Investigating eating behaviours as predictors of body composition and dietary intake in New Zealand European, Māori and Pacific women – the women's EXPLORE study.

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

Master of Science

in

Nutrition and Dietetics

Massey University, Albany

New Zealand

Katrina Jade Shepherd

2018

Abstract

Background/Aim: Internationally, eating behaviour has been linked with an optimal and adverse body composition in women. However no study to date has examined eating behaviour in female New Zealand ethnic groups. Therefore, the aim of this study was to investigate eating behaviours as predictors of different body composition factors and dietary intake in New Zealand European (NZE), Māori and Pacific women, aged 16-45 years, participating in the women's EXPLORE study.

Methods: Women (N=368) were assessed for basic anthropometry, total adiposity, regional adipose distribution and lean mass using height, weight, circumferences, dual x-ray absorptiometry and air-displacement plethysmography. Body composition profiles (normal-fat, hidden-fat and apparent-fat) were established using parameters of body mass indices and body fat percentages. The validated Three-Factor Eating Questionnaire (TFEQ) and New Zealand Women's Food Frequency Questionnaire were both used to examine eating behaviour and dietary intake, respectively. The TFEQ examined Restraint (Flexible and Rigid), Disinhibition (Habitual, Emotional and Situational) and Hunger (Internal and External). Combinations of behaviour (sub-groups) were established from the main categories and also examined.

Results: Restraint was significantly higher in NZE than Pacific women ($p = 0.015$). Disinhibition) was significantly higher in the apparent-fat profile than normal-fat profile ($p < 0.001$). Likewise, Hunger was significantly higher in Pacific ($p < 0.001$) and the apparent-fat profile ($p = 0.034$) than NZE women and women with normal-fat profile, respectively. Adverse tendencies of Habitual Disinhibition, and External Hunger were more prominent in Pacific and the apparent-fat profile than NZE women and normal-fat profile, respectively (all $p < 0.05$). External Hunger was more prominent in the hidden-fat profile than normal-fat profile ($p = 0.001$). When accounting for age and ethnicity the most significant predictors of BMI and BF % were Restraint ($p = 0.007$ and $p = 0.005$ respectively), Disinhibition (both $p < 0.001$), Habitual Disinhibition (both $p < 0.001$) and Emotional Disinhibition (both $p < 0.001$). Non-ideal behaviour combinations (Low Restraint High Disinhibition and High Hunger High Disinhibition) generally corresponded to significantly higher body composition markers and dietary intake ($p < 0.05$). Pacific women were three times more likely to have High Hunger High Disinhibition than NZE women ($p = 0.004$). Low Restraint High Disinhibition and High Hunger High Disinhibition increased by 12% and 11%, respectively from the normal-fat profile to hidden-fat profile (both $p < 0.001$).

Conclusions: The TFEQ eating behaviour categories, sub-categories and sub-groups can significantly vary between ethnicities and body composition groups. Tailored interventions to promote Restraint (particularly Flexible Restraint) and counteract Disinhibition (particularly Habitual Disinhibition and Emotional Disinhibition), Hunger (particularly External Hunger), Low Restraint High Disinhibition and High Hunger High Disinhibition could enhance eating behaviour and dietary intake and help optimise weight management in young New Zealand women.

Key words: *Eating behaviour, body composition profiles, New Zealand women*

Acknowledgements

There are many people I would like to acknowledge that have enabled me to complete this thesis.

Firstly, thank you to the women who participated in the EXPLORE study. There would be no results to examine without the generous donation of your time. Secondly, thank you to wonderful EXPLORE team (Rozanne Kruger, Pamela Von Hurst, Cathryn Conlon, Kathryn Beck, Maralize Richter, Sarah Philipsen, Owen Mudridge, PC Tong, Wendy O'Brien, Shakeela Jayasinghe, Richard Swift, Andrea Fenner, Adrianna Hepbrun, Ridvan Firestone, Welma Stonehouse and Lily George, Sara Bodel, Maria Casale, Alexandra Lawn and Jenna Schrijvers) who worked tirelessly on the study design, recruitment, screening, data collection and data processing. I do not take for granted the amount of work that went into the data set that I was provided with.

Thank you to my supervisors Rozanne Kruger and Marilize Richter for the countless hours you have spent reviewing my work. Your dedication and support has been outstanding and it has been great working with you both.

Thank you to my parents (Alison and David), sister (Rebecca) and boyfriend (Aaron) for your unconditional love, patience, and encouragement throughout my Masters. You have been the most incredible support system in your own ways, and I could not have gotten through any of this without you four. Also, thank you to my cat Heidi who sat with me nearly every single day, and kept me company, while I wrote this.

To Beatrice Drury, we started our Massey journey together as teenagers in 2013. Thank you for your friendship and being there for me every step of the way.

Finally, thank you to all of my wonderful friends who have been exceptionally understanding and supportive during my Masters. You all inspire me and I am truly grateful each and every one of you.

Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

ADP	Air displacement plethysmography
AEBQ	Adult Eating Behaviour Questionnaire
AT	Adipose tissue

BCP	Body composition profile
BD	Body density
BF	Body fat
BF %	Body fat percentage
BIA	Bioelectrical impedance analysis
BMD	Bone mineral density
BMI	Body mass index
BV	Body volume
CT	Computerised tomography
DEBQ	Dutch Eating Behaviour Questionnaire
DXA	Dual x-ray absorptiometry
EAT	Eating Attitude Test
EDI	Eating Disorder Inventory
EXPLORE	Examining Predictors Linking Obesity Related Elements
FFM	Fat-free mass
FFQ	Food Frequency Questionnaire
FPS	Food Pleasure Scale
G	Gram
HC	Hip circumference
HDL-C	High density lipoprotein cholesterol
IES	Intuitive Eating Scale
IL-6	Inflammatory marker 6
KG	Kilogram
LBM	Lean body mass
LDL-C	Low density lipoprotein cholesterol
M	Metre
MEQ	Mindful Eating Questionnaire
Mrem	Millirem
MRI	Magnetic resonance imagine
N	Number
NZ	New Zealand

NZE	New Zealand European
NZWFFQ	New Zealand Women's Food Frequency Questionnaire
OGTT	Oral glucose tolerance test
PET	Positron emission tomography
PSS	Perceived Stress Scale
rEI	Reported energy intake
RMR	Resting metabolic rate
SAT	Sub-cutaneous adipose tissue
SEIC	Satter Eating Competency Inventory
SREBQ	Self-Regulation Eating Behaviour Questionnaire
STAI	State Trait Anxiety Inventory
TAC	Tissue time activity curves
TBW	Total body water
TEE	Total energy expenditure
TEF	Thermic effect of food
TFEQ	Three Factor Eating Questionnaire
VAS	Visual Analogue Scale
WC	Waist circumference
WHR	Waist to hip ratio
WREQ	Weight Related Eating Questionnaire
WTHR	Waist to height ratio
YFAS	Yale Food Addiction Scale

Chapter 1

Introduction

1.1 Background

The global prevalence of obesity has nearly tripled since 1970 (Malik et al., 2013). To date, approximately 1.9 billion people are overweight (39% of all adults) and among those, 650 million people are obese (13% of all adults) (World Health Organisation, 2017). In New Zealand the prevalence of overweight and obesity has increased in the past decade, from 27% of all adults in 2006/7 to 32% in 2016/17 (Ministry of Health, 2017). From a gender perspective, the 2016/17 Adult Nutrition Survey revealed that 63.8% of women in New Zealand are overweight and obese (Ministry of Health, 2018a), which was positively correlated with age. In particular, Māori and Pacific women currently have the highest rates of overweight and obesity (78.7% and 91.1%, respectively) (Ministry of Health, 2018a). The current national health cost and productivity deficit, associated with being overweight or obese, are an estimated $784 million and $911 million per year, respectively (Lal et al., 2012). Collectively, these population health and economic figures demonstrate the magnitude and profound nature of obesity, which arguably calls for drastic measures to be taken to counteract weight gain in young New Zealand women.

The Quatelet Index, or Body Mass Index (BMI), is a cost-effective and user-friendly calculation that provides a first-line indication of weight-related health status and disease risk (Lee and Nieman, 2007). The international reference standard for BMI classifies a normal BMI, overweight BMI and obese BMI to be 18.5-24.9 kg/m^2, 25-29.9 kg/m^2 and ≥ 30kg/m^2, respectively (World Health Organisation, 1995). Historically, a normal BMI has implied good overall health and lower mortality rate (World Health Organisation, 1995). However, recent studies have shown that a normal BMI can mask metabolic dysfunction when body fat percentage (BF %) is high (Oliveros et al., 2014, De Lorenzo et al., 2006, Dobson et al., 2016, Goossens, 2017). This concept has been described as "normal-weight obesity" (NWO) (Oliveros et al., 2014).

A high BF % can elicit impaired glycaemic control and dyslipidaemia, which are preliminary factors for type 2 diabetes and cardiovascular disease, respectively (Laforest et al., 2015, Jia et al., 2018). These metabolically-adverse states would typically exist in someone with a high BMI (BMI ≥ 25%) and/or high BF % (BF % ≥ 30%), however they have also been linked with the NWO profile (Oliveros et al., 2014). The NWO profile challenges our current metabolic understanding of a normal and "healthy" BMI and whether women with a normal BMI have NWO (Kruger et al., 2015). Therefore, this has prompted BMI and BF %, to not only be examined individually, but also concurrently as body composition profiles (BCP’s). This is to obtain a more physiologically concise understanding of weight-related disease risk in women of any BMI (Kruger et al., 2015). Although BMI alone can provide a general picture of weight-related health status (when BF % measurements are not available), the in-depth level of categorisation from BCP’s can act as a preliminary indicator of metabolic dysregulation (e.g. adipocyte hyperplasia and hypertrophy), particularly in those with NWO. Furthermore, early identification of NWO could potentially result in preventing future obesity.

Eating behaviour has been defined as a “*complex interplay of physiologic, psychological, social and genetic factors that mediate meal timing, quantity of food intake and food preferences”* (Grimm and Steinle, 2011). Eating behaviour is considered to be a predictor of an optimal, or adverse body composition, and a key modifiable risk-factor in preventing obesity-related disease risk (Poveda et al., 2016). For example, mounting evidence has shown that eating behaviour is heavily linked with BMI (Capuron et al., 2011, Bond et al., 2001, Bryant et al., 2008, Stunkard and Messick, 1985, Keys et al., 2014); waist/hip circumferences (Hootman et al., 2018, Urbanek et al., 2015); blood pressure (Van Dyke and Drinkwater, 2014); lipidaemia (Westenhoefer et al., 2013), glycaemic control (Schwab et al., 2016, Zyriax et al., 2012) and weight gain/loss (Jospe et al., 2017, Bachman and Raynor, 2012, von Seck et al., 2017).

