.5-24.9kg/m^2 (n=82) n(%)
Waist circumference category	Normal	<80	0 (0.00)	77 (93.9)
	High	80.1-87.9	5 (6.67)	5 (6.09)
	High Risk	>88	70 (93.3)	0 (0.00)
Waist to hip ratio category	Low Risk	<0.80	32(42.7)	73(89.0)
	Moderate Risk	0.81-0.85	20(26.7)	7(8.54)
	High Risk	>0.85	23(30.7)	2(2.44)
Waist to height ratio category	Normal	<0.50	1(1.33)	77(93.9)
	Elevated	>0.51	74(98.7)	5(6.10.0)
Body fat percentage category	Low	<22%	0 (0.00)	22 (26.87.0)
	Normal	22.1-29.9%	0 (0.00)	41 (50.0)
	High	30-34.9%	1 (1.33)	17 (20.70)
	Obese	35-39.9	15(20.0)	2(2.44)
	Very Obese	>40%	59(78.7)	0 (0.00)

BMI: Body mass index (kg/m^2); obese >29.9 kg/m^2, normal 18.5-24.9 kg/m^2
Body fat percentage categories defined as low: <22%, normal 22.1-29.9%, high: 30-34.9%, obese: 35-39.9%, very obese: >40%
EER: Reported as 0.33(BMR+TEF(10%)xPAL(1.6))
†Appropriate Oxford equations used according to participant age
Oxford equation for BMR: 18-30years: 0.0546W+2.33
Oxford equation for BMR: 30-60years: 0.0429W +2.90
Waist circumference categories defined as normal: <80cm, high, 80.1-87.9cm, high risk >88cm
Waist to height ratio categories defined as normal: <0.50, elevated: >0.51
Waist to hip ratio categories low risk <0.80, moderate risk 0.81-0.85, high risk >0.85
*Independent samples t- test, p<0.05 denotes statistical significance
Breakfast: defined as between 6 and 10am or within 2 hours of waking
Skipped breakfast: defined as consumed water or nothing
FR: Average daily intake of breakfast food record per day of food record completion
‡Breakfast consumed at the food record

3.3.2 Breakfast Analysis: Food Weight, Energy, Macronutrient and Micronutrient Intakes

The food weight, energy, macronutrient and micronutrient intakes of both obese and normal BMI groups are compared within and between the mean ± SD intake at the recorded and observed breakfast, in comparison to national recommendations (**Table 3.2**) (NHMRC, 2005). The weight of food consumed was significantly greater at the recorded breakfast for the normal BMI women (590 ± 343 g) than obese BMI women (446 ± 234 g), p<0.001, and the normal BMI group also ate more food at the recorded breakfast than the observed breakfast (417 ± 165 g) p<0.001. The energy density of food consumed was greater at the observed breakfast for both groups based on their self-selected breakfast. The energy density at the recorded breakfast intake was greater in the obese BMI women (3.69 ± 2.02 kJ/g) compared to the normal BMI women (3.19 ± 1.65 kJ/g), p=0.04, but not at the observed breakfast. Energy intake at breakfast was compared to one third of estimated energy requirements (EER); neither group met one third of their requirements in comparison to either method of EER calculation at either breakfast occasion. Obese BMI women consumed significantly more energy at the observed breakfast (1915 ± 868 kJ) than at the recorded breakfast (1431 ± 690 kJ) p<0.001.

Macronutrient intakes were compared with both the NRV and AMDR. Protein consumption was within AMDR recommendations in both BMI groups for the food record breakfast (16.3% and 17.5%) but not at the observed breakfast (13.0% and 14.0%) for obese BMI and normal BMI women respectively. At the observed breakfast, 69.4% percent of obese BMI women met NRV requirements for protein, compared with 51.4% meeting requirements for the food record breakfast. Compared with the AMDR, total fat consumption exceeded recommendations for the food record breakfast in both BMI groups (35.9% and 36.5%), but not at the observed breakfast (34.8% and 34.2%), obese BMI and normal BMI respectively. However, the percentage energy from fat consumed was at the highest end of the AMDR at the observed breakfast. Saturated fat also exceeded AMDR recommendations in both groups on both occasions.

Table 3.2 Intake at Breakfast on an Average Day of Food Record in Comparison with Observed Breakfast in each BMI Group

n=154
(n=72 Obese BMI, n=82 Normal BMI)

Dietary component		AMDR (%)	Obese BMI (mean ± SD)	Normal BMI (mean ± SD)	p-value*	NRV (1/3rd)	Obese BMI Adequate n(%)	Obese BMI Inadequate n(%)	Normal BMI Adequate n(%)	Normal BMI Inadequate n(%)
Weight of Food (g)	FR		446±234	590±343	<0.001					
	VO		425±161	417±165	0.77					
	p-value**		0.52	<0.001						
EER (BIA)			2463 ±225	2204 ±168						
EER (Oxford) †			2743 ±249	2148 ±119						
Energy (kJ)	FR		1431± 690	1528± 648	0.48					
	VO		1915± 868	1672± 621	0.05					
	p-value**		<0.001	0.15						
Energy Density (kJ/g)	FR		3.69± 2.02	3.19± 1.65	0.04					
	VO		5.06± 3.13	4.59± 2.52	0.35					
	p-value**		0.002	<0.001						
Protein	FR (g)		13.9± 7.82	15.0± 6.87	0.38	EAR: 12.2g	37(51.4)	35(48.6)	53(64.6)	29(35.4)
	FR (%kJ)	15-25%	16.3	17.5						
	VO (g)		14.6± 5.79	13.7± 6.02	0.41	EAR: 12.2g	50(69.4)	22(30.6)	44(53.7)	38(46.3)
	VO (%kJ)	15-25%	13.0	14.0						
	p-value**		0.55	0.13						
Total fat	FR (g)		15.1± 10.5	15.6± 9.07	0.98					
	FR (%kJ)	20-35%	35.9	36.5						
	VO (g)		18.0± 12.4	15.3± 9.80	0.16					
	VO (%kJ)	20-35%	34.8	34.2						

Dietary component		AMDR (%)	Obese BMI (mean ± SD)	Normal BMI (mean ± SD)	p-value*	NRV (1/3rd)	Obese BMI Adequate n(%)	Obese BMI Inadequate n(%)	Normal BMI Adequate n(%)	Normal BMI Inadequate n(%)
	p-value**		0.12	0.79						
Saturated fat	FR (g)		5.74± 4.52	5.41± 3.86	0.43					
	FR (%kJ)	<10%	13.6	12.6						
	VO (g)		6.56± 4.55	5.37± 3.71	0.07					
	VO (%kJ)	<10%	12.7	11.9						
	p-value**		0.24	0.94						
Carbohydrate	FR (g)		35.4± 18.4	38.2± 19.1	0.31					
	FR (%kJ)	45-65%	42.6	40.7						
	VO (g)		56.6± 25.8	48.2± 19.0	0.02					
	VO (%kJ)	45-65%	50.3	49.0						
	p-value**		<0.001	<0.001						
Sugars (g)	FR		15.5± 11.1	16.4± 10.4	0.65					
	VO		31.5± 18.5	27.9± 15.5	0.19					
	p-value**		<0.001	<0.001						
Starch (g)	FR		19.8± 12.1	21.8± 13.1	0.27					
	VO		25.1± 12.8	20.3± 9.20	0.01					
	p-value**		0.01	0.35						
Dietary fibre (g)	FR		4.53± 2.71	5.69± 3.78	0.04	AI: 8.25g	11(15.3)	61(84.7)	13(15.3)	69(81.2)
	VO		6.10± 2.73	5.94± 2.51	0.78		12(16.7)	60(83.3)	14(16.5)	68(80.0)
	p-value**		<0.001	0.56						
Calcium (mg)	FR		202± 131	237± 155	0.18	EAR: 280mg	15(20.8)	55(76.4)	24(28.2)	55(64.7)
	VO		307± 185	311± 191	0.91		38(52.8)	34(47.2)	42(49.5)	40(47.1)
	p-value**		<0.001	<0.001						
Folate (DFEs, µg)	FR		93.9± 75.6	134± 105	0.01	EAR: 107ug	25(34.7)	44(61.1)	38(44.7)	40(47.1)
	VO		84.7± 75.7	80.0± 92.6	0.87		21(29.2)	51(70.8)	18(21.2)	64(75.3)
	p-value**		0.506	<0.001						

*Independent samples t- test, **Paired samples t-test, p<0.05 denotes statistical significance
BMI: Body mass index, kg/m^2
FR: intake consumed on an average day of food record
VO: intake observed at breakfast video observation
AMDR: acceptable macronutrient distribution range, (NHMRC, 2005)
NRV: Nutrient Reference Values, standard value 33% of EAR/AI to account for breakfast meal only
EAR: estimated average requirement. Whole day EAR: Protein 37g, calcium 840mg, folate 320µg (NHMRC, 2005)
AI: Adequate Intake. Whole day AI: dietary fibre 25g (NHMRC, 2005)
Sugars include: fructose, lactose, maltose, sucrose
EER: Reported as 0.33(BMR+TEF(10%)xPAL(1.6))
†Appropriate Oxford equations used according to participant age
Oxford equation for BMR: 18-30years: 0.0546W+2.33
Oxford equation for BMR: 30-60years: 0.0429W +2.90
The PAL of 1.6 represents someone who is minimally active (Black, 1996, Trumbo *et al.*, 2002)