As outlined above, eating behaviour can be influenced by an array of overarching biological (e.g. age, ethnicity, gender) and environmental factors (e.g. micro-environment and macro-environment) (Egger and Swinburn, 1997). However, on a smaller scale it can come down to one’s ability to self-restrict energy intake (Restraint); tendencies to over-indulge (Disinhibition) and the regulation of hunger cues (Hunger) (Stunkard and Messick, 1985). These three behaviours are the central categories of the Three Factor Eating Questionnaire (TFEQ) (Stunkard and Messick, 1985). These categories can exist alone or in combination with another, as sub-groups (e.g. Low Restraint High Disinhibition or High Hunger High Disinhibition) (Lesdema et al., 2012). In addition, the individual TFEQ categories can be unpacked into sub-categories. Firstly, Restraint can be exist in a relaxed approach (Flexible Restraint) or an all-or nothing approach (Rigid Restraint) (Westenhoefer et al., 1999). Secondly, Disinhibition can exist as Emotional Disinhibition (e.g. over-eating secondary to an adverse metal state), Habitual Disinhibition (e.g. over-eating secondary to a routine/circumstance) or Situational Disinhibition (e.g. over-eating secondary to social/environmental cues) (Bond et al., 2001). Finally, Hunger can be derived from psychological cues (Internal Hunger) or external cues (External Hunger) (Bond et al., 2001).

1.2 Justification and statement of the research problem

Although eating behaviour can be a good indicator of body composition (Singh et al., 2017, Canuto et al., 2017, Di Renzo et al., 2016), there is a debate as to which TFEQ category, sub-category or sub-group has the most significant effect on body composition (Ernst et al., 2015). This could be due to the different age, ethnic and gender parameters of the research papers. Some research suggests that Restraint and Disinhibition (independently and concurrently) have the most prominent effects on a healthy or unhealthy body composition (Sawamoto et al., 2017, Urbanek et al., 2015, de Lauzon-Guillain et al., 2006, Westenhoefer et al., 2013, Blumfield et al., 2018, Feig et al., 2018). This could be because the ability to self-restrict, preferably in a flexible sense, can prevent excessive energy intake long term (Westenhoefer et al., 2013); whereas having over-indulgent tendencies, particularly in a habitual or emotional sense (Hays and Roberts, 2008), could override satiety cues and promote an energy imbalance and metabolic dysregulation (Blumfield et al., 2018, Bryant et al., 2008, French et al., 2012).

In contrast, other studies argue that Hunger and Disinhibition are the most significant predictors of body composition (Bryant et al., 2008, Zyriax et al., 2012, Westenhoefer et al., 1994, Bresch et al., 2017). This could be due to some individuals having an over-active internal hunger signal which promotes excessive intake (Yeomans and McCrickerd, 2017). Some studies have examined the sub-categories and/or sub-groups of eating behaviour in relation to body composition (Kruger et al., 2016, Westenhoefer et al., 2013, Zyriax et al., 2012, Hays and Roberts, 2008, Hootman et al., 2018, Lesdema et al., 2012). However, these studies are the minority and have a mixed consensus as to which TFEQ eating behaviour category, sub-category or sub-group is most prominent in an adverse body composition. Again, this could be due to the different ethnic, age and gender parameters of the respective studies. Given that eating behaviour is multi-dimensional, having limited studies with in-depth sub-group information, in terms of effect on body composition information, is problematic. Therefore, further research is necessary to better understand eating behaviour in attempt to support/improve weight management.

It is important to note that most researchers only use BMI as an indicator of body composition rather than BMI and BF % (Ezquerro et al., 2017). Despite BMI being an excellent preliminary measurement of weight-related health, BF % information enables a more complete picture of metabolic, body-composition-related health status (Oliveros et al., 2014). Those who *have* measured BF % generally found high Restraint was inversely correlated with a normal and healthy BF % (Urbanek et al., 2015, Zyriax et al., 2012, Zhao et al., 2017), whereas high Disinhibition was often positively associated with an unhealthy and high BF % (Blumfield et al., 2018, Feig et al., 2018, Bresch et al., 2017, Mailloux et al., 2014). To our knowledge only one study has examined both BMI and BF % individually in terms of eating behaviour sub-categories and sub-groups (Kruger et al., 2016, Provencher et al., 2003). This is problematic because eating behaviour is more dynamic that just the three categories alone. Likewise, no study to date has examined eating behaviour categories, sub-categories or sub-groups in terms of different BCP's, which is concerning given the NWO concept. Moreover, much of the attention has been directed towards the TFEQ categories/sub-categories in relation to BMI and BF % (Kruger et al., 2016), but not study to date has looked at the TFEQ sub-groups in great body composition detail beyond BMI and BF% (e.g. markers of adiposity - abdominal adiposity, adipose distribution and non-adipose mass). This would provide a more robust and dynamic understanding of body composition rather than just a singular BF % figure.

It is well regarded that dietary intake is an important measure of health status and a good predictor of body composition (Williams et al., 2015, World Health Organisation, 2017). Although studies have investigated macronutrient intake (e.g. total percentages of protein, carbohydrate and fat intakes) in relation to eating behaviour (Provencher et al., 2003) and in New Zealand ethnicities (Metcalf et al., 2008, Beck et al., 2018, Metcalf et al., 2014), no study to date has examined the derivatives of general macronutrient intake (e.g. starch, sugar, saturated fat intake) in relation to eating behaviour sub-groups, nor across BCP groups in New Zealand female ethnicities. This in-depth, quantitative information could shed light on which eating behaviour groups needs to modify their intake of a particular nutrient for optimal health and weight management.

To date, there are only two New Zealand-based studies that have examined eating behaviour in relation to body composition (Brown et al., 2014, Kruger et al., 2016). This suggests that there is a considerable underrepresentation of New Zealand-relevant research on this topic, which is concerning given the heightened obesity rates in Maori and Pacific women (Ministry of Health, 2018a). Brown et al. (2014) shed light on the appetite differences in normal weight and overweight adults, in relation to BMI and BF %. Although BMI and BF % were considered, they were not examined concurrently as BCP's. This is concerning given the NWO concept. In addition, Brown et al. (2014) did not prioritise recruiting ethnic diversity, or examining any sub-categories of eating behaviour, which could have given more insight to specific ethnic behavioural precursors of obesity (particularly for Māori and Pacific women in comparison to New Zealand European (NZE) women). Comparably, Kruger et al. (2016) had better ethnic diversity and age specificity (NZE), Māori and Asian post menarche and pre-menopausal women), however their sample was predominantly NZE (87%) and there were no Pacific participants recruited. This is unfortunate given that 91.1% of Pacific women are overweight and obese (Ministry of Health, 2018a) and understanding their eating behaviour could be useful in combatting the issue. In terms of body composition, Kruger et al. (2016) did examine which factors were significant predictors of BMI and BF%, however their sample size was small and they did not control for confounding factors (e.g. energy intake and ethnicity). However, neither BCP's nor macronutrient intake were examined in their study, therefore there remains to be no information on the relationship between eating behaviour, BCP's and dietary intake in New Zealand women. Moreover, Kruger et al. (2016) examined the sub-groups of Restraint and Disinhibition but only in relation to age, BMI and BF%. Therefore, further research is required to assess more elements of demographic information, body composition (particularly markers of adiposity) and dietary intake, as well as examine these in relation to sub-groups, to provide a more robust and dynamic understanding of eating behaviour. Overall, although both studies combined managed to obtain detailed body composition measurements (e.g. BMI, BF %, waist circumference, lean body mass), neither study fully encompassed the relationship between eating behaviour categories, sub-categories and sub-groups in a wider audience of NZ ethnic groups or in BCP's. Therefore, further investigation of eating behaviour (e.g. TFEQ categories, sub-categories and sub-groups) is required in young NZE, Māori and Pacific women, with different body compositions.

1.3 Purpose of the research study

The proposed research is a sub-study from the women's EXPLORE (Examining Predictors Linking Obesity Related Elements) study (Kruger et al., 2015) which will have unique attributes that will separate it from the current national literature (Brown et al., 2014, Kruger et al., 2016). Firstly, not only will it examine both BMI and BF % parameters, but it will also examine three composite BCP's: normal-fat profile (BMI < 25k g/m^2 BF % < 30%), NWO renamed "hidden-fat profile" for this study (BMI < 25 kg/m^2 BF % ≥ 30%), and the apparent-fat profile (BMI ≥ 30 kg/m^2 BF % ≥ 30%). Examining these groups will help provide a more accurate picture of health status than BMI alone. Moreover, the study will also examine laboratory-based body composition measurements and simple anthropometric measurements to determine whether their respective measures differ amongst the BCP's (particularly between the normal-fat profile and hidden-fat profile, as these two have the same BMI but different BF %). Secondly, this study will be the first of its kind to examine the eating behaviour categories, sub-categories and sub-groupings of categories in post-menarche, pre-menopausal NZE, Māori and Pacific women with differing BCP's. Overall, this study will provide a more in-depth understanding of these eating behaviour components in a New Zealand setting. Subsequently, this could allow tailored behaviour-based interventions, at an ethnic and BCP level, to be devised in attempt to optimise eating behaviour and support/improve weight management.

1.3.1 Aim

To investigate eating behaviours predictors of different body composition factors and dietary intake in post-menarche and pre-menopausal New Zealand European, Māori and Pacific women, aged 16-45 years, participating in the women's EXPLORE study.

1.3.2 Objectives

- **Objective 1:** To investigate three eating behaviour categories (TFEQ categories: Restraint, Disinhibition and Hunger) in NZ European, Māori and Pacific women within three BCP's (normal-fat, hidden-fat and apparent-fat groups).
- **Objective 2:** To investigate the seven TFEQ sub-categories of Restraint (Flexible and Rigid); Disinhibition (Habitual, Emotional and Situational) and Hunger (Internal and External) in NZ European, Māori and Pacific women within three BCP's.
- **Objective 3:** To investigate which TFEQ categories and sub-categories are significant predictors of BMI and BF % in NZ European, Māori and Pacific women.
- **Objective 4:** To investigate TFEQ sub-groupings in NZ European, Māori and Pacific women in relation to the different BCP's, markers of adiposity, and dietary intakes.
    - **Sub-objective 4.1:** TFEQ sub-grouping of Restraint and Disinhibition categories.
    - **Sub-objective 4.2:** TFEQ sub-grouping of Hunger and Disinhibition categories.

1.3.3 Hypothesis

Based on the four objectives of the study, we hypothesise the following:

- **Hypothesis 1 (Objective 1):** In view of Objective 1 we hypothesise that
    - **H1.1:** The eating behaviour category of Restraint will be significantly lower in hidden-fat and apparent-fat profiles, respectively, compared to the normal-fat profile.
    - **H1.2:** The eating behaviour category of Disinhibition will be significantly higher in hidden-fat and apparent-fat profiles, compared to the normal-fat profile.
- **Hypothesis 2 (Objective 2):** In view of Objective 2 we hypothesise that
    - **H2.1:** The eating behaviour sub-categories of Flexible Restraint will be significantly lower in the hidden-fat and apparent-fat profiles, respectively, compared to the normal-fat profile.
    - **H2.2:** The eating behaviour sub-category of Emotional Disinhibition will be significantly higher in the hidden-fat and apparent-fat profiles, compared to the normal-fat profile.
- **Hypothesis 3 (Objective 3):** In view of Objective 3 we hypothesise that

- **H3.1:** The category of Restraint will be an inverse predictor of both BMI and BF %
- **H3.2:** The category of Disinhibition will be a positive predictor of both BMI and BF % (similar to Kruger et al. (2016)).
- **H3.3:** The sub-category Flexible Restraint will be an inverse of predictor of both BMI and BF %.
- **H3.4:** The sub-category Emotional Disinhibition will be a positive predictor of both BMI and BF % (similar to Kruger et al. (2016)).

- **Hypothesis 4 (Objective 4):** In view of Objective 4 we hypothesise that
  - **H4.1:** The sub-group of High Disinhibition Low Restraint will have an adverse body composition (e.g. high markers of adiposity, high BMI, BF %, hidden-fat profile and apparent-fat profile) and an adverse dietary intake (e.g. high energy and nutrient intake).
  - **H4.2:** The sub-group of High Hunger High Disinhibition will be associated with an adverse body composition (e.g. high markers of adiposity, high BMI, high BF %, hidden-fat profile and apparent-fat profile) and an adverse dietary intake (e.g. high energy and nutrient intake).

1.4 Structure of the thesis

This thesis has been assembled in four parts. Firstly, Chapter 1 provides an insight into the scope of the research, as well as the background and relevance. Subsequently, an extensive review of the literature has been conducted in chapter 2. This examines the prevalence and magnitude of obesity, methods of measuring body composition, eating behaviour, and the relationship between eating behaviour and body composition. Chapter 3 comprises of the research study manuscript. The manuscript has been formatted in accordance with the Nutrients Journal and includes six parts: Firstly, the abstract provides a collective summary of the thesis. This is followed by the Introduction which provides the overall scope of the topic. Subsequently, the Methods section presents the processes, tools and equipment used to conduct the research. This is followed by the Results section which highlights the relationship between eating behaviour, body composition and ethnicity. These findings are further discussed in the Discussion section, which compares them to pre-existing research. The final part of the manuscript is the Conclusion section, which provides a final summary of findings. Lastly, the thesis will summarise the research study in Chapter 4 and report the strengths, limitations, suggested uses of the findings and overall recommendation for future studies. Appendices are available to obtain copies of the questionnaires used (Appendix A-C) and supplementary results (Appendix D-L).

1.5 Researchers contribution

An outline of the researcher's contributions and roles have been outlined in Table 1.1. All authors and research contributors declared no conflict of interest.

Table 1.1 Researcher's contributions to the thesis

Researcher	Contribution to thesis
Katrina Shepherd	Author of thesis, statistical data analysis, interpretation of results.
Associate Professor Rozanne Kruger	Main academic supervisor, primary investigator and designer of the EXPLORE study, ethics application, interpretation of results and thesis reviewing and editing for approval.
Dr. Marilize Richter	Academic co-supervisor, interpretation of statistical methods and results, statistical data analysis support.
Rozanne Kruger, Sarah McNaughton, Sarah Shultz, Aaron Russell, Ridvan Firestone, Welma Stonehouse and Lily George	Designed protocol for women's EXPLORE study
Wendy O'Brien and Shakeela Jayasinghe	Organisation of participant recruitment, screening and testing.
Rozanne Kruger, Wendy O'Brien, Shakeela Jayasinghe, Zara Houston, Jenna Schrijvers, Maria Casale, Sarah Philipsen, Adrianna Hepburn and Sara Bodel	Participant recruitment and screening, data collection.
Rozanne Kruger, Wendy O'Brien, Shakeela Jayasinghe, Pamela Von Hurst, Cathryn Conlon, Kathryn Beck, Adrianna Hepburn, Zara Houston, Richard Swift, Owen Mugridge, PC Tong, Sarah Philipsen, Jenna Schrijvers, Maria Casale, Alexandra Lawn	Participant testing across eight stations: general health screening questionnaire, blood pressure, blood testing, BODPOD, DXA scan, dietary questionnaires (TFEQ, NZWFFQ, eating habits).
Jenna Schrijvers, Maria Casale, Alexandra Lawn, Sarah Philipsen, Zara Houston, Adrianna Hepburn and Chelsea Symons, Wendy O'Brien, Shakeela Jayasinghe	Data entry.
PC Tong	Equipment assistance for data collection.

Chapter 2

Literature review

2.1 Obesity

Obesity is a dynamic and multifactorial epidemic that affects 650 million adults worldwide (World Health Organisation, 2017). The World Health Organisation (2017) defines obesity as "*an excessive accumulation of visceral or abdominal adipose tissue that poses a risk to health*". Obesity can be classified using an inexpensive, population measure called the Quatelet's Index or Body Mass Index (BMI) (Lee and Nieman, 2007). BMI is typically used as a preliminary screening tool to assess an individual's body weight relative to height (weight in kilograms divided by squared height in metres) in clinical or epidemiological research setting (World Health Organisation, 2017, Lee and Nieman, 2007). Table 2.1 demonstrates the constructs of BMI and the metric parameters associated risk of morbidity.

Table 2.1 Body mass index categories and the associated risks of morbidity (World Health Organisation, 2017).

BMI category	Parameter (kg/m^2)	Risk of morbidity
Underweight	<18.5	Low (but risk of other clinical problems increased)
Normal	18.5 - 24.9	Average
Overweight	25.0 - 29.5	Increased
Class 1 obesity	30.0 - 34.9	Significant
Class 2 obesity	35.0 - 39.5	Severe
Class 3 obesity	> 40.0	Very severe

BMI Body mass index, kg kilogram and m metre.

Having an overweight and obese BMI has been linked with a number of lifestyle diseases such as pulmonary disease, non-alcoholic fatty liver disease, gall bladder disease, gynaecological issues, osteoarthritis, gout, stroke, cataracts, coronary heart disease, pancreatitis, several cancers and phlebitis (Smith et al., 2001, Hwang et al., 2015, Williams et al., 2015); as illustrated in Figure 2.1. These diseases individually, and accumulatively, require increased health resources funding which can put considerable financial pressure on the public health system (Lal et al., 2012).

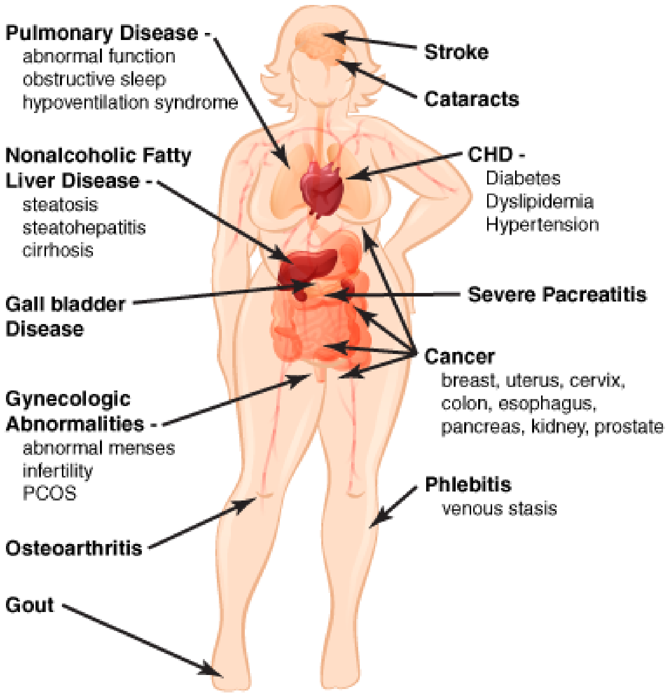


Figure 2.1 Potential complications and diseases associated with increased adiposity (Rochester Medical Weight Loss Center, 2018).

The prevalence of obesity is profound (Malik et al., 2013). From 1970-2016 the total number of obese women increased from 69 million to 390 million (Non-Communicable Disease Risk Factor Collaboration, 2017). This implies that 39% and 15% of adult women are overweight and obese, respectively (World Health Organisation, 2017). Alarmingly, these figures have tripled since 1975 (Afshin et al., 2017) and the average BMI in women has increased by approximately 0.3 kg/m^2 each decade, from 1970-2016 (Non-Communicable Disease Risk Factor Collaboration, 2017). This is concerning because for every one unit increase in female BMI, when BMI > 25kg/m^2, there can be a 7% increase in cardio-dysfunction risk (Bastien et al., 2014). To date, the global average BMI for women is 24.6-25.0 kg/m^2 (Non-Communicable Disease Risk Factor Collaboration, 2017), which is on the cusp of a healthy range. Overall, these findings emphasise that obesity, particularly in women, is an international health crises.

Despite being a geographically small country, New Zealand has had a severe obesity epidemic for the past three decades (Rush et al., 2009). The 2016/17 New Zealand Health Survey reported that 34% of adults are overweight (BMI > 25 kg/m^2) and 32% of adults are clinically obese (BMI > 30 kg/m$^{2)}$) (Ministry of Health, 2017). This is a significant increase from the preceding 2006/7 New Zealand Health Survey, which reported overweight and obesity to 32% and 31% respectively (Ministry of Health, 2008). In particular, currently 63.8% of New Zealand women are obese or overweight (Ministry of

Health, 2018a). Table 2.2 highlights the prevalence of overweight and obesity (BMI > 25 kg/m^2) in terms of age and ethnicity in New Zealand women.

Table 2.2 The prevalence of overweight and obesity in New Zealand women, in relation to age and ethnicities (Ministry of Health, 2018a).

Demographic	**New Zealand women**	
	%	**(95% CI)**
Total	63.8	(62.2-65.3)
Age group (years)		
15-24	44.2	(40.1-48.4)
25-34	60.6	(56.8-64.3)
35-44	65.3	(61.4-68.9)
45-54	69.6	(65.7-73.3)
55-64	71.2	(67.2-74.8)
65-69	75.3	(71.1-79.0)
70+	66.3	(61.9-70.4)
Ethnic groups		
Pacific	91.1	(87.3-93.8)
Māori	78.7	(76.2-81.0)
European	63.6	(62.0-65.3)
Asian	42.1	(36.8-47.7)

Table 2.2 clearly shows a positive correlation between the prevalence of female overweight and obesity and age (Ministry of Health, 2018a). Moreover, it is concerning that post-menarche and pre-menopausal women (aged 16-45) have an exponentially increasing BMI (Ministry of Health, 2018a), as this could hinder optimal reproduction (Oliveira, 2016, Legro, 2017). Table 2.2 also demonstrates that the overweight and obesity prevalence varies amongst different female New Zealand ethnic groups, with Pacific and Māori women having the highest rates (91.1% and 78.7%, respectively) (Ministry of Health, 2018a). Likewise, studies have found Pacific and Māori women are the most at risk for developing obesity-related co-morbidities, (Sundborn et al., 2008, Sundborn et al., 2010). Although Pacific and Māori women could have an element of ethnic pre-disposition to a higher body composition (due to having a generally higher muscle mass, bone mass and fat mass) (Johnson et al., 2014, Rush et al., 2009), it does not entirely justify their staggering rates of overweight and obesity.

The financial burden of overweight and obesity in New Zealand profound. The cost of health care, associated with obesity, is approximately $784 million (4.5% of the health care budget) and the productivity deficit is approximately $911 million per year (Lal et al., 2012). In sum, the magnitude of the clinical and financial burdens of obesity calls for drastic action be taken, to combat this preventable condition.