Carbohydrate consumption was within the AMDR for the observed breakfast (50.3% and 49.0%), but was under-consumed for the recorded breakfast (42.6% and 40.7%) in both groups (obese BMI and normal BMI respectively). Carbohydrate consumption was greater in obese BMI women at the observed breakfast (56.6 ± 25.8 g) than for the recorded breakfast (35.4 ± 18.4 g), p<0.001. Carbohydrate consumption was much greater in the obese BMI women at the observed breakfast (56.6 ± 25.8 g) than in normal BMI women (48.2 ± 19.0 g), p=0.02. Obese BMI women consumed more dietary fibre at the observed breakfast (6.10 ± 2.73 g) compared with the recorded breakfast (4.53 ± 2.71 g), p<0.001. However, on both occasions only 16.7% and 15.3% of obese BMI women met the requirements in comparison to one third of NRV recommendations (NHMRC, 2005). Normal BMI women consumed more dietary fibre (5.67 ± 3.78 g) than obese women (4.53 ± 2.71 g, p=0.04) for the recorded breakfast. Similarly, only 15.3% and 16.5% respectively of normal BMI women had adequate dietary fibre intakes in comparison to one third of requirements, at recorded versus observed breakfasts.

Calcium intake was significantly greater at the observed breakfast than at the recorded breakfast for both obese (307 ± 185 mg versus 202 ± 131 mg, p<0.001) and normal BMI women (311 ± 191 mg versus 237 ± 155 mg p<0.001). Folate consumption was greater in normal BMI women at the recorded breakfast (134 ± 105 µg) versus obese BMI women (93.9 ± 75.6 µg, p=0.01). Additionally, folate intake for the normal BMI women was greater at the recorded versus observed breakfast (134 ± 105 µg and 80.0 ± 92.6 µg, p<0.001).

3.3.3 Breakfast Analysis: Energy Density and Frequency of Food Consumption

The energy density, weights and frequency of consumption of the top food types consumed at breakfast at the recorded and observed breakfast are presented in **Tables 3.3** and **3.4.** For the recorded breakfast, both normal BMI and obese BMI women's top two food groups with the greatest contribution to energy density were the same - namely fats, nuts and seeds. For the recorded breakfast, the obese BMI women had seven discretionary or high fat food types in their top 15 most energy dense foods - fats, sugar added to food and drink, margarine, coconut fats, sweet spreads, oil and oil based dressings, and sweet snack foods. The normal BMI women had six - fats, sugar added to food and drink, oil and oil based dressings, margarine, sweet spreads, and coconut fats. Full fat milk and other high fat dairy were higher on the list of energy density in the obese BMI women (13th) than the normal BMI women (17th), whereas fruits and vegetables were higher for normal BMI women (starting at 14th) than obese participants (starting at 18th).

The contribution of energy density at the observed breakfast was different across both groups (**Table 3.4**). The top two foods contributing to energy intake for obese women were discretionary items – fats, cake and biscuits, where for normal BMI women, sweetened cereals and nuts and seeds were the top two contributors. Dairy products were higher on the list for normal BMI women (11th) than for obese participants (14th), whereas cake and biscuits were lower on the list for normal BMI participants (5th) than obese BMI participants (2nd). Sweetened milk products were the greatest contributor to energy density for dairy products for obese BMI women at the observed breakfast, whereas full fat milk was the greatest contributor for normal BMI women.

Table 3.3 Top 40 Foods Consumed in the Recorded Breakfast across All Days of Food Record Completion by Energy Density, Weight of food and Frequency of Consumption, in Obese BMI and Normal BMI groups

Obese BMI (n=75)

Food	Total Energy Density (kJ/g)	Total Weight of food (g)	Frequency of consumption
Fats	1335	580	44
Nuts and seeds	1010	633	43
Sugar added to food and drink	938	392	57
Sweetened cereals	904	2854	52
Peanut butter and peanuts	809	593	33
Whole grain breads	763	5860	80
Oats	679	3694	55
Margarine	604	361	25
Coffee	561	11851	175
Coconut fats	475	222	19
Sweet spreads	441	627	36
Oil and oil based dressings	406	90	11
Full fat milk	374	9050	114
Egg and egg dishes	341	5802	54
Sweet snack foods	326	384	16
White breads	320	2443	30
Cream or other high fat dairy	279	541	18
Herbs and spices	276	29	24
Sweetened milk products	267	2644	22
Processed meats	252	1415	26
High fat cheese	248	459	16
Other non-starchy vegetables	241	1995	31
Other fruit	216	4548	62
Discretionary breads	203	2212	21
Apple, banana, orange	200	6322	56
Low fat milk	195	9240	103
Yoghurt	192	5764	52
Creamy dressings	144	235	6
Fruit drink and other beverages	133	5178	23
Cocoa and cacao	110	38	6
Cake and biscuits	96	382	6
Savoury spreads	86	111	13
Crumbed and deep fried	68	621	7
Fast-food	62	1166	6
Low fat cheese	57	145	5
Crackers	37	100	2
Legumes	33	216	6
Wholegrains	30	15	2
Sauces	30	118	7
White meats	29	150	4

Energy density calculated: kJ/g

Data presented as total of all food record days

Normal BMI (n=82)

Food	Total Energy Density (kJ/g)	Total Weight of food (g)	Frequency of consumption
Fats	1916	578	64
Nuts and seeds	1718	780	74
Sweetened cereals	1477	6565	92
Peanut butter and peanuts	1055	529	43
Whole grain breads	930	5866	95
Sugar added to food and drink	834	240	50
Coffee	748	15936	181
Oats	671	4842	52
Oil and oil based dressings	627	184	17
Margarine	500	154	20
Sweet spreads	456	402	37
Coconut fats	401	496	21
Sweetened milk products	377	3600	35
Herbs and spices	374	40	30
Egg and egg dishes	359	5212	59
Sweet snack foods	337	630	19
Full fat milk	325	12687	130
Other non-starchy vegetables	286	2347	43
Processed meats	281	1037	24
White breads	256	1658	24
Apple, banana, orange	236	6162	67
Low fat milk	229	12540	121
Other fruit	227	5330	71
Discretionary breads	209	2602	21
High fat cheese	202	621	15
Yoghurt	150	3074	39
Creamy dressings	141	85	8
Savoury spreads	117	183	18
Low fat cheese	104	210	8
Milk alternatives	90	7527	45
Cocoa and cacao	88	16	5
Fruit drink and other beverages	79	6197	19
Cake and biscuits	69	751	6
Fast-food	65	898	6
Sauces	65	296	12
Soy products	59	2412	20
Artificial sweetener	50	3	5
Crumbed and deep fried	47	680	5
Wholegrains	45	691	5
Crackers	40	41	2

Beverage
Breads and cereals
Dairy (and alternatives)
Discretionary
Fats and oils
Flavouring or condiment
Fruit
Nuts and seeds
Water
Protein
Vegetables and legumes

Table 3.4 Foods Consumed at the Observed Breakfast by Energy Density, Weight of Food and Frequency of Consumption, in Obese BMI and Normal BMI Groups

Obese BMI (n=72)

Food	Total Energy Density (kJ/g)	Total Weight of food (g)	Frequency of consumption
Fats	763	210	25
Cake and biscuits	490	1490	28
Nuts and seeds	428	534	16
Peanut butter and peanuts	376	176	15
Coffee	367	292	33
Sweetened cereals	343	965	21
Whole grain breads	259	1678	27
Margarine	166	72	7
Apple, banana, orange	113	3057	29
Sweet spreads	109	143	9
Savoury spreads	108	59	16
Sugar added to food and drink	102	35	6
White breads	101	608	10
Sweetened milk products	87	368	6
Yoghurt	80	4575	32
Low fat cheese	78	238	9
High fat cheese	71	166	5
Full fat milk	62	1789	25
Crackers	58	135	3
Sweet snack foods	56	97	3
Oats	44	102	3
Other fruit	30	791	7
Low fat milk	27	1153	18
Fruit juice	8	394	4
Tea	0	3988	17
Water	0	8614	38

Energy density calculated: kJ/g

Normal BMI (n=82)

Food	Total Energy Density (kJ/g)	Total Weight of food (g)	Frequency of consumption
Sweetened cereals	540	1491	32
Nuts and seeds	508	621	19
Coffee	460	377	35
Fats	458	120	15
Cake and biscuits	363	840	20
Peanut butter and peanuts	351	193	14
Whole grain breads	201	1338	21
Oats	116	255	8
Apple, banana, orange	114	3044	30
Sweet spreads	85	116	7
Full fat milk	77	2853	31
Yoghurt	74	4930	35
High fat cheese	71	145	5
Savoury spreads	54	39	8
Margarine	48	16	2
Sweetened milk products	47	1368	7
Other fruit	43	1045	10
Low fat cheese	35	83	4
White breads	30	128	3
Low fat milk	29	1547	19
Crackers	19	18	1
Sugar added to food and drink	17	5	1
Sweet snack foods	16	32	1
Fruit juice	6	328	3
Tea	0	4690	20
Water	0	8438	38