2.2 Measuring body composition

Measuring body composition can be an important way to assess health status and disease risk (Lee and Nieman, 2007). There are various methods used to measure body composition in epidemiological studies, clinical trials and clinical settings (Gibson, 2005, Lee and Nieman, 2007). These can include, but are not limited to, laboratory-based measurements (e.g. bio-electrical impedance (BIA), underwater weighting, air displacement plethysmography (ADP), dual x-ray absorptiometry (DXA), computerised tomography and magnetic resonance imaging) and anthropometric measurements (e.g. skin folds, waist circumference, hip circumference, waist-to-hip ratio, waist-to-height ratio and BMI). An evaluation of the purpose, strengths and weaknesses, of laboratory-based measures and anthropometric measures, is presented in Table 2.3 and Table 2.4, respectively.

Table 2.3 The purpose, strengths and weaknesses of laboratory-based body composition assessments (Lee and Nieman, 2007, Gibson, 2005).

Laboratory-based assessments of body composition	Purpose	Strengths	Weaknesses
Bio-electrical impedance analysis (BIA)	To measure TBW and FFM and to estimate BF as the difference between body weight and FFM.	• Easily accessible and portable • Non-invasive • Safe and fast • Easy to use • No exposure to radiation	• Regression equation used to estimate FFM and BF • Large initial start-up cost • Accuracy effected by subjects position, electrode placement, hydration status • Has a maximum weight capacity
Air displacement plethysmography (ADP)	To measure BV, BF, and FFM.	• High accuracy • Medium specificity • Good reproducibility • Can be used for all population groups • Safe • No exposure to radiation	• Less accessible • Expensive • Subjects must sit in a small constricted space with nose peg and mouth tube • Minimal clothing required (e.g. swimsuit and swim cap) to reduce surface area • Not transportable • Not suitable during pregnancy
Hydrostatic underwater weighing	To measure BV and BD.	• Gold standard measurement for identifying body fat and body density • High reproducibility • Safe	• Time consuming • Less accessible and requires a lot of equipment (e.g. pool/tank, scales, chair/frame) • Participants are submerged in water • Not suitable for all population groups • Expensive to set up and conduct • Results can be modified by intake of carbonated drinks, fluid retention and ability to expel air

Laboratory-based assessments of body composition	Purpose	Strengths	Weaknesses
Dual x-ray absorptiometry (DXA)	To measure BMD of the axial and appendicular skeleton, total/regional FM and LBM	• High accuracy • Fast and non-invasive • Safe • Requires little cooperation from subjects • Minimal radiation (0.01-0.04 mrem) • Can obtain specific region measurements • User-friendly software	• Less accessible • Not transportable • Large initial cost • Accuracy varies depending on hydration and tissue calcification • Not suitable for children or pregnant women
Computerized tomography (CT)	To measure the density of body compartments of the different body compartments using x-ray beams.	• Shows a cross-sectional image • Good for assessing the amount and distribution of SAT, VAT, skeletal muscle, bone Can assess visceral organ mass to measure regional muscle mass • Can be done on the entire body of specific areas	• Impractical in a nutrition research setting • Exposure to ionising radiation • Expensive • Inaccessible • Not suitable for pregnant women or children • Does not provide a chemical analysis
Magnetic resonance imaging (MRI)	To provide imaging of the body and chemical analysis under the presence of a strong magnetic field.	• Non-invasive • Does not involve ionising radiation • Safe for pregnant women and children • Illustrates the amount and distribution of BF with better res • Can assess chemical elements (e.g. sodium	• Impractical in a nutrition research setting • Expensive • Large equipment • Less accessible • Not transportable

Mrem millirem, TBW Total body water, FFM Fat free mass, FM Fat mass, BF Body fat, LBM Lean body mass, BD Body density, BMD Bone mineral density, BV Body volume, SAT Sub-cutaneous adipose tissue, VAT Visceral adipose tissue. Assumptions regarding the laboratory-based assessments of body composition can be found elsewhere (Lee and Nieman, 2007, Gibson, 2005).

The scanning and non-scanning techniques in Table 2.3 are all suitable ways of assessing the amount and distribution of total mass, fat mass, fat-free mass and bone mineral density in a laboratory setting. The most typically used laboratory-based apparatuses in the nutrition research setting are the BIA, ADP and DXA (Lee and Nieman, 2007). However, when examining total adiposity ADP is often preferred over BIA and DXA, as its methodology is similar to the gold-standard, but less suitable, hydrostatic underwater weighing (Gibson, 2005, Lee and Nieman, 2007). Comparably, the strength of the DXA is that it can provide unique information on regional adiposity that the other two cannot obtain (e.g. trunk, arms and legs) (Hussain et al., 2014). This can provide a more in-depth understanding of adiposity than just a singular BF % figure alone, which is useful to know as regional adiposity has been linked with several metabolic abnormalities (e.g. high fasting glucose and insulin resistance) (Shuster et al., 2012). Likewise, the DXA can provide information on exclusive lean muscle mass, which ADP cannot (ADP can only show fat-free mass which is an accumulation of bone and muscle mass). Although both of these non-adipose mass measurements are valuable they both serve different purposes (singular and accumulative non-adipose mass) and therefore should be examined together when possible. ADP, DXA and BIA have been validated to analyse body composition in women (Von Hurst et al., 2016, Tallroth et al., 2013). In particular, Von Hurst et al. (2016) examined the BIA, DXA and ADP and found they all had good validity and reliability, with < 0.2% difference for reoccurring tests at miniscule 95% confidence intervals. However, the BIA underestimated BF % by approximately 2%, in comparison to ADP and DXA (Von Hurst et al., 2016). In terms of total BF % measurements, the DXA can skew the results at a high and low BF % and therefore potentially under/over-estimate values (Von Hurst et al., 2016). Therefore, it is best to use ADP for total BF % (which has methodology similar to the gold-standard under water weighing) and use DXA primarily for regional adiposity measurements. To assess the reliability of the DXA regional data a comparison between the DXA and ADP total BF % can be done.

The common limitations of cost, portability, radiation exposure and accessibility of these measurements can often limit their use in a clinical and population sense. In view of these limitations, manual anthropometric measurements can provide a fast, safe and cost-effective way to also collect body composition data (Gibson, 2005, Lee and Nieman, 2007). Table 2.4 presents their individual purposes, strengths and weaknesses.

Table 2.4 The purpose, strengths and weaknesses of manual anthropometric assessment methods of body composition (Gibson, 2005, Lee and Nieman, 2007).

Anthropometric assessments of body composition	Purpose	Strengths	Weaknesses
Body mass index (BMI)	To assess weight relative to height squared	• Inexpensive • Safe and fast • Non-invasive • Well regarded classifications for health	• Cannot detect difference in body compartments (e.g. fat and muscle), therefore someone with a high muscle mass could be classed as obese by BMI standards
Waist circumference (WC)	To assess android fat distribution.	• Inexpensive • Safe and fast • Non-invasive • Accurate measurement of abdominal fat, total fat and can correlate to visceral fat • Known marker of metabolic syndrome • Can be used as part of waist-to-hip ratio	• Measurement may not always reproducible depending on experience of examiner • Readings can vary depending on hydration status, fluid retention and prandial state
Hip circumference (HC)	To assess gynoid fat distribution.	• Inexpensive • Safe and fast • Non-invasive • Good measure of lower adipose distribution • Can be used as part of waist-to-hip ratio	• Measurement may not always reproducible depending on experience of examiner • Readings can vary depending on hydration status, fluid retention and prandial state
Waist-to-hip ratio (WHR)	To assess android fat relative to gynoid fat distribution.	• Inexpensive • Safe and fast • Non-invasive • Incorporates hip measurements therefore more AT distribution than WC alone • Determines adiposity in the lower and upper trunk (e.g. android and gynoid distribution)	• Inferior measurement to WC in terms of abdominal fat and metabolic disease risk, due to poor reproducibility • Readings can vary depending on hydration status, fluid retention and prandial state

Anthropometric assessments of body composition	Purpose	Strengths	Weaknesses
		• Strong association with total adiposity	
Waist-to-height	To assess android fat distribution (WC) relative to height squared.	• Inexpensive • Safe and fast • Non-invasive • Incorporates general height • Measures AT distribution	• Not considered a risk marker by American Heart Association • Readings can vary depending on hydration status, fluid retention and prandial state
Skinfolds	To measure and estimate BF.	• Estimates BF • Inexpensive method of measuring BF • No large space required • Transportable	• Requires skills for site selection, technique and interpreting the readings • Reproducibility can vary between qualified examiners • Time consuming (takes approximately 1 hour for all sites)

AT Adipose tissue. Assumptions regarding the laboratory-based assessments of body composition can be found elsewhere (Gibson, 2005, Lee and Nieman, 2007)

Overall, all methods listed in Table 2.3 and Table 2.4 can collect a variety of different measurements and therefore, serve several purposes in health screening. To date, BMI is most widely used tool in both clinical and epidemiological settings to assess body composition (Gibson, 2005). However, old adage that a normal BMI implies “reduced risk of morbidity” (World Health Organisation, 2017) has been questioned, as several studies have shown metabolic dysfunction can occur in individuals with a normal BMI (De Lorenzo et al., 2006, Di Renzo et al., 2006, Ding et al., 2016). However, it is important to note that the intended purpose of BMI is to be a preliminary screening tool and to *not* assess metabolic dysfunction. Therefore, studies have suggested that other measures, along with BMI, are required to understand whether an individual is metabolically healthy or unhealthy (De Lorenzo et al., 2006, Ding et al., 2016). In view of this, adipose tissue (AT), or body fat, has been deemed a good metabolic marker of health (Wells, 2012, Reece et al., 2014a). Table 2.5 illustrates the parameters of body fat percentage (BF %) categories in relation to health.

Table 2.5 Body fat percentage categories, for women > 18 years, in relation to health (Shuster et al., 2012).

Body fat category	Body fat percentage in women	Relationship to health
Low body fat	< 15	Dangerous level of fat. Body fat should be elevated
Very lean	15 - 18	Excellent level of health. Typically seen in professional athletes
Lean	19 - 22	High-quality levels for optimal health
Moderately lean	23 - 30	Acceptable levels for good health
Excess fat	31 - 40	Possibility of compromised health
High body fat	> 40	Dangerous level of fat. Body fat should be reduced

Excessive fat (BF % > 30%) can elicit several metabolic (e.g. impaired glucose metabolism and dyslipidaemia) and structural modifications (e.g. atherosclerosis and endothelial dysfunction) (Bellanger and Bray, 2005). Overall, the measurements of BMI and BF % do not have the same intended purposes. However, their individual strengths have led many to examine both measurements concurrently for a more robust understanding of body composition (De Lorenzo et al., 2006, Di Renzo et al., 2006, Di Renzo et al., 2010, Dobson et al., 2016). This concept is called body composition profiles (BCP’s) (Kruger et al., 2015). In terms of metabolic risk, Table 2.6 suggests an individual can fall within one of three BCP’s: normal fat, hidden-fat or apparent fat (Kruger et al., 2015). A normal-fat profile can occur when an individual has a normal BMI and a normal BF %; a hidden-fat profile can occur when an individual has a normal BMI but a high BF % (originally called normal-weight obesity by Oliveros et al. (2014)) and an apparent-fat profile can exist when an individual has a high BMI and high BF % (Kruger et al., 2015).

Table 2.6 Body composition profiles and their associated body mass indices and body fat percentages (Kruger et al., 2015).

Body composition profile	Parameters
Normal-fat	Normal BMI (< 25 kg/m^2), normal BF % (> 22%, < 30%)
Hidden-fat	Normal BMI (< 25 kg/m^2), high BF % (> 30%)
Apparent fat	High BMI (> 25kg/m^2), high BF % (> 30%)

BMI Body mass index. BF % Body fat percentage.

Studies have shown that the state of many disease precursors in an apparent-fat profile (e.g. adiposity, low muscularity, dyslipidaemia and impaired glycaemic markers) can mirrored in a hidden-fat profile (Bays et al., 2008, Goran and Alderete, 2012, Kloting and Bluher, 2014). This concept is illustrated in Table 2.7.

Table 2.7 Metabolic biomarkers and measurements, across different body composition profiles, in young women (Oliveros et al., 2014).

Characteristic	Normal-fat	Hidden-fat	Apparent-fat
BMI	Normal	Normal	High
Fat mass	Low	High	High
Lean muscle mass	High	Low	Low
Visceral fat	Low	High	High
Hepatic fat	Low	High	High
Triglycerides	Low	High	High
HDL-C	High	Low	Low
Insulin sensitivity	High	Low	Low
Insulin resistance	Low	High	High
Fasting glucose	Low	High	High
Blood pressure	Low	High	High
Inflammatory markers (IL-6)	Low	High	High

Green colour = optimal for health. Red colour = adverse for health. HDL-C High density lipoprotein cholesterol ("good cholesterol"). IL-6 Interleukin 6. Young women were defined as between 18-45 years.

Alarmingly, the hidden-fat profile can occur in 52% of normal BMI adults (Collins et al., 2017) and in 28% of women (Hwang et al., 2015). Moreover, approximately 66% of these women (aged 34-73) are more likely to develop obesity and atherosclerosis over a decade (Hwang et al., 2015). What's more concerning is that age has a positive correlation with the prevalence of hidden-fat and apparent obesity (Singh et al., 2017, Kim et al., 2015). Yannakoulia et al. (2007) accredited this to a generally reduced muscle mass post-menopause. Overall, the hidden-fat profile can be a first-line indicator of metabolic dysregulation and potential future obesity. Researchers suggest that an early identification could assist in reducing and preventing this profile (Ding et al., 2016, Goran and Alderete, 2012).

2.3 Measuring eating behaviour

Egger and Swinburn (1997) proposed that biological (e.g. age, sex, gender, and ethnicity) and environmental factors (e.g. the micro and macro environment) can contribute to the aetiology of obesity, due to their physiological and psychological effects on eating behaviour. Based on learnt experiences, behaviour is the net result of a several entrenched elements, such as values, beliefs, education, attitudes, emotions and feelings (Meule and Vogele, 2013, Geary, 2014). These elements can be heightened by visual, olfactory and/or gustatory food stimuli, which can prompt eating initiation, volume of consumption and the rate of consumption (Egger and Swinburn, 1997, Michimi and Wimberly, 2015, Spadaro et al., 2017). Likewise, eating behaviour can be influenced by several factors: For example, individuals seeking to adhere to cultural or social norms to achieve social acceptance or belongingness (Barrena et al., 2015); eating secondary to emotion/mood (e.g. choosing specific foods that correlate to a positive mood) (Pickett and McCoy, 2017, Whitaker et al., 2014) or an individual’s health awareness and/or education, or lack thereof (Poinhos et al., 2013, Gaspar et al., 2014).

Dietary behaviour assessments are direct, or indirect, examinations that decipher eating behaviour. They can explore the rationale behind *why* an individual makes healthy or un-healthy food decisions, which can often be overlooked in a dietary intake assessment (e.g. 24 hour recall) (Freitas et al., 2018). The literature suggests that there are two distinct categories that underpin eating behaviour: Food appeal/externality (e.g. external sensory signals that promote to eating) and food avoidance/restraint (e.g. the conscious regulation of hunger and fullness) (French et al., 2012, Anderson et al., 2016). By understanding the dominance that these factors play, researchers might be able to identify why an individual makes particular healthy or adverse food choices and whether their choices influence their body composition. To date, there have been several psychometric tests created to examine dietary behaviour in relation to food externality and food avoidance: This can include, but is not limited to, the Restraint Scale, Latent Obesity Scale, Binge Eating Scale, Three Factor Eating Questionnaire (TFEQ), Dutch Eating Behaviour Questionnaire, TFEQ R-18, TFEQ R-21, Mindful Eating Questionnaire, Weight Related Eating Questionnaire, Adult Eating Behaviour Questionnaire and the Self-Regulation Eating Behaviour Questionnaire. Table 2.8 compares the intended uses and limitations of these dietary behaviour assessment methods and is presented in year order of their development.

Table 2.8 Dietary behaviour assessment methods used in epidemiological studies (Hunot et al., 2016, Framson et al., 2009, Clementi et al., 2017, James et al., 2017, Schembre et al., 2009, Schembre and Geller, 2011, Kliemann et al., 2016, Van Strein et al., 1986, Gormally et al., 1982, Herman and Mack, 1975, Pudel et al., 1975).

Dietary behaviour assessment methodology	Description	Intended use	Weaknesses
Restraint Scale Herman and Mack (1975)	10-item questionnaire that assesses restraint in terms of • Preload of foods • Ingestion of alcohol • Dysphoric emotions	Obese individuals	• Fails to accurately identify other eating behaviours other than restraint • Questionable construct validity in terms of overweight and obese individuals (Stunkard and Messick, 1985) • Less reliable in obese populations where restraint is less-likely to be the dominating eating behaviour (Stunkard and Messick, 1985)
Latent Obesity Scale Pudel et al. (1975)	40-item questionnaire that assesses • Rate of eating • Satiety regulation	Obese individuals	• Takes longer to complete • Fails to captures the restrained-obese individual • Only been used in a laboratory setting
Binge Eating Scale Gormally et al. (1982)	16-item questionnaire that assesses • Behavioural outcomes of binge eating • Thoughts and feelings associated with binge eating	Obese individuals and individuals with disordered eating	• Has only been validated in an obese population • Not suitable for individuals with high cognitive restraint
Three-Factor Eating Questionnaire (TFEQ) (or Eating Inventory) Stunkard and Messick (1985)	51-item questionnaire which measures • Restraint • Disinhibition • Hunger	All individuals	• Takes longer to complete

Dietary behaviour assessment methodology	Description	Intended use	Weaknesses
Dutch Eating Behaviour Questionnaire (DEBQ) Van Strein et al. (1986)	33-item questionnaire that assesses: • Restraint • Emotional Eating • External Eating	All individuals	• Minor inconsistencies of question wording between ethnic versions (e.g. German and Spanish versions) • Variability observed in the emotional response construct (Dutton and Dovey, 2016)
TFEQ-R 18 Karlsson et al. (2000)	18-item questionnaire derived from the TFEQ-51 which measures • Restraint • Emotional eating • Uncontrolled eating	All individuals	• Shortened version may mask the dominance of sub-categories (if present) that could exist in a longer questionnaire, such as the 51-item TFEQ. • Risks incorrectly generalising eating behaviour (Cappelleri et al., 2009) • Does not factor in hunger
TFEQ-R 21 Elfhag and Linne (2005)	21-item questionnaire derived from the TFEQ and TFEQ-R 18 which measures • Restraint • Emotional eating • Uncontrolled eating	All individuals	• Shortened version may mask the dominance of sub-categories (if present) that could exist in a longer questionnaire, such as the 51-item TFEQ. • Risks incorrectly generalising eating behaviour (Cappelleri et al., 2009) • Does not factor in hunger
Mindful Eating Questionnaire (MEQ) Framson et al. (2009)	28-item questionnaire assessing mindfulness in relation to the following factors: • Disinhibition • Distraction • Awareness • Emotional response • External cues	Obese individuals	• No definition of "mindfulness" provided though out, therefore participants might not understand the term in questions • Lacks external validity testing to date • Test re-test reliability has not been examined to date • Does not have an acceptance/non-judgemental section which contributes to being mindful

Dietary behaviour assessment methodology	Description	Intended use	Weaknesses
Weight-Related Eating Questionnaire (WREQ) Schembre et al. (2009)	16-item questionnaire which measures • Routine restraint • Compensatory restraint • External disinhibition • Emotional disinhibition	Obese and normal weight individuals	• Has questions that would not be suitable to all populations (e.g. a vegetarian would not accurately respond to a question regarding whether the scent of "cooking meat" increases appetite) • Lacks external validity testing • Potential reduced participant reliability due to shorter format
Adult Eating Behaviour Questionnaire (AEBQ) Hunot et al. (2016)	35-item questionnaire to assess and categorise participants into 8 appetite habits: • Hunger • Food Responsiveness • Emotional Over Eating • Emotional Under Eating • Slowness in Eating • Food Fussiness • Satiety Responsiveness • Food Enjoyment	All individuals	• Moderate participant and researcher burden • The definitive nature of the categories does not incorporate how one can influence another • Created in 2016, therefore currently lacks multiple validity tests
Self-Regulation Eating Behaviour Questionnaire (SREBQ) Kliemann et al. (2016)	5-item questionnaire to examine self-management of dietary intentions. The questionnaire assesses: • Ability to resist temptations • Ability to self-regulate dietary intentions	Individuals with high restraint	• Difficult to obtain an in-depth understanding of eating behaviour form 5 questions • Potential reduced participant reliability due to shorter format • Has not been validated only been validated by creators

Note: The strengths of the tools lie within what they assess (description) and their intentional audience (intended use)

Any of these psychometric tools can be used to assess different angles of dietary behaviour. However, one area where most fall short with is their validity and population reliability (Dutton and Dovey, 2016, Lluch et al., 1996, Schembre and Geller, 2011). This could be because many of them have only been created in the past decade and lack validation testing (e.g. AEBQ, WREQ, MEF and SREQ) and because of the format or question types. In contrast to these limitations, one questionnaire that has received high praise (Bond et al., 2001, Cappelleri et al., 2009, Chong et al., 2016, Rosnah et al., 2015) for its validity, reliability, reproducibility and layout is the Three Factor Eating Questionnaire (TFEQ) by Stunkard and Messick (1985).

Previous questionnaires (e.g. the Restraint Scale and Latent Obesity Questionnaire) had assumed that all obese individuals ate fast and did not exhibit any form of dietary self-control (Pudel et al., 1975, Herman and Mack, 1975). However, Stunkard and Messick (1985) hypothesised, and proved, that eating behaviour in obese individuals was *less* to do with lack of restriction and *more* to do with eating secondary to food desirability, depression and hunger. This prompted the duo to devise a comprehensive and all-inclusive questionnaire that examined three main categories of eating behaviour: Cognitive dietary restraint (Restraint), Disinhibition and susceptibility to Hunger (Hunger) (Stunkard and Messick, 1985).

The term Restraint has been one of the most reviewed and debated topics of eating behaviour, since it was inversely associated with obesity in 1975 (Herman and Mack, 1975). Restraint can be described as consciously and frequently restricting ones food intake despite environmental cues and metabolic cues (e.g. hunger, satiation and satiety) (Herman and Mack, 1975, Westenhoefer et al., 1990, French et al., 2012). The TFEQ captures Restraint in 21 questions and assesses the deliberate resistance to eat (e.g. smaller portion sizes, refraining at meal time); attitudes towards eating self-management (e.g. I do not worry about dieting, I eat what I want) and avoiding high-fat foods (e.g. how likely are you to avoid high-caloric/nutrient poor foods) (Stunkard and Messick, 1985).