Beverage
Breads and cereals
Dairy (and alternatives)
Discretionary
Fats and oils
Flavouring or condiment
Fruit
Nuts and seeds
Water

3.3.4 Predictors of Obesity

Predictors of obesity are presented in **Table 3.5**. Having a faster pace of eating significantly increased the likelihood of being in the obese category (b=3.11, p=0.016). Energy density was also associated with obesity, with a greater energy density of recorded breakfast increasing the likelihood of being in the obese category (b=1.35; p=0.042)

Table 3.5 Binary Logistic Regression for Predictors of BMI

	n=157 n=75 obese BMI, n=82 normal BMI		
Predictor	b	95% Confidence Interval	p-value
Age	1.11	1.05-1.17	0.001
Recorded Energy Density	1.35	1.09-1.66	0.042
Number of days breakfast skipped	1.62	1.04-2.53	0.281
Pace of eating	3.11	1.18-8.21	0.016

R2=0.13 (Hosmer &Lemeshow) ,0.16 (Cox & Snell), 0.215 (Nagelkerke), Model $\chi^2(4)=27.6$, p=<0.000. Significance set at p<0.05. Recorded energy density is average energy intake per day of food record (kJ) divided by grams of intake. Pace of eating was slow compared with medium and fast eating as self-identified by participants in diet record review.

3.4 Discussion

Breakfast consumption is a key aspect of dietary intake and healthy daily eating behaviour, and has a significant influence on health parameters. This study sought to explore the breakfast consumption of New Zealand European women with different body composition profiles, as part of the wider PROMISE study. The objectives were to firstly describe and compare the breakfast eating practices (reported and observed) of obese versus normal weight New Zealand European women, aged between 18 and 45 years, and secondly to characterise factors such as pace of eating associated with breakfast consumption.

3.4.1 Anthropometry

The women in our study of obese BMI were older than those with a normal BMI. This is comparable to figures illustrated in the New Zealand Health Survey (2016/17), where adiposity was more prevalent with increasing age (Ministry of Health, 2017). This is also similar to other research studies, where obesity and body fat percentage increased with age (Boneva-Asiova and Boyanov, 2008, Marques-Vidal *et al.*, 2008, Barr *et al.*, 2016). The obese BMI New Zealand European women in this study had a mean body fat percentage of 44.2%, of which 78.7% had body fat percentages >40%, considered very obese (Oliveros *et al.*, 2014). Interestingly, 20.0% of normal BMI women in our study had body fat percentages between 30% and 34.9%, whilst 2.44% of the normal BMI women in our study had body fat percentages ≥35%, indicating the presence of normal weight obesity (Oliveros *et al.*, 2014). This is a similar finding to the women's waist circumference (WC) measurements, where all obese women had a WC greater than 80cm, whilst only 3.2% of normal BMI participants had an elevated WC, indicating that the high body fat percentage is hidden fat. This illustrates that despite appearing to be of normal BMI (and therefore presumed to have a low chronic disease risk), some women with a normal BMI may have increased abdominal adiposity and subsequent elevated risk of disease (Renzo *et al.*, 2006, Cameron *et al.*, 2009, Oliveros *et al.*, 2014). This is concerning, as it has been well established that abdominal obesity and visceral fat are strong predictors of cardiovascular disease risk (Cameron *et al.*, 2009, Huxley *et al.*, 2010). The waist to height ratio, a relatively recent measure used to determine abdominal obesity in relation to height, illustrated largely similar obesity classification to BMI groups; 1.33% obese women were classified as normal (<0.50) and 6.10% normal BMI women were classified as elevated (>0.51).

3.4.2 Breakfast Consumption

The number of women skipping breakfast in this study was similar to previous population based studies (reporting 19-28%); where 25.3% of obese BMI women and 15.8% of normal BMI women skipping breakfast on at least one of their food record days (Timlin and Pereira, 2007, Levitsky, 2013, Chowdhury *et al.*, 2015). This is a similar finding to a general population based study in the USA, with 25% of the population in the NHANES 1999-2002 skipped breakfast (Deshmukh-Taskar, 2010). Additionally, 74.6% of obese women and 84.1% of normal BMI women did not skip breakfast on any day in our study. These findings are similar to the New Zealand Adult National Nutrition Survey (2008/9) (ANS), where 50.2% of women aged 19-30 years and 69.8% of women aged 31-50 years reported consuming something for breakfast on every day of the week (Ministry of Health, 2012). Various studies have reported on frequency of breakfast consumption, where breakfast was consumed on an average of 5.6 ± 2.0 days per week in one study, and on most days of the week by 79% of participants in a Canadian population based study (Betts *et al.*, 2014, Megson *et al.*, 2017). These findings suggest that the population of women in our study exhibit similar breakfast consumption habits to other New Zealand women, as well as other Western populations; however it remains to be determined whether the composition of the breakfast meal is adequate.

3.4.3 Energy and Energy Density

To determine whether energy intake at breakfast was sufficient to meet requirements, one third of the calculated EER (Oxford method) was compared against energy intake determined at recorded and observed breakfast occasions. The energy content of breakfast consumed was not sufficient on either occasion to meet one third of the calculated EER for either group. This finding suggests that women in our study did not consume a substantial breakfast with sufficient energy. For the recorded breakfast, this may be explained by the under-reporting of energy intake - a significant limitation in self-reported dietary data, particularly amongst overweight and obese individuals (Subar *et al.,* 2003, Gemming *et al.*, 2014). Obese BMI women consumed on average 1000kJ less than one third of the average calculated EER, indicating that energy consumption must be compensated for at another time point during the day to account for total energy intake. As this study used preliminary data, the complete nutrient analysis for the food record data was not available; therefore it was not possible to determine whether energy consumption was compensated for later in the day. It can be assumed that particularly for the obese BMI participants this must be the case. As mentioned previously, it is also likely that an element of under-reporting was present in this study, which may explain the low energy intake at the recorded breakfast.

Timing of eating is a recent topic of scientific investigation, and it has become clear that sporadic meal patterns involving scattered meal times, nocturnal eating and extended periods of fasting followed by large meals can be associated with negative health effects and obesity (Gluck *et al.*, 2001, Keim *et al.*, 1997, Ma *et al.*, 2003, Jung Su Lee, 2016). Consuming meals late in the day has been associated with an increase in body fat (McHill *et al.*, 2017). Additionally, in one study energy intake was greater on days when subjects reported skipping breakfast, and regularly skipping breakfast was associated with 4.5 times higher risk of obesity (Ma *et al.*, 2003). It has been proposed that as a result of increased appetite due to breakfast omission, increased energy consumption may result in increased fat storage, which is exacerbated by elevated insulin concentrations and increased fat deposition (Ma *et al.*, 2003, Farshchi, 2005).

Regarding energy density, our study found that obese BMI women consumed foods with a greater energy density (3.7 ± 2.0kJ/g) than normal BMI women (3.1 ± 1.6kJ/g), p=0.04. Greater energy density has been shown to be a predictor of obesity and metabolic syndrome (Mendoza *et al.*, 2007), and has been linked to overall poorer diet quality and micronutrient intake (Kant *et al.*, 2008). Additionally, reducing the energy density of the diet has proven in short-term studies to be a successful method of achieving weight loss (Kant and Graubard, 2006, Ledikwe *et al.*, 2007). In this study, the greater energy density in combination with lower weight of food consumed by obese BMI women suggests that their food choices were higher in fat, as fat is the most energy dense nutrient (Drewnowski, 2004). It has been illustrated that fat is not a particularly satiating nutrient, and that high fat meals induce hyperphagia at a subsequent time point (Clegg and Shafat, 2010). The sensory preference for fat is particularly evident in obese individuals (Mela and Sacchetti, 1991). In a recent Italian study, obese individuals showed greater hedonic liking for foods with high energy density than normal weight individuals (Proserpio *et al.*, 2016). Taken together with the high palatability of high-fat foods, the over-consumption of high-fat energy dense foods may lead to positive energy balance and weight gain (Blundell *et al.*, 1993, Blundell and MacDiarmid, 1997).

The top two foods contributing to energy density in both BMI groups for recorded intake were fats, nuts and seeds. This is not surprising, as nuts and seeds have a high fat content. Added sugar was the third largest contributor to energy density for the obese BMI participants, whilst it was the sixth contributor for normal BMI participants. On the whole, food choices and contributions to energy density across both groups were quite similar, suggesting similar food choices at breakfast. As well as discretionary foods such as oil and oil based dressings, margarine and coconut fats and sweet spreads being present in the top 10 foods, nutritious foods such as oats, cereal and wholegrain bread were present in both groups. Sweetened cereals and whole grain breads were the third and fifth most energy dense food for normal BMI participants, compared with the fourth and sixth for obese BMI participants.