The second category of the TFEQ is Disinhibition (Stunkard and Messick, 1985). Disinhibition refers to the tendency to over-consume in the presence of emotional, situational or environmental stimuli (Hays and Roberts, 2008). For decades research has suggested that there is a strong psychological connection between food consumption and mood and emotions (Blumfield et al., 2018, Bryant et al., 2008, French et al., 2012). The TFEQ captures Disinhibition in 16 questions and examines over-indulgence due to reoccurring circumstances (e.g. "I give up on my diet mid-week"); negative emotional states (e.g. I eat when I feel sad) and environmental cues (e.g. "I overeat when I am at social gatherings") (Stunkard and Messick, 1985).

The final category of the TFEQ is the susceptibility to hunger (Hunger) (Stunkard and Messick, 1985). Hunger refers to the physiological signals of hunger and satiety that promote and inhibit oral ingestion of food, respectively (Stunkard and Messick, 1985, Bond et al., 2001). Hunger is well regarded as a key contributor of how much an individual will consume (Bresch et al., 2017, Lindroos et al., 1997, Loeber et al., 2013, Madden et al., 2012). The TFEQ incorporates Hunger in 14 questions and examines eating consumption due to social situations and internal feeling of hunger (Stunkard and Messick, 1985). .

Seven years after the TFEQ was created Westenhoefer (1991) proposed that Restraint was multi-dimensional and could be split into two sub-scales: Flexible Restraint and Rigid Restraint. Flexible Restraint refers to controlled approach to eating/weight management, whereas Rigid Restraint refers to an all-or-nothing restrictive approach to eating/weight management (Westenhoefer, 1991). Later, Bond et al. (2001) illustrated how Disinhibition and Hunger were also multi-dimensional. Bond et al. (2001) proposed that Disinhibition could be sub-divided into Habitual, Emotional and Situational Disinhibition which refer to routine attitudes towards eating; negative emotions affecting eating and eating secondary to social cues, respectively. In addition, Bond et al. (2001) proposed that Hunger could be either Internal (physiological hunger) or External (hunger secondary to external cues) Collectively, the TFEQ categories and sub-categories have been widely validated and supported in the literature (Gallant et al., 2010, Karlsson et al., 2000, Lesdema et al., 2012, Yeomans and McCrickerd, 2017, Provencher et al., 2003). Table 2.9 presents a summary of the TFEQ categories and sub-categories.

Table 2.9 A summary of the Three Factor Eating Questionnaire categories and sub-categories (Bond et al., 2001, Westenhoefer, 1991).

Three Factor Eating Questionnaire category	Three Factor Eating Questionnaire sub-category	Description	Example
Restraint (21 questions) The conscious and consistent ability to restrict unnecessary energy intake.	Flexible (Seven questions)	Neutral mind set to food control that is neither obsessive nor compulsive.	*"Dieting is not important to me", "I eat anything I desire".*
	Rigid (Seven questions)	A stern "all or nothing" approach to food control to reduce weight gain.	*"I always reduce my portion sizes", " I deliberately hold back at meals".*
Disinhibition (16 questions)	Habitual (Five questions)	Particular circumstances and attitudes that regularly trigger	*"I diet early in the week then give up later in the week and eat excessively".*

Three Factor Eating Questionnaire category	Three Factor Eating Questionnaire sub-category	Description	Example
The lack of self-regulation when eating, resulting in excessive energy intake.		disinhibition (e.g. busy schedule).	
	Emotional (Three questions)	An adverse mental state associated with over-consumption (e.g. sad, depressed or alone).	*"I feel sad/alone/depressed, therefore I resolve it be eating".*
	Situational (Five questions)	Environmental cues that exacerbate disinhibition (e.g. social events, special occasions)	*"I over indulge at social events", "I over eat when I am with another person who is overeating".*
Hunger (14 questions) A physiological or psychological response that promotes hunger and energy intake.	Internal (Six questions)	Self-translated and controlled inner hunger.	*"Normally I am so hungry that I actually eat more than I should", "I regularly feel starving and need to eat".*
	External (Six questions)	Hunger derived from external cues (e.g. delicacies, buffet) rather than individual physiological cues	*"I have to eat when I am around other people who are eating", "If I am around luxurious food I have to eat it immediately".*

It is important to note that the TFEQ sub-categories do not incorporate all of the questions from the respective category. For example, six questions are not classified by Flexible or Rigid Restraint from the Restraint category. In spite of this, the TFEQ categories and sub-categories have been widely validated across several languages and ethnic groups, such a Spanish, German and French (Jauregui-Lobera et al., 2014, Martin-Garcia et al., 2016, Loffler et al., 2015b). Moreover, two studies have re-designed the original TFEQ to make it shorter and solely restraint focused (TFEQ-R 18 and TFEQ-R 21) (Karlsson et al., 2000, Elfhag and Linne, 2005). However, subsequent studies have shown that the original TFEQ, and use of sub-categories, provides a more detailed understanding of eating behaviour (Choquette et al., 2012, Gallant et al., 2010, Provencher et al., 2003), and therefore should be the preferred choice of questionnaire.

2.4 The relationship between eating behaviour, body composition, dietary intake and ethnicity

Eating behaviour has continuously been shown to influence dietary intake (Goulet et al., 2008, Green et al., 2000, Wardle et al., 2000). For example, over-indulgence (e.g. beyond one's recommended daily intake) and energy dysregulation can occur if adverse eating behaviours continuously take precedence over circadian endocrine/hunger/satiety cues (Reece et al., 2014b, Geary, 2014). Over time this can lead to a positive energy balance and can be a precursor for increased adiposity and weight gain (Bellou et al., 2013, Raynor and Vadiveloo, 2018). In contrast, an individual with optimal eating self-control (e.g. within one's recommended daily intake) would be more likely to achieve energy homeostasis (Mahan and Raymond, 2017), which can be a predictor of a normal body composition (Mahan and Raymond, 2017) and weight-maintenance over time (Anderson et al., 2016).

Research has shown that dietary patterns, food choices and cooking practises differ between major ethnic groups in New Zealand (Ministry of Health, 2018a, Metcalf et al., 2008). For example, a study by Metcalf et al. (2014) demonstrated that Pacific women had significantly higher energy intake (10.3 MJ/day) compared to New Zealand European (NZE) women (8.3 MJ/day, $p < 0.001$). This was due to Pacific women having larger portion sizes of energy-dense foods (higher percentage of people eating greater than the standard serving sizes for energy dense food); increased frequency of consuming energy-dense foods (e.g. mean serves per month of meat, bread, and coconut cream) and high-fat cooking practises (e.g. increased percentage of frying in butter, lard or dripping) than their NZE counterparts. Moreover, Schrijvers et al. (2016) showed post-menarche NZE women were more likely to follow an "energy-dense" dietary pattern (e.g. high energy and carbohydrate intake based on a statistically derived dietary pattern), whereas pre-menopausal NZE women followed mainly a "snacking" dietary pattern (e.g. high carbohydrate and high saturated fat intake based on a statistically derived dietary pattern). Both of these studies revealed that dietary patterns were associated with a high BMI (BMI ≥ 30 kg/m^2) (Schrijvers et al., 2016, Metcalf et al., 2014) and BF % (BF % ≥ 30%) (Schrijvers et al., 2016). Comparably, Beck et al. (2017) found a "healthy" dietary pattern (based on a statistically derived dietary pattern which comprised of cereal, low-fat dairy, tea, with minimal alcohol, baked goods, confectionary and takeaways) was positively correlated with age and female gender, whereas inversely associated with food insecurity, neighbourhood deprivation, waist circumference and BMI. Moreover, a "traditional" dietary pattern (based on a statistically derived dietary pattern which comprised of starchy carbohydrates, full-fat dairy, beef and sugar) was positively correlated with age, tobacco use, food insecurity and neighbourhood deprivation and inversely related to education level (Beck et al., 2017). These findings mirror the work of Wall et al. (2014) who found a healthy diet pattern (as per the macronutrient recommendations by Ministry of Health (2018b) and

Ministry of Health (2004)) was linked with reduced risk of developing cardiovascular disease in New Zealand. Overall, it is clear that dietary intake in New Zealand women is heavily affected by ethnicity and demographic factors.

In terms of the TFEQ categories and dietary intake, an international study showed obese British women with low Restraint, high Disinhibition and high Hunger had significantly higher energy (kilojoule) intake ($p < 0.05$) than their opposite counterparts (Goulet et al., 2008). In addition, Provencher et al. (2003) demonstrated that energy and total fat percentage intake was inversely associated with Restraint, Flexible Restraint and Rigid Restraint (all $p < 0.01$), whereas Disinhibition, Habitual Disinhibition, Emotional Disinhibition, Situational Disinhibition, Hunger and Internal Hunger were all positively correlated with energy and fat percentage intake (all $p < 0.01$ except for Habitual Disinhibition $p < 0.05$). Although this is useful information, Provencher et al. (2003) did not examine the grams of fat, which have shown fat intake irrespective of energy intake and perhaps given a more complete picture of fat intake. Likewise, they did not explore other macronutrients in terms of eating behaviour (e.g. carbohydrate, protein), let alone the derivatives of macronutrient (e.g. starch, sugar, saturated fat) which would have also provided a more complete picture of intake. Overall, some studies have examined food groups in relation to eating behaviour (Lahteenmaki and Tuorila, 1995, Moreira et al., 2005, Green et al., 2000), few have examined eating behaviour in relation to energy/nutrient intake (Goulet et al., 2008, Provencher et al., 2003) and no study to date has examined eating behaviour in relation to energy/nutrient intake in NZE, Māori or Pacific women with normal and high body compositions. This is problematic because examining quantitative energy/nutrient intake can paint a broader picture of dietary intake than just food groups alone. Moreover, measures of grams and percentages of energy/nutrient intake can be compared to nutrient reference values and recommended daily intakes (Ministry of Health, 2018b).

There is a mixed consensus as to which TFEQ category, sub-category or sub-groups (e.g. levels of Restraint and Disinhibition versus levels of Hunger and Disinhibition) is the most related to body composition (Bresch et al., 2017). Section 2.4 explores this and evaluates the TFEQ categories, sub-categories and sub-groups in relation to their impact on body composition. A total of 45 studies were reviewed. The inclusion criteria consisted of being from 1990 onwards (as this was when the TFEQ was being used) and using some form of body composition analysis (e.g. BMI, BF %, waist circumference). Of the 45 studies found, only 23 studies showed a significant relationship between one or more of the TFEQ constructs in relation to body composition. The subsequent sub-sections are presented in terms of TFEQ categories (Restraint, Disinhibition and Hunger) and sub-categories, in relation to body composition, followed by the sub-groups of the categories in relation to body composition. Each section will also evaluation dietary intake where possible.