At the observed breakfast, the food group choices leading to the greatest energy density were different between BMI categories. Fats, and cake and biscuits were the top two food groups for obese BMI participants whereas cereals, and nuts and seeds were the top two food groups for normal BMI participants. This is a significant finding, as it illustrates that when foods were provided, obese participants made poorer food choices, despite a range of both healthy and unhealthy options being provided. This finding is in agreement with one review that showed that in buffet meals obese subjects consume dessert earlier in the meal, and consume more energy dense foods than lean subjects (Spiegel, 2000).

No dairy products featured in the top 10 most energy dense foods for either group, suggesting a low habitual consumption of milk products at breakfast. Despite the provision of milk, yoghurt, and cheese at the observed breakfast, there was no meaningful change in dairy product choice between recorded and observed breakfasts, confirming the poor intake of dairy products at breakfast in women in this study. Dairy products are rich in bioavailable calcium; hence, the low consumption of dairy products in this study population has concerning implications for their calcium intake (NHMRC, 2005). Calcium is a vital nutrient for bone formation, and poor calcium intakes may have adverse effects on health parameters such as bone density, resulting in an increased risk of osteoporosis (NHMRC, 2005). In the 2008/9 ANS, 67.3% of New Zealand European women aged 19-30 years had inadequate intakes of calcium, as did 51.6% of those aged 31-50 years (Ministry of Health, 2012). The inadequate intake of calcium rich foods has also been found to be prevalent amongst the population in the USA, with only 30% of the US population meeting the recommended level of calcium in the NHANES (1999-2004) (Nicklas *et al.*, 2009). Additionally, both dairy and calcium intake has been found to be inadequate in postmenopausal New Zealand women (Gunn *et al.*, 2014). As well as having important functions in bone health, the role of calcium in body weight management has been investigated, with high calcium intake leading to increased fat oxidation and faecal fat excretion (Zemel, 2005, Astrup, 2008). Additionally, poor calcium intake among individuals with excess body fat has been found in a number of studies (Jacqmain *et al.,* 2003, García *et al.*, 2009). These findings suggest that the women in our study may be at increased risk for inadequate calcium intake and associated adverse bone health and weight management effects, particularly when considering that breakfast consumption (especially cereal) facilitates the consumption of milk and yoghurt (Song *et al.*, 2006).

3.4.4 Macronutrient Consumption

The acceptable macronutrient distribution range, as discussed previously, is one method of assessing overall diet quality (NHMRC, 2005). Insufficient nutrient intake and increased risk of chronic disease can occur as a result of deviations from recommended ranges. Recorded breakfast intake illustrated that protein consumption for both BMI groups was within AMDR recommendations. Total and saturated fat were higher than recommendations, while carbohydrate intake was below recommendations. Carbohydrate consumption, particularly complex carbohydrates such as those from whole grains, has been associated with favourable effects on satiety, appetite, and glycaemia (Rebello *et al.*, 2013, Chowdhury *et al.*, 2015). Women involved in this study may have been influenced by common dietary trends, particularly the avoidance of carbohydrate-rich foods and sugar. There has been significant media coverage regarding the purported health benefits of low carbohydrate, high fat (LCHF) diets recently (Dietitians NZ, 2016). Mean dietary fibre intake in both groups on both occasions did not reach adequacy in comparison to one third of the NRV, with 83-87% of participants having an inadequate intake. This aligns with the observed low carbohydrate intake, also suggesting that fruit and vegetables and whole grain foods were missing from the breakfast meal. This is a concern, as dietary fibre has been associated with the prevention of bowel cancer, a significant contributor towards mortality in New Zealand (Ministry of Health, 2017). Dietary fibre is also a particularly satiating nutrient, and has been shown to contribute to reduced energy intake (Rebello *et al.*, 2013). Dietary fibre is a key nutrient to consume at the breakfast meal, and the traditional foods of cereals, bread and fruit are rich sources of dietary fibre (Barr *et al.*, 2013).

For the observed breakfast intake, average protein consumption was below the recommended AMDR, and total and saturated fat intake were similar, whereas carbohydrate intake was within recommendations. This is an interesting finding, as it appears that when appropriate breakfast options were provided, choices were still not conducive to meeting the AMDR, thus possibly increasing the risk for nutritional deficiencies and increased chronic disease risk, if nutrients are not consumed in sufficient amounts later in the day. Neither group met protein requirements in relation to AMDR at the observed intake (13% and 14% for obese and normal BMI groups respectively). However, the mean protein intake for all participants at both breakfast occasions exceeded the EAR (12.2g): recorded intake (14.1 ± 7.7g and 15.1 ± 6.9g) and for observed intake (14.6 ± 5.8g and 13.8 ± 6g): obese and normal BMI groups respectively.

3.4.5 Micronutrient Consumption

Micronutrient intake was analysed in relation to one third of the Estimated Average Requirement (EAR) as defined in the Nutrient Reference Values for Australia and New

Zealand (NHMRC, 2005). The estimated average requirement is the intake level of a nutrient where the needs of half the population will be met (NHMRC, 2005). As previously discussed, calcium is a significant nutrient involved in bone health, particularly in developing peak bone mass, as well as in the prevention of chronic disease. The most significant source of calcium in the New Zealand diet is milk, according to the 2008-9 New Zealand Adult Nutrition Survey. The calcium intake within New Zealand women aged 19-50 was approximately 700-800mg/day; the EAR is 840mg (NHMRC, 2005). An inadequate intake of calcium was prevalent in around 60% of New Zealand European women (19-50 years) in the 2008-9 New Zealand Adult Nutrition Survey (Ministry of Health, 2012). In this study, 78% of obese BMI women and 70% normal BMI women had inadequate calcium intakes in comparison to one third of requirements, indicating that most women in this study may have low calcium intakes at breakfast. In particular, if more calcium was not consumed later in the day or if the consumption of calcium at breakfast was indicative of that of the whole day, their calcium intake for the day may also be low. This is especially concerning, as only one third of the EAR was used for comparison to account for a single meal. It is also possible that the true occurrence of calcium intake inadequacy is greater than that observed in this study, as it has been previously shown that the breakfast meal is a key time point for milk consumption (Song *et al.*, 2006). It is likely that women in this study may be influenced by current fad diet trends which propose that dairy is not a healthy food choice (Bezzant, 2017). These findings also support other prevalent dietary trends such as ketogenic and paleo dietary practices (Burrell, 2017, Hansen, 2017).

Folate is a key nutrient particularly during pregnancy for the prevention of neural tube defects, but also in the general population for cell replication, growth and red blood cell formation (NHMRC, 2005). Folate consumption was significantly greater among normal BMI women at the recorded breakfast (134 ± 105 μg) than obese BMI women (93.9 ± 75.6 μg, p=0.01). It is suggested that this is due to the greater energy consumption in normal BMI women at the recorded breakfast, particularly from folate containing foods such as fortified cereal and non-starchy vegetables.

3.4.6 Predictors of BMI: Pace of Eating and Energy Density

The present study illustrated that women with a faster pace of eating were 3.11 times more likely than slower eaters to be in the obese BMI category, a finding which has been supported by evidence in Japan (Maruyama *et al.*, 2008). It has been shown in various studies that having a slower pace of eating can be related to reduced energy intake (and vice versa) (Albertson *et al.*, 2008, Andrade *et al.* 2008, Shah *et al.*, 2014). It has also been illustrated that eating slowly may result in lower energy intake in normal weight subjects but not obese subjects (Shah *et al.*, 2014). It is suggested that this may be as a result of the increased time available for satiation signals such as stomach distension and hormonal responses to register (Andrade *et al.*, 2008). As previously mentioned, the energy density of the diet has been found to be a predictor of obesity, which supports the findings in this study, where consuming breakfast with a greater energy density increased the likelihood for being in the obese BMI category by 1.35 times.

3.4.7 Strengths and Limitations

Strengths of this research include the large sample size (n=157), the rigorous methodology involved in data collection, and analysis of dietary intake data (in particular, the comprehensive dietary review completed by NZRDs). This maximised the accuracy of food records, allowing greater confidence in the results. Obtaining reported and observed data is another strength of this study, as observed data is generally more accurate than self-reported. The wide variety of foods at the observation is another strength, as it enables observation of whether an improved breakfast intake is possible when a range of choices was available. Limitations include the cross-sectional study design, making it impossible to infer causality, as is the inability to account for over- and under-reporters as a result of using preliminary data, and not having the complete energy and nutrient intake across the day to assess breakfast against overall intake. The strict definition for breakfast may also lead to under-representation of the dietary intake of those who have more than three eating occasions in a day. The observed breakfast was also not undertaken in a natural environment, which may alter eating behaviour and habits as participants may be aware of the focus on dietary intake and eating and thus adjust food consumption (Stubbs *et al.* 1998).

3.5 Conclusion

This study identified that breakfast consumption habits of New Zealand European women are inadequate, in terms of energy, fibre and calcium, particularly among women with obese BMI. Obese BMI women also made poorer food choices, with greater discretionary food, energy density, total and saturated fat intake. Both obese and normal BMI groups of women had a low intake of dairy products. Additionally, obese BMI women consumed food at a faster pace than normal BMI women. These findings suggest that breakfast consumption can be improved by including dairy products, wholegrain cereals, and fruit, which will improve the quality of dietary intake. Recommending a slow eating pace is also a key message. These recommendations may serve to inform future public health interventions, with the aim to reduce the risk of chronic disease and improve health outcomes for New Zealand women.

3.5.1 Acknowledgements

This study gratefully acknowledges funding provided by the Health Research Council.

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Chapter 4 Conclusions and Recommendations

4.1 Aim of the Research

The aim of this study was to describe and compare reported and observed breakfast consumption between obese BMI and normal BMI New Zealand European women, aged between 18 and45 years, living in Auckland, New Zealand participating in the PROMISE study. The objectives of this study were to describe and compare reported and observed breakfast consumption, nutrient consumption, food choices, and eating behaviours in each body composition group, and to determine factors that increase the likelihood of being obese. Investigating these factors will enable a greater understanding of breakfast consumption in different BMI groups, and enable the development of interventions to improve health outcomes related to excess adiposity.

4.2 Main Findings and Recommendations

The main findings and conclusions are presented in the same order as the objectives were in chapter 1.

Objectives relating to nutrient and food consumption at recorded and observed breakfast:

- To describe reported and observed breakfast consumption between normal weight and obese women.
- To compare differences between reported and observed breakfast consumption within each body composition group.
- To describe and compare recorded versus observed nutrient consumption between each body composition group.
- To describe and compare reported versus observed food choices between each body composition group.

The first four objectives involved the analysis of the breakfast intake of the women in this study. The aforementioned objectives were achieved by analysing and interpreting data collected in the 5-day food record and at the observed breakfast. The study found that while normal BMI women consumed more food at the recorded breakfast than obese BMI women, obese women consumed foods with a greater energy density. Women in both BMI groups did not consume adequate carbohydrate, fibre, or calcium during the recorded breakfast when compared to one third of the AMDR or NRV. However, when appropriate food choices were provided at the observed breakfast, both carbohydrate and calcium intake improved in line with the AMDR and EAR respectively. Dietary fibre intake significantly increased in obese BMI women from recorded to observed breakfast intake. This suggests that when appropriate food choices are provided, nutrient intake does improve and alludes to the fact that education messages regarding appropriate breakfast choices may have some benefit in this population. Additionally, the study found that obese BMI women consumed foods with greater energy density, and made poorer food choices than normal BMI women, particularly at the observed breakfast, which is in line with previous research (Spiegel, 2000). This is not surprising as excess energy intake from nutrient poor energy dense foods is a key driver of excess body fatness and has been found consistently in a number of studies (Mendoza *et al*., 2007; Kant *et al.,* 2008; Proserpio *et al*., 2016).

Objectives related to eating behaviours and likelihood of obesity:

- To describe and compare reported and observed eating behaviours (meal skipping, meal timing, and rate or pace of eating) between each body composition group.
- To determine the factors that increase the likelihood of being obese.

The final two objectives are related to eating behaviours, which were assessed by both self-reported measures and observation. It was found that more normal BMI women than obese BMI women consumed breakfast daily, prior to 10am. It was also determined that having a faster eating pace, and consuming foods with greater energy density increased the likelihood of being obese. Both these factors have been consistently shown to be associated with obesity and greater energy intake (Mendoza *et al.* 2007, Maruyama *et al.* 2008, Leong *et al.,* 2011).

The findings of this study confirm that New Zealand European women of both normal and obese BMI may benefit from encouragement to consume breakfasts containing adequate carbohydrate, fibre and calcium in particular to contribute to total dietary requirements in conjunction with intake during the rest of the day. The encouragement of an appropriate breakfast intake may be a useful and important public health strategy to optimise the quality and quantity of food consumed, with the potential to positively influence health outcomes. Particularly encouraging the consumption of cereal facilitates milk consumption, and therefore would improve calcium intake in addition to providing a source of protein, carbohydrate and dietary fibre (Song *et al.*, 2006, Barr *et al.*, 2013). These factors suggest that recommending high fibre cereal with milk (or fortified alternatives) with the addition of fruit would be advantageous in this population and may serve to improve nutrient intakes with long–term health benefits.

4.3 Strengths of the Study

There are a number of strengths associated with the study, which support the key findings. Firstly the sample size of 157 women is a strength in this study, as is the relatively even numbers in each BMI group. Secondly, the rigorous food record methodology used in conducting the study. Although it has been clearly established that a weighed food record is the gold standard for dietary assessment, the rigorous methodology involved in the collection of data is a key strength (Gibson, 2005). Firstly, participants were required to watch an instructional DVD, detailed written and verbal instructions were provided, and a portion book was provided. These serve to enhance the accuracy of recording. Secondly, the comprehensive dietary review completed by New Zealand Registered Dietitians, which was instrumental in obtaining detailed information from each participant in the instance that required information was not provided. This meant that when it came to entering the food records into FoodWorks for dietary analysis, many portion weights and specific information was available which minimised assumptions. Recording of food intake over week days and weekend days enables the assessment of usual intake, as patterns frequently change across work days and days off. Another strength of this study includes the ability to compare breakfast from the 5-day food record with the observed breakfast. This enabled trends to emerge such as the lack of carbohydrate and fibre intake, and strengthened interpretation of results. When clear trends are evident when foods are provided, it is likely that the food choices are made deliberately rather than due to convenience or price. Obtaining self-reported pace of eating and confirming it via the breakfast observation is another strength of the study, as this made it possible to establish pace of eating. Another strength of this study is the wide variety of food available at the breakfast buffet, which enabled us to observe whether improved breakfast intake was possible when a range of healthy and unhealthy choices were available. Finally, this study also used comprehensive body composition data enabling thorough analysis of body composition. Additionally, all days for food record data recording were spread across the group to ensure data collection over all days of the week.

4.4 Limitations of the Study

There are some limitations which can be associated with this study. First of all, this was a cross-sectional study design, therefore information is only provided at a single time point, and causality cannot be established. The breakfast definition used is also a limitation, as only one eating occasion based on one of three meals in a day was included. This may have resulted in the exclusion of snacks and thus under-representation of dietary intake in those who generally consume food at more than three eating occasions. Additionally, only having access to preliminary data which was only available for breakfast is a key limitation. Being able to investigate the association between breakfast consumption in relation to food intake across the entire day would have been beneficial and would allow greater understanding of overall diet quality and nutrient intake in relation to breakfast eating, eating habits, and timing of eating across the day. This would have enabled more specific recommendations and stronger conclusions to be made. Another limitation of this study is that it was impossible to exclude over and under reporters, in relation to estimated energy requirements, as the energy intake across the whole day was unavailable at the time, consequently there may be a selection of individuals who did not accurately report food intake during the five-day food record. However, the stringent data reviewing process should have minimised this problem. Another limitation of this study is the foods provided at the video observation. The lack of emphasis of protein content of the buffet breakfast, where protein was mainly offered via dairy is also a limitation. Additionally, had this study been designed specifically to address pace of eating, it would have been beneficial to have an identical test meal for all participants. The study was designed with a greater focus on an *ad libitum* intake at the buffet breakfast, with energy and food choices considered more important. Participants arrived at the buffet breakfast observation directly after the taste testing, where they were required to taste quinine, glucose and cream in varying concentrations. This is not the best time to assess food intake, as participants reported occasionally that they felt unwell as a result of the strong tastes. Being part of a study, in a laboratory environment prior to having a meal is not a normal setting for meal consumption, and this may have influenced food consumption in some participants particularly those more sensitive to taste. Finally, although the five-day food record was undertaken in a natural environment, the observed breakfast was not, which may have altered usual eating behaviour and habits.

4.5 Recommendations for Further Research

There are a number of aspects within this study which would be interesting to alter should the study be repeated:

- Analyse breakfast consumption in comparison to the entire day of food record. This would enable more in-depth analysis of factors such as timing of eating, patterns of energy and nutrient intakes across the day, to further define areas for public health efforts.
- Provide an identical environment for each participant in the observed breakfast, particularly related to number of people at the table or in the room. Some women ate with a group, therefore were able to interact with each other and appeared more relaxed while others ate in solitude and left the room quickly.

- Use weighed measures for dietary data: weighed food record, and weighed plate waste for the breakfast observation. This will enable increased accuracy of food consumed.
- Adjust set up of the room where observed meal occurs, removing rubbish bins, screening the dishes area to ensure that participants to leave their plate waste and trays at the table to be cleared by the research assistants. Such a procedure would be more beneficial for analysis of the food consumed at the observed breakfast.
- Dual x-ray absorptiometry scan for abdominal fat and a bone scan for bone density would enable further understanding of firstly abdominal fatness, and secondly of bone density, which may be impacted by the low intake of selected nutrients such as dietary calcium.

There are also aspects which would be interesting to investigate in further detail:

- Compare nutrient intake (for breakfast consumption and the entire day) and body composition measures with metabolic markers such as leptin, glycated haemoglobin, lipids and inflammatory markers such as CRP. This could provide more detailed information regarding the impact of breakfast consumption on markers of health and disease risk.
- Additional comparison between high and low protein breakfast consumption, considering satiety and pace of eating in relation to obesity.
- Conduct the study with a longitudinal design, such as repeating observations yearly, which would enable the interpretation of causality.