2.4.1 Restraint

Several studies have demonstrated that a high Restraint score is inversely associated with BMI and BF % (Zhao et al., 2017, Park et al., 2016, Lesdema et al., 2012, Urbanek et al., 2015). In particular, Urbanek et al. (2015) observed that high Restraint was the most influential factor in BMI, BF %, weight loss, waist circumference, hip circumference and waist-to-hip ratio (all $p < 0.05$). Moreover, the sub-categories of Restraint (Flexible and Rigid Restraint) have been shown to have differing effects on body composition (Berg et al., 2018, Westenhoefer et al., 2013, Zyriax et al., 2012). For example, Flexible Restraint has been linked with healthier dietary patterns (e.g. increased vegetable intake, lower energy/carbohydrate intake), lower waist circumference, fasting plasma glucose, central obesity, improved weight loss and a normal BMI (Coffino et al., 2016, Sawamoto et al., 2017, Westenhoefer, 1991, Wardle et al., 2000), whereas Rigid Restraint has been associated with higher tendencies of binge-eating (high caloric, nutrient poor foods) and a high BMI (Coffino et al., 2016, Cox and Brode, 2018, Mailloux et al., 2014, Berg et al., 2018, Gallant et al., 2012). Of the 23 studies, who showed a significant relationship eating behaviour constructs and body composition, six studies showed Restraint to be related to body composition in normal weight, overweight or obese adults. This is presented in Table 2.10. The first four studies show a significant relationship between general Restraint and body composition, whereas the last two studies show a significant relationship between the sub-categories of Restraint.

Table 2.10 Studies investigating the relationship between Restraint and body composition in normal weight, overweight and obese adults.

Author	Study design	Aim	Participants	Methods and measurements	Results and conclusions
Coffino et al. (2016) United States of America.	Cross-sectional.	To understand the relationship between impulsivity, restraint and binge eating in female undergraduate students.	N=506. Comprised of N=333 female students with a BMI < 25 kg/m^2 and N=173 with a BMI > 25 kg/m^2.	• Age • Ethnicity • BMI • Difficulties in Emotion Regulation Scale • DEBQ • BES	Impulsivity was related to binge eating in individuals with a BMI >25 kg/m^2 but not to restraint. Those with a BMI <25 kg/m^2 had higher restraint which reduced impulsivity ($p < 0.05$).
de Lauzon-Guillain et al. (2006) France.	Longitudinal study over 2 years.	To examine the relationship between eating behaviour and BF % in a general adult and adolescent population.	N=737. Comprised of N=466 adults aged 31-67 years and N=271 of adolescents aged 14-24 years.	• Data collection at baseline and two year follow up • TFEQ • BMI • WWC • Skin-fold thickness • BF %	Restrained eating is 73% more dominant in normal BMI/BF % subjects than individuals with overweight or obesity ($p < 0.05$).
Sawamoto et al. (2017) Japan.	Two-phased randomised control study.	To identify the determination of successful weight loss in overweight and obese women.	N=90 women aged 20-65 years with a BMI ≥ 25kg/m^2.	• Data collection at baseline and two year follow up • Fasting plasma glucose	Significant weight loss was determined by high Restraint and low Disinhibition and food addiction scores ($p < 0.01$).

Author	Study design	Aim	Participants	Methods and measurements	Results and conclusions
				• BBP • TFEQ • BES • YFAS	
Urbanek et al. (2015) United States of America.	Two-phased randomised control study.	To assess whether cognitive restraint and disinhibition related BMI and weight loss in overweight and obese pre-menopausal women.	N=60 premenopausal women aged 45-55 years with a BMI ≥ 25 kg/m^2	• Data collection at baseline and week 18 • BMI • WWC • HHC • DXA • TFEQ	High restraint was the most significant indicator or reduced weight, WC, HC and BF % ($p < 0.01$). All factors were increased with disinhibition ($p < 0.01$).
Westenhoefer et al. (2013) Germany.	Cross-sectional study.	To assess the relationship between restraint eating and weight loss adherence in overweight and obese women in a weight loss group.	N=106 women aged 20-50 years who had lost 10.9 kg ± 6.4 kg already from a weight loss group.	• BMI • Skin fold thickness • TFEQ	Flexible restraint was associated with better weight loss ($p < 0.05$; ß 0.32) compared to rigid restraint ($p < 0.05$; ß -0.31).
Zyriax et al. (2012) Germany.	Cross-sectional and 2 year longitudinal study.	To examine the relationship between eating behaviour and obesity and prediabetes in a general population with a high WC.	N=340 men and women aged 21-64 with a high WC (men > 94 cm, women > 80 cm)	• Fasting plasma glucose • TFEQ • BP • LDL-C and HDL-C	Individuals with flexible restraint had optimal dietary intake, lower waist circumference and lower glucose ($p < 0.001$).

BP Blood pressure, WC Waist circumference, HC Hip circumference, TFEQ Three-Factor Eating Questionnaire, DXA Dual x-ray absorptiometry, BF % Body fat percentage, STAI State Trait Anxiety Inventory; BES Binge Eating Scale, YFAS Yale Food Addiction Scale, LDL-C Low density lipoprotein cholesterol, HDL-C High density lipoprotein cholesterol.

All six of studies in Table 2.10 have generally demonstrated that high Restraint can be associated with positive health outcomes in terms of body composition and weight. Studies who have examined Restrained eaters attribute this to these individuals regularly practising mindful eating (Anderson et al., 2016); generally having small portion sizes (Labbe et al., 2017); having optimal energy intake for their weight/gender (Goulet et al., 2008) and eating more vegetables (Moreira et al., 2005). Despite the studies in Table 2.10 having good designs (e.g. randomised control and longitudinal studies) and good distributions of women with normal and high body composition, not one study examined BCP's, nor New Zealand ethnic groups.

In New Zealand women with low Restraint had a significantly higher BMI (> 25 kg/m^2) and higher appetite signals compared to their normal counterpart (Brown et al., 2014). However, one limitation of this study was that it did not examine the sub-categories of the TFEQ categories (e.g. Flexible and Rigid Restraint). In light of this, Kruger et al. (2016) *did* evaluate the sub-categories of the TFEQ, however they found Restraint was not a significant contributor of BMI (p = 0.340) or BF % (p = 0.110), nor was it significantly different between women with a normal and high BMI (p = 0.845) or BF % (p = 0.128). In addition Kruger et al. (2016) did not examine ethnic groups either and neither study examined dietary intake. Moreover, it is important to note that several studies have found Restraint (and its sub-categories) to have no significant correlation between BMI or BF % (Painchaud Guerard et al., 2016, Barkeling et al., 2007, Bathalon et al., 2000, Dykes et al., 2004, Lawson et al., 1995, Westenhoefer et al., 1990). All of these studies found Disinhibition and Hunger to be more significantly related to body composition, which suggests that further exploration of eating behaviour is required.

2.4.2 Disinhibition

It is well regarded that a lack of dietary self-control can exacerbate excessive energy intake and increase weight (Stunkard and Messick, 1985). In view of this, many studies have demonstrated that Disinhibition (or lack thereof) is the greatest contributing factor to body composition outcomes (Barkeling et al., 2007, de Lauzon-Guillain et al., 2006, Kruger et al., 2016, Painchaud Guerard et al., 2016, Urbanek et al., 2015, Westenhoefer et al., 2013, Westenhoefer et al., 1990). Table 2.11 presents a review of ten studies that showed Disinhibition to be significantly related to body composition in normal weight, overweight or obese adults. The first seven studies show a significant relationship between general Disinhibition and body composition, whereas the final three studies show a significant relationship between the sub-categories of Disinhibition and body composition.

Table 2.11 Studies investigating the relationship between Disinhibition and body composition in normal weight, overweight and obese adults.

Author	Study design	Aim	Participants	Methods and measurements	Results and conclusions
Dykes et al. (2004) England.	Cross-sectional.	To examine the relationship between eating behaviour and body composition in middle aged women.	N=1,470 women aged 45-68 years.	• BMI • TFEQ • WC • HC • WHR	Participants with high Disinhibition scores had the highest BMI (28.5 kg/m^2) and waist circumference scores (85.5 cm) in comparison to their low Disinhibition counterparts (24.2 kg/m^2 and 76.3 cm) ($p < 0.001$).
Ernst et al. (2015) Switzerland.	Cross-sectional.	To assess eating behaviour in relation to sex and BMI classifications in obese patients from an Obesity Centre.	N=664. Comprised of N=465 obese women and N=199 obese men.	• BMI • TFEQ TFEQ	Women had higher Disinhibition and Hunger ($p < 0.001$). Disinhibition ($p < 0.001$) and Hunger ($p = 0.042$) were the main predictors of BMI in class 1, 2 and 3 obesity.
Mailloux et al. (2014) Canada.	Cross-sectional study.	To identify the leading factor in binge eating in young female adults aged 18-21.	N=1,477 female college students aged 18-21 from three different metropolitan Canadian cities.	• BMI • TFEQ • BF % • DXA • BEQ	Disinhibition was the most significant eating behaviour in binge eaters, which was positively associated with BMI and BF % ($p < 0.001$).
Lawson et al. (1995)	Cross-sectional study.	To understand which construct of the TFEQ is the greatest predictor	N=44 premenopausal women.	• BMI • TFEQ • BES	High Disinhibition was associated with increased

Author	Study design	Aim	Participants	Methods and measurements	Results and conclusions
United States of America.		of body composition in pre-menopausal women who are self-reported binge eaters.		• EAT • EDI • Physical activity • RMR • TEF	adiposity and body composition (*p* < 0.001).
Painchaud Guerard et al. (2016) Canada.	Cross-sectional.	To assess the eating behaviour constructs in relation to appetite sensations in normal weight and obese adults.	N=341. Comprised of N=160 women and N=181 men.	• BMI • TFEQ • DEBQ • FFQ • FPS • VAS	Disinhibition was the main influencer of appetite and BMI in women (*p* = 0.039).
Schwab et al. (2016) United States of America.	Cross-sectional.	To understand the relationship between eating behaviour and glycaemic control.	N=779. Comprised of N=77 with diabetes, N=133 with impaired glucose tolerance and N=569 with normal glucose tolerance.	• BMI • TFEQ • OGTT • Insulin testing	Poor glycaemic control was associated with increased Disinhibition and insulin levels (*p* < 0.001).
Wagenknecht et al. (2007). Prague	Cross-sectional.	To examine the relationship between the TFEQ behaviour constructs, body composition and health.	N=3,053 adults. Comprised of N=1,618 women and N=1,435 men.	• BMI • TFEQ • WC • HC • TC • LDL • HbA1c	Restraint and Disinhibition were the greatest predictors of BMI and WC (*p* < 0.05). Disinhibition and Hunger also were key indicators of lifestyle diseases

Author	Study design	Aim	Participants	Methods and measurements	Results and conclusions
Hays and Roberts (2008) United States of America.	Cross-sectional study.	To examine the relationship between body composition and eating behaviour in older women aged 55-65 in comparison to women aged 30-39 years.	N=535 women aged 55-65.	• BMI • Weight difference to age • TFEQ	Habitual and Emotional disinhibition was the strongest factor associated with increased BMI with age ($p < 0.001$). Situational Disinhibition was not correlated with weight gain ($p > 0.05$).
Hootman et al. (2018) United States of America.	Cross-sectional study.	To determine sex differences, stress levels and eating behaviour in tertiary students, aged 18-24 years, in relation to adiposity.	N=264 college students, aged 18-24 years, which comprised of N=168 females and N=96 males.	• DEXA • WWC • BMI • PSS • SECI	Emotional Disinhibition is the greatest predictor of increased PSS stress score, BMI ($p < 0.001$), WC ($p = 0.006$) and adiposity ($p = 0.014$).
Kruger et al. (2016) New Zealand.	Cross-sectional study.	To examine the associations between eating behaviour, BMI and BF %.	N=116 women aged 18-44 years.	• BMI • ADP • TFEQ	Emotional Disinhibition was positively correlated with BF % ($p < 0.028$). Disinhibition was significantly higher in women with high BMI ($p < 0.001$) and high BF % ($p = 0.003$) than their normal counterpart.