4.6 Conclusion

It was found that the breakfast consumption of New Zealand European women in this study did not meet energy requirements or nutrient requirements in comparison to one third of recommendations particularly among obese BMI women. The energy intake for women in this group was below recommendations, and total and saturated fat were above AMDR, suggesting an increased risk of chronic disease in this group if dietary intake at breakfast is reflective of intake across the day. Obese BMI women also made poorer food choices, and consumed foods with greater energy density than normal BMI women. Both groups of women had a low intake of dairy products at breakfast, which may further increase their chronic disease risk, if this is reflective of total dairy intake across the day. Furthermore, obese BMI women consumed foods at a faster pace than normal BMI women. Overall, these key findings suggest that the breakfast consumption among these women can be improved. It is recommended that consuming breakfast consisting of whole grain cereal with milk (or calcium fortified alternative) and fruit may serve to improve the intake of carbohydrate, protein, dietary fibre, folate and calcium, while reducing the intake of discretionary items and high fat food. Consistent regular meal times, an even spread of energy intake throughout the day, and maintaining a slow pace of eating is a key message to convey in future public health interventions to enhance health outcomes.

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Appendices

Appendix A: Supplementary Results

Supplementary table 1: Recorded and observed pace of eating in comparison to tertiles of energy intake

		FR n= 157, VO n=154 Eating pace n(%)		
	Tertiles of energy intake (kJ)	Slow	Medium	Fast
FR	<1220.9	10(6.37)	26(16.6)	16(10.2)
	1221-1727.9	6(3.82)	31(19.8)	16(10.2)
	>1728	10(6.37)	28(17.8)	14(8.92)
VO	<1421.9	9(5384)	17(11.0)	23(14.9)
	1422-1975.9	11(7.14)	20(13.0)	20(13.0)
	>1976	19(12.34)	25(16.2)	8(5.19)

FR: intake consumed on an average day of food record
VO: intake observed at breakfast video observation

Appendix B: Procedure for Food Record Data Entry

Databases

- The New Zealand Food Composition Database (FOODFiles 2014) will be the main source of food composition data
  - Otherwise, overseas food composition databases will be considered. Hierarchy of databases: NUTTAB2010*/AusFoods/AusBrands in that order
  - Select NZ database initially, complete as much as possible using NZ database, then select Australian ones as above. The Australian databases have many packaged foods

Recipes

- When it is necessary to enter a new recipe:
  - For meat and vegetables always enter the cooked weight in its respective cooked form (baked, boiled etc.)
  - If participant has provided the raw weight for meat please use 70% yield
  - For fish, 80% yield
  - Foods that are roasted/baked in oil but only have boiled/ steamed as an option:
    - Enter in boiled form and add 5g fat per 100g vegetable.
  - Take care to note down the bottom left hand side of the recipe how many serves the recipe makes

General comments

- Portions of food e.g. how much does one celery stick/1 piece cake weigh?
  - Search the food and beverage portion tables excel file for weight of food to enter
- Foods if consumed cooked need to be written as cooked (meat and vegetables particularly)
- Grains – FoodWorks accounts for addition of water e.g. if individual ate 1cup cooked rice, if 1cup raw rice was entered this would be ~3x more. This comes up a lot with porridge/oats
- Enter the food in a few different ways if struggling to find a match e.g. beef / steak /, zucchini/courgette etc

**NUTTAB2010 is FSANZ analysed data, AusFoods2015 is an expanded set of data from AusNUT2013 (from FSANZ and the Australian Nutrition Survey), and AusBrands2015 is packaging and nutrition information panels plus information from AusNUT2013*

Appendix C: Foods Provided at the Observed Breakfast and Corresponding FoodWorks Food Choice

Food Group	Food Item	FoodWorks Food Choice	Quantity of 1 Serving
Breads	White bread	Bread, white, sliced, prepacked (sandwich slices)	1 piece sandwich
Breads	Wholegrain bread	Bread, swiss bake grains plus, molenberg, quality bakers	1 piece sandwich
Cereals	Rolled oats, Uncle Tobys	Oats, rolled, raw	34g
Cereals	Light 'n' tasty, Sanitarium	Light 'n' tasty, apricot, sanitarium, fortified	40g
Cereals	Weet-bix, Sanitarium	Weet-bix, sanitarium, fortified	30g
Cereals	Skippy cornflakes, Sanitarium	Skippy cornflakes, sanitarium, fortified	25g
Cereals	Ricies, Sanitarium	Ricies, sanitarium, fortified	22g
Cereals	Toasted muesli, golden oats & fruit, Sanitarium	Toasted muesli, golden oats & fruit, Sanitarium	55g
Cereals	Untoasted muesli, fruit, Sanitarium	Muesli, commercial, untoasted (natural), with dried fruit, with nuts (AUSFOODS)	50g
Cereals	Honey puffs	Breakfast cereal, wheat based, whole wheat, puffed, honey, unfortified (AUSFOODS)	25g
Dairy products	Full cream milk, dark blue	Milk, cow, standard, 3.3% fat, fluid	300mL
Dairy products	Trim milk, green	Milk, cow, trim, 0.5% fat, fluid	300mL
Dairy products	Yoghurt, fruit flavoured	Yoghurt, meadow fresh low fat assorted fruits fortified	150g
Dairy products	Yoghurt, plain, low fat, unsweetened, Dewinkle	Yoghurt, plain, low fat, unsweetened	150g
Dairy products	Cheese	Cheese, processed	1 slice
Dairy products	Cheese lite	Cheese, sliced, processed, reduced fat	1 slice
Discretionary item	Cookie Time	Biscuit, chocolate chip, cookie time	25g
Discretionary item	Bar, nut and chocolate	Nut bar, peanut & chocolate, chocolate nut bar original	30g
Discretionary item	Muesli bar, fruit & nut	Muesli bar, fruit & nut	32g
Discretionary item	Muffin	Muffin, blueberry	1 muffin
Discretionary item	Breakfast cracker	Cracker, wheat, cream	18g (2 crackers)
Discretionary item	Sugar	Sugar, white	5g

KEY	
(shaded)	*Unhealthy[1] item*

Drinks	Juice box, twist	Juice, orange & mango, just juice, fortified	125mL
Drinks	Juice box, splash	Juice, orange & mango, just juice, fortified	62.5mL PLUS 62.5mL water per serve
Drinks	Coffee, instant	Coffee, instant, dry powder	1tsp PLUS 250mL water per cup
Drinks	Tea, black	Tea, beverage, black	250mL
Drinks	Tea, peppermint	Tea, beverage, herbal, brewed	250mL
Drinks	Tea, green	Tea beverage green	250mL
Drinks	Latte – caramel/vanilla	Coffee mix, instant, dry powder, café menu cappuccino	18.5g PLUS 250mL water per cup
Drinks	Hot chocolate	Energy food drink, dry powder, drinking chocolate	20g PLUS 250 mL water per cup
Drinks	Up&go, vanilla and chocolate	Liquid breakfast, assorted flavours, up&go	250mL
Fruit	Fruit salad, in syrup	Fruit salad, canned in syrup, undrained	113g
Fruit	Banana	Banana, yellow, ripened, raw	Enter 1 fruit / 0.5 fruit etc
Fruit	Apple	Apple, flesh & skin, raw	Enter 1 fruit / 0.5 fruit etc
Other	Tasti raw snacking nuts	Enter as a recipe (Nut, peanut raw 7g, nut cashew raw 7g, nut brazilnut raw 7g, nut almond raw)	35g (use the recipe and enter as 1 serve if eaten 1 pack, 0.5 serve etc)
Spreads	Marmite	Spread, yeast, extract, marmite, Sanitarium, fortified	56
Spreads	Jam	Jam, berry fruit	15g
Spreads	Margarine	Margarine, catering, choice	8g
Spreads	Butter	Butter, salted	8g
Spreads	Peanut butter	Peanut butter, smooth and crunchy, salt and sugar added	11g

[1]Food items classified as unhealthy on the basis of the Ministry of Health Eating and Activity Guidelines, Ministry of Health, 2015)

If unable to determine milk volume enter the following quantity[2]:

Coffee: 75mL

Tea: 40mL

Muesli: 125mL

[2]Langenhoven, 1991

Appendix D: Assumptions for Food Record Data Entry

MEAT	
Lamb	Lamb, forequarter & hindquarter assorted cuts, separable lean & fat, cooked
Pork	Pork, shoulder, roast, lean and fat, roast
Bacon	Pork bacon, lean & fat (then choose appropriate cooking method)
Steak	Beef, hindquarter rump steak, separable lean & fat, fast-fried
Chicken - hot chicken from supermarket, unspecified cut	Chicken, composite cuts, lean & fat, roasted (choose skin/no skin as appropriate)
Sausage Roll	Sausage roll flaky pastry baked
FRUIT & VEGETABLES	
Olive	Olive, purple, plain
SNACKS	
Bliss ball (of any variety e.g. Frooze balls, Tom & Luke balls)	Byron Bay Bliss Balls Gluten Free
Flavoured chocolate not in database	Chocolate, plain (or chocolate, dark if appropriate)
Churros	Doughnut, sugar & cinnamon
Protein nut bar nice and natural dark choc cacao	Nut bar, peanut & chocolate nut bar original (1 bar) (Food files) plus protein powder, soy based 25g
DRINKS	
Hot chocolate (unspecified ingredients e.g. from cafe)	Hot chocolate from regular powder (with appropriate milk choice)
Coconut milk (for drinking, smoothies, coffee e.g. VitaSoy)	Sanitarium so good almond and coconut milk
Coca cola lite	Half coca cola, half diet cola
Coconut water	Be Pure Coconut Water
Non-whey based protein (e.g. Sachi Inchi)	Protein powder, other
Pea protein	Vital Protein Chocolate Pea Protein Isolate
Tea (Alpine, peppermint, chamomile or other herbal)	Tea, herbal
Energy drink (e.g. Lift Plus, Mother)	Energy drink, other
Coffee frappe/iced coffee (e.g. from McDonald's)	Iced coffee, made with full cream milk, without ice cream or whipped cream, added sugar
Chocolate frappe/iced chocolate	Iced chocolate
Sparkling OH	Tap water plus 10mL Juice, tropical with apple base, fortified per 250mL
Flavoured coffee powder (Nescafe, Moccona)	Coffee powder flavoured mix caffeinated mix regular
Juice 50% less sugar (1cup)	125ml Juice (100% juice, tropical) plus 125mL water

Kombucha	Organic & Raw Mojo Kombucha
Macadamia nut milk	Almond milk
Stove Top Espresso	Coffee beverage, brewed from grounds, plunger
TAKEAWAYS	
Fries	Fries, potato, Independent Shop All
Noodles (e.g. Noodle Canteen, Wok Express or similar)	Noodles, fried, with chicken & vegetables, takeaway style
BREADS & CEREALS	
Pizza bread	Bread roll with topping cheese only
Gluten free bagels	Bread, gluten free, mixed grain, sliced, prepacked
Flat bread	Bread, pita, white
Sourdough	Irrewarra Sourdough White Sandwich Loaf (or wholewheat, seeded as indicated)
Finger bun	Bun, sweet with dried fruit, uniced 75g
Buckwheat puffs	Good Morning Cereals Buckwheat Puffs
Fruit loops	Breakfast cereal, corn based, flakes, sugar coated
Berry berry nice	Uncle Tobys Natural Style Muesli Apple & Berry
DAIRY	
Cheese (unspecified)	Cheese, Cheddar Mild
Mascarpone	Cream cheese
Halloumi	Cheese, haloumi
Margarine (unspecified)	Margarine, catering, Choice
Gourmet yoghurt, flavoured (e.g. Puhoi Valley, Piako)	Yoghurt, premium, assorted fruits
Greek yoghurt	Yoghurt, Greek style, full-fat
Milk dark blue	Milk, cow, standard 3.3% fat, fluid
Milk light blue	Milk, cow, lite 1.5% fat, fluid
Milk green / trim	Milk, cow, trim 0.3% fat, fluid
Milk non-homogenized eg Lewis Road Creamery, Puhoi Valley	Milk, cow, whole 4% fat, fluid, non-homogenised
Milk yellow top calci trim	Milk, cow, high calcium 0.1% fat, fluid, fortified
Soy milk standard	Soy milk, So Good Regular Soy Milk, Sanitarium, fortified
Ice cream vanilla/tip top	Ice cream, vanilla, standard
Ice cream e.g. Movenpick	Ice cream, vanilla, premium
Parmesan cheese (not powder)	Cheese, parmesan, ungrated
MEALS	
Homemade pizza (no recipe)	Pizza, supreme, thin crust, Pizza Hut
OTHER	
Coconut sugar	Sugar, brown
Apple cider vinegar	Vinegar, cider
Garam Masala	Powder, curry

Weight/portion assumptions

MEAT	
Corned beef (can)	340g
Rasher bacon	40g
Chicken drumstick (cooked)	52g
Bone	¼ of weight
FRUIT & VEGETABLES	
Kumara (unspecified)	140g
Taro	160g (whole)
Button mushroom	14g
SNACKS	
Square of chocolate	5g
Ice cream one scoop	50g
Mini chocolate bar (fun size)	15g
Handful of chips	0.5 cup
DRINKS	
Raro per glass	16g
Fast food soft drink	Size large 700ml
TAKEAWAYS	
McDonald's fries	Large 120g
	Medium 100g
	Small 75g
KFC fries	Regular 120g
	Large 246g
McDonald's nuggets	6 pack = 100g
Noodles takeaway (e.g. Noodle Canteen)	400g for 1 box
Spud fries (burger fuel)	280g
Mince and cheese pie	Pie, mince individual size, ready to eat, commercial PLUS 1 slice cheese, processed (20g per ~170g pie)
OTHER	
Dumplings	250g = 15 dumplings
Instant noodle serve	85g
Miso paste	Miso
Aioli	Dressing, Mayonnaise, commercial
Cacao nibs	Lovingearth Raw organics cacao nibs
Macadamia butter	Ceres Organics Almond Butter
Rainbow Cake	Madeira Cake
Teriyaki Chicken	Chicken, composite cuts, lean & fat, roasted PLUS sauce, teriyaki
BREADS & CEREALS	
Weight Watchers berry flakes	Breakfast cereal, mixed grain, wheat & oat, flakes, with apple & sultana & cranberry

Vogel’s peanut butter clusters	Breakfast cereal, flakes of corn added nuts added vitamins
Sanitarium Options cashew & quinoa	Cluster Crisp, Manuka Honey with Roasted Cashew, Sanitarium, fortified
Brioche	Bronte bakery brioche

Appendix E: Food Groups

Food Group	Food Items Included
Full fat milk	Full fat milk (dark blue top)
Low fat milk	Lite milk (light blue top), trim milk (green top)
Sweetened milk products	Breakfast drinks, flavored milk, evaporated milk, hot chocolate
Yoghurt	Yoghurt (plain, fruity, Greek, unsweetened)
High fat cheese	Cheddar, processed cheese, cream cheese, blue vein
Low fat cheese	Edam, cottage cheese, brie, camembert, feta
Apple, banana, orange	Apple, banana, orange
Other fruit	Fresh, canned, frozen, dried
Tomatoes	Tomatoes
Dark yellow vegetables	Carrots, pumpkin
Green vegetables	Lettuce, spinach, cabbage, broccoli, watercress, green beans, sprouts, courgette
Other non-starchy vegetables	Capsicum, onion, mushrooms, frozen mixed vegetables, beetroot
Potatoes (excluding chips)	Potato (boiled, mashed, baked, stuffed, scalloped)
Starchy vegetables	Kumara, yam, parsnip, turnip, swedes (boiled, mashed, baked), Taro (flesh, roots, stalks), green banana, sweet corn kernels
White breads	White bread, wraps, fruit bread, focaccia, bagel, pita, paraoa bread, rewena bread, doughboys
Discretionary breads	Crumpets, scone, savory muffin, croissant, pancakes/waffles, iced bun
Crackers	Cream, cruskit, corn, rice, vitawheat
Whole grain breads	Bread (high fiber, wholemeal, wholegrain)
Refined grains	White rice, pasta (penne, spaghetti, vermicelli), noodles (instant, egg, rice), canned spaghetti
Wholegrains	Brown rice, quinoa, couscous, bulgur wheat
Oats	Porridge, rolled oats, oat bran, oat meal
Sweetened cereals	Milo cereal, coco pops, nutrigrain, honey puffs, fruit loops, special K, light and tasty, sultana bran
Red meats	Beef (mince dishes, casserole, stew, stir-fry, roast, steak), Lamb (stew, casserole, stir-fry), Venison, hogget (roast, chops, steak, casserole, stew, stir-fry), offal (liver, kidney, pate)
White meats	All chicken (breast, leg, wing, casserole, stir-fry), Turkey/quail, pork (roast, chop, steak), mutton bird/duck, veal
Processed meats	Sausages, frankfurters, saveloys, cocktail sausages, bacon, ham, luncheon meats, salami, chorizo, meatloaf, corned beef, patties
Fish and seafood	Canned salmon, canned tuna, canned mackerel, Snapper/hoki, gurnard, shark, tuna, salmon, Shrimp/prawn, crab, mussels, pipi, whitebait, kina, squid
Egg and egg dishes	Eggs, egg mixed dishes (omelette, quiche, frittata, other baked egg dishes)
Legumes	Canned/dried (lentils, chickpeas, peas, beans, baked beans), hummus, dahl
Soy products	Soybeans, tofu
Peanut butter and peanuts	Peanut butter, peanuts
Nuts and seeds	Nuts (peanut, brazil, walnut, almond, cashew, pistachio), Seeds (pumpkin, sunflower)
Fats	Butter, lard, dripping, ghee
Coconut fats	Coconut milk, cream, oil
Oil and oil based dressings	Canola, sunflower, olive, vegetable oils, cooking sprays, Salad dressing (French, Italian), Avocado
Margarine	Margarine—all types
Creamy dressings	Mayonnaise, creamy dressings, white/cheese sauce, sour cream
Sauces	Tomato, barbeque, chilli, mint, soy, gravy, mustard, chutney, instant soup
Sweet spreads	Jam, honey, marmalade
Savoury spreads	Vegemite, marmite
Cake and biscuits	Cakes, loaves, muffins, sweet pies, pastries, tarts, doughnuts, biscuits (plain, chocolate coated)
Puddings	Ice cream, custard, milk puddings (semolina, instant), Other non-dairy based puddings (pavlova, sticky date pudding), jelly, ice blocks
Sweet snack foods	Chocolate, candy/confectionary, muesli bars
Savoury snack foods	Potato chips, corn chips, twisties

Crumbed and deep fried	Crumbed chicken/fish, battered fish, potato fries, chicken nuggets
Fast-food	Meat pie, sausage roll, savories, burgers, kebab, Chinese, Indian, Thai, Pizza
Fruit juice	Fruit and vegetable juice
Fruit drink and other beverages	Fruit drink, sparkling grape juice, cordial, iced tea, energy drinks, sports drinks, flavored water, soft drinks
Diet drinks	Diet energy drinks, diet soft drinks, diet cordial
Tea	Black tea, herbal tea
Coffee	Instant coffee, brewed water-based coffee, espresso
Water	Water, soda water
Sugar added to food and drink	White, brown, coconut sugar
Herbs and spices	Fresh and dried herbs, dried spices, spice blends
Cream or other high fat dairy	Cream, sour cream, crème fraiche
Pickled products	Jalapenos, olives,
Milk alternatives	Rice or almond milk, coconut and almond milk
Cocoa and cacao	Cocoa powder, cacao powder, cacao nibs
Vinegar	Apple cider vinegar
Sushi	All sushi types
Artificial sweetener	Stevia
Salt	Table salt, Himalayan salt, sea salt

Adapted from: Schrijvers, J. K., McNaughton, S. A., Beck, K. L., & Kruger, R. (2016). Exploring the dietary patterns of young New Zealand women and associations with BMI and body fat. Nutrients, 8. doi:10.3390/nu8080450

Appendix F: Author Guidelines (Nutrition Reviews)

Narrative Reviews. Reviews of this type should contain the following sections and headings in addition to the abstract:

- Introduction (directly following the abstract)
- Conclusion (at the end of the text)
- Acknowledgements (after the Conclusion)
- Funding and sponsorship (as part of the Acknowledgments)
- Declaration of interest (as part of the Acknowledgments)
- References (after the Acknowledgments)

Between the Introduction and Conclusion, headings and subheadings are at the discretion of the author. They should be used to organize the text and guide the reader.

Length restrictions. Articles in any category must be formatted as indicated in the Manuscript format guidelines section and may not exceed 50 double-spaced pages in length, including references and illustrative material. Each article should be a focused, concise, and objective investigation of a clearly defined topic. The option to publish certain material as "Supporting Information" in an online-only format is provided, as outlined here. Authors are encouraged to make use of this option to accommodate material that may be of interest to the reader but is not integral to the work itself. Examples would include extensive summary tables and appendices.

Manuscript format. Manuscripts should be prepared electronically using word-processing software, preferably Microsoft Word. Article pages should be formatted as double-spaced and left-justified text with 1-inch margins and 12-point type. Pages and lines must be numbered.

Tables and illustrations. Tables and illustrations should be numbered in the sequence in which they appear in the text. They should appear in sequence after the reference list.

Tables. All tables should be included in the text file after the reference list. Each table should be constructed using the table functions of the word-processing program being used. A title should appear at the top of each table. A column heading should appear in the top cell of each column. Within the table, each data set should appear in a single cell; the return key should not be used within any cell. Text should be justified to the left. Numerical data should be justified to the decimal point. Capitalization should be restricted to the first letter of the legend, the first letter in each cell, and applicable abbreviations or acronyms. Abbreviations used in the table should be spelled out in a footnote. When citing prior studies in tables please use the following format: Smith et al. (1998)[21].
Illustrations. All artwork should be submitted in digital format in separate files saved using the following convention: surname of first author_figure number (e.g., Smith_figure 1). Figure legends should be cited in the manuscript after the reference list. Charts and graphs downloaded from the Internet are not acceptable. Line artwork (vector graphics) should be saved in Encapsulated PostScript (EPS) format and bitmap files (halftones or photographic images) in Tagged Image Format (TIFF), with a resolution of at least 300 dpi at final size. Do not send native file formats. More detailed guidance for submitting electronic artwork can be found at http://www.blackwellpublishing.com/bauthor/illustration.asp. A free tool for converting files to other formats can be located at www.zamar.com.

References. The number of references cited should be tailored to the material being reviewed and be from reputable sources. As a general rule, articles in the Lead, Special, and Nutrition Science -> Policy categories do not typically include more than 200 references, while articles in the Emerging Science and Nutrition in Clinical Care categories do not typically have more than 120. References should be numbered sequentially upon first appearance in text, tables, and figures. They should be typed as superscripts and placed after commas and periods but before colons and semicolons. References cited only in figure or table legends should be numbered according to the first mention of the graphic in the text. Reference to unpublished work or personal communications should be avoided but, when essential, should be identified in the text as “unpublished data” or “personal communication from ...”, not in the reference list. When citing a series of consecutive numbers, provide the first and last with a dash between them (e.g., 5–7). When referring to a group of authors in the text, the format "Smith et al.[23]" should be used.

References cited only in figure or table legends should be numbered according to the first mention of the graphic in the text and should be cited in the text at that point. Reference to unpublished work or personal communications should be avoided but, when essential, should be identified in the text as "unpublished data" or "personal communication from ...", not in the reference list. To ensure long-term accessibility, internet citations should only be used if that is the sole source of the information.

The reference list should be formatted according to AMA style. For each citation, sufficient information must be provided to allow a reader to know in what medium the material appeared and to access the information. Please list all authors if there are six or fewer; for seven or more authors, list the first three followed by "et al."

Appendix G: Author Guidelines (Asia Pacific Journal of Clinical Nutrition)

Style Manuscripts should follow the style of the Vancouver agreement detailed in the 'Uniform Requirements for Manuscripts Submitted to Biomedical Journals', as presented in JAMA 1997;277:927–34 (www.acponline.org/ journals/anals/01jan97/unifreqr.htm). APJCN uses US/ UK spelling and authors should therefore follow the latest edition of the Merriam–Webster's Collegiate Dictionary/Concise Oxford Dictionary. Please indicate your preference and use one or the other exclusively. If you do not specify, by default UK spelling will be used. A Guide for Medical and Scientific Editors and Authors (Royal Society of Medicine Press, London). Abbreviations should be used sparingly and only where they ease the reader's task by reducing repetition of long, technical terms. Initially use the word in full, followed by the abbreviation in parentheses. Thereafter use the abbreviation. At the first mention of a chemical substance, give the generic name only. Trade names should not be used. Drugs should be referred to by their generic names, rather than brand names. For vitamins, notation use is B-2, B-2, B-3, B-6 and B- 12 not B1, B2, B3, B6 and B12. "Fetal" is more etymologically correct than "Foetal". Note style for probability: p

Abstract and key words: The abstract should be structured with Background and Objectives, Methods and Study Design, Results, and Conclusions in 250 words or less. The abstract should not contain abbreviations or references. Five key words should be supplied below the abstract. Text Authors should use subheadings to divide the sections of their manuscript: INTRODUCTION, MATERIALS AND METHODS, RESULTS, DISCUSSION, ACKNOWLEDGMENTS, REFERENCES. Numerical results and p values should be presented in text, tables and figures with no more than 3 significant figures, unless there are exceptional circumstances. Examples would be: 52.37 kg which should be 52.4 kg p=0.15234 which should be p=0.152 Authors can make a case that their methodology requires further exception to these guidelines.

Tables: should be self-contained and complement, but not duplicate, information contained in the text. Each table must be formatted by using the table feature in

WORD and presented as a separate file with a comprehensive but concise heading. Tables should be numbered consecutively in Arabic numerals in the sequence in which they are mentioned in the text. Use a single top rule, a single rule below the headings, and a single bottom rule. Do not use rules within the table body. Column headings should be clearly delineated, with straddle rules over pertinent columns to indicate subcategories. Column headings should be brief, with units of measurement in parentheses; all abbreviations should be defined in footnotes. Footnote symbols: †, ‡, §, ¶, ††, should be used (in that order) and *, **,*** should be reserved for p values. The table and its legend/ footnotes should be understandable without reference to the text. All lettering/ numbers used in tables should be font style 'Times New Roman' and font size 8.5 or 9.

Figures: All illustrations (line drawings, bar charts and photographs) are classified as figures. Figures should be cited in consecutive order in the text. Figures should be sized to fit within the column (85 mm), intermediate (114 mm) or the full text width (177 mm). Line figures or bar chart figures should be drawn in a computer graphics package (e.g. EXCEL, Sigma Plot, SPSS etc.). All lettering used in figures should be font style 'Times New Roman' and font size 9.