WC Waist circumference, WHR Waist to hip ratio, VAS Visual Analogue Scale, EI Eating Inventory, OGTT Oral Glucose Tolerance Test, PSS Perceived Stress Scale, SEIC Satter Eating Competency Inventory, BEQ Binge Eating Questionnaire, EAT Eating Attitude Test, EDI Eating Disorder Inventory, FPS Food Pleasure Scale, VAS Visual Analogue Scale, RMR Resting Metabolic Rate, TEF Thermic Effect of Food. Normal BMI < 25 kg/m^2. High BMI ≥ 25 kg/m^2. Normal BF % considered < 30%. High BF % considered ≥ 30%.

The general consensus from Table 2.11 is that a high Disinhibition score (≥ 8) is associated with an adverse body composition. In particular, Dykes et al. (2004) found that pre-menopausal women, with high Disinhibition, had a significantly higher BMI of 25.8 kg/m^2 (overweight) and a waist circumference of 85.8 cm (overweight for women) compared to women with low Disinhibition (a score < 7) who had normal BMI and waist circumference (24.1 kg/m^2 and 76.3 cm, respectively) ($p < 0.001$) (Dykes et al., 2004). Moreover, they concluded that high Disinhibition may be a pre-disposing factor for metabolic dysfunction (e.g. high LCL-C, low HDL-C) (Dykes et al., 2004). Several studies have attributed a high Disinhibition and high body composition to high energy intake (greater than the recommended daily amount) (Goulet et al., 2008); high total fat intake (> 30% of total energy intake) (Provencher et al., 2003); large portion sizes (greater than the recommended standard serving size for a given commodity) (Smith et al., 1998); frequent and excessive consumption high-caloric, nutrient-poor food intake (e.g. mean weekly/monthly intake of baked goods, processed meat, sweetened beverage) (Bryant et al., 2008, Green et al., 2000) and eating impulsivity and minimal self-discipline (Cox and Brode, 2018), in comparison to those with low Disinhibition. In sum, these studies suggest that there are deeper psychological undertones to Disinhibition than a physical need to consume food.

Table 2.11 also shows that high Emotional Disinhibition (a score ≥ 2) is associated with an overweight and obese BMI (≥ 30 kg/m^2) and BF % (≥ 30%) (Hootman et al., 2018, Kruger et al., 2016, Hays and Roberts, 2008). This has been linked with high energy take (beyond the recommended daily intake for adults) and high fat intake (>30%) (Provencher et al., 2003) and higher tendencies of depression, sadness and loneliness (based on the NEO Personality Inventory) (Kim et al., 2016), than those with a low Emotional Disinhibition score (< 2). In contrast, some studies have shown high Habitual Disinhibition is not significantly related to body composition (Barkeling et al., 2007), whereas others have shown that it is (Hays and Roberts, 2008) and is positively correlated to energy and fat intake (Provencher et al., 2003). Contrastingly, Situational Disinhibition has been poorly represented as marker of body composition (Ernst et al., 2015, Dykes et al., 2004), despite some claiming that a constantly disposable and inexpensive obesogenic environment can lead to excessive energy intake (Egger and Swinburn, 1997).

In New Zealand, Brown et al. (2014) found low Disinhibition scores were significantly more prominent in normal weight women (defined by a normal BMI) than their overweight and obese counterparts (defined by an overweight and obese BMI). Moreover, Kruger et al. (2016) found BMI and BF % increased by 0.4 kg/m^2, and 0.82% respectively, for every one point increase in Disinhibition in women. In addition BF % increased by 1.59% for every point increase in Emotional Disinhibition (Kruger et al., 2016). However, their sample size was small (N=116). Furthermore, neither study examined Disinhibition in relation to NZ ethnic groups, BCP's or dietary intake. Overall, despite the studies in

Table 2.11 having good sample sizes, and a good distribution of women, there are still conflicting arguments as to which sub-categories of Disinhibition may be the most prominent contributor to BMI and BF %. In contrast, there were also studies who found body composition had no significant effect of Disinhibition (Berg et al., 2018) or found Disinhibition only existed when Hunger was increased (Yeomans and McCrickerd, 2017). Therefore, further investigation into Disinhibition, its sub-categories and body composition, is required on a national and international level.

2.4.3 Hunger

The final tier to the TFEQ eating behaviour construct is Susceptibility to Hunger (Hunger) (Stunkard and Messick, 1985). Some studies have shown that Hunger, particularly External Hunger, has a positive correlation with BMI and BF % (Yeomans and McCrickerd, 2017, Ernst et al., 2015, Carr et al., 2014). For example, an early study demonstrated that a high Hunger score was associated with a 21% higher BF % compared to individuals with a low-to-normal score (Bathalon et al., 2000). Of the 23 studies who showed a significant relationship eating behaviour constructs and body composition, eight studies showed Hunger to be the most predictive factor of body composition. Table 2.12 reveals the current studies that have observed a relationship between Hunger and body composition.

Table 2.12 Studies investigating the relationship between Hunger and body composition in normal weight, overweight and obese adults

Author	Study design	Aim	Participants	Methods and materials	Results and conclusions
Bathalon et al. (2000) United States of America.	Cross-sectional.	To determine psychological factors influencing reported energy intake in restrained and unrestrained adult eaters.	N=60. Comprised of N=26 restrained eaters (aged 60.3 years ± 0.6, weight 68kg ± 0.7 kg) and N=34 unrestrained eaters (aged 59.4 years ± 0.6. weight 64 kg ± 0.2).	• 24-hr recall • FFQ • Seven day weighed food diary • DLW • BMI • BF % • FFM (%)	Hunger was significantly related to energy intake and total energy expenditure ($p < 0.05$). High Hunger scores correlated with excessive energy intake, high BMI and high BF % ($p < 0.05$).
Bresch et al. (2017) Germany.	Cross-sectional.	To assess the relationship between eating behaviour, NET's and body composition.	N=20. Comprised of N=10 obese individuals and N=10 normal weight individuals.	• BMI • TFEQ • MRI • TTAC • PET	Hunger and Disinhibition was significantly higher in obese individuals than their normal weight counterpart ($p < 0.01$). Obese individuals had significantly fewer PET's ($p < 0.05$).
Ernst et al. (2015) Switzerland.	Cross-sectional.	To examine the relationship between sex, BMI and eating behaviour in obese individuals.	N=644 obese subjects which comprised of N=454 women.	• BMI • TFEQ	Hunger and BMI were positively related ($p = 0.042$).
Lindroos et al. (1997) Sweden.	Cross-sectional.	To identify which eating behaviour is the most predominant in normal	N=326. Comprised of N=176 obese women and N=150 normal BMI women.	• BMI • TFEQ	High Hunger scores were associated with obese patients ($p < 0.001$) compared to non-obese

Author	Study design	Aim	Participants	Methods and materials	Results and conclusions
		weight and obese middle-aged women.		• Three day weighed food diary	patients and correlated with excessive energy intake (*p* < 0.001), rather than recommended energy intake.
Madden et al. (2012) New Zealand.	Cross-sectional.	To understand the relationship between eating secondary to hunger cues/satiety and BMI in New Zealand women.	N=2,500 New Zealand European and Māori women aged 40-50 years.	• BMI • IES • FFQ • Smoking status • Physical activity questionnaire	Hunger was inversely associated with BMI (5.1% decrease in BMI every 10-unit increase in IES, *p* < 0.01). Low Hunger was associated with a normal BMI (*p* < 0.001).
Yeomans and McCrickerd (2017) England.	Cross-sectional.	To examine the relationship between eating behaviour and body composition in British women.	N=626. Comprised of N=507 women and N=118 men.	• BMI • TFEQ • VAS	High Hunger and Disinhibition were the most significant positive predictors of BMI (both *p* < 0.001).
Van Dyke and Drinkwater (2014) Australia.	Systematic review.	To study the similarities between intuitive eating and health in Australian adults.	26 articles (17 cross sectional studies and 9 randomised control trials).	Studies used measured • BMI • BP • Lipidaemia • Glycaemia • TFEQ • WC	Intuitive eating was inversely associated with BMI, cholesterol, blood pressure.

rEI Reported Energy Intake, IES Intuitive Eating Scale, DLW Doubly labelled water, TEE Total Energy Expenditure, FFQ Food Frequency Questionnaire, FFM Free Fat Mass, BP Blood Pressure, WC Waist Circumference, VAS Visual Analog Scale, ADP Air Displacement Plethysmography, MRI Magnetic Resonance Imaging, TTAC Tissue Time Activity Curves, NET Norepinephrine Emission Transporters, PET Positron Emission Tomography. Normal BMI < 25 kg/m^2. High BMI ≥ 25 kg/m^2. Normal BF % considered < 30%. High BF % considered ≥ 30%.

Increased Hunger scores are often associated with the continuous overriding of innate satiety cues (Barkeling et al., 2007, Drapeau et al., 2005). This can be secondary to increased food appeal and food cravings (Loeber et al., 2013, Burton et al., 2007). Provencher et al. (2003) demonstrated that Hunger and Internal Hunger were positively correlated with energy and total fat intake (both $p < 0.01$). Likewise, studies have shown that obese women with high Hunger have a significantly higher energy intake compared to their lower Hunger counterparts ($p < 0.05$) (Goulet et al., 2008) and an increased consumption of processed foods ($p < 0.05$) (Green et al., 2000). With this in mind, many researchers are concerned that increased Hunger could fuel an overindulgence and weight-gain futile cycle, and thus exacerbate metabolic dysfunction (Hirsch et al., 2016, Bellanger and Bray, 2005). In view of this, mindful eating interventions have shown to curb Hunger and regulate portion control/consumption rate (Riesco et al., 2009). Some studies have shown that reduced Hunger can elicit weight loss (Dunn et al., 2018, Mantzios and Wilson, 2015, Lillis et al., 2016, Lillis et al., 2015), which could be used as a tool to optimise weight management. In contrast, several studies have argued that Restraint and Disinhibition have the greatest impact on BMI and BF %, rather than Hunger (Burton et al., 2007, de Lauzon-Guillain et al., 2006, Hays and Roberts, 2008, Lawson et al., 1995, Sawamoto et al., 2017, Williamson et al., 1995), which implies further research is required to reach an overall consensus.

In New Zealand Kruger et al. (2016) found that Hunger scores were significantly higher in women with a high BMI than normal BMI ($p = 0.021$). However, Hunger was not significantly different between women with a normal BF % and high BF % ($p = 0.872$), nor did it significantly influence BMI or BF %. In comparison, Brown et al. (2014) found that ghrelin levels (a hunger stimulating hormone) were surprisingly consistent between normal weight and overweight/obese individuals ($p > 0.05$), however they believe this was due to the presence of Restraint and Disinhibition having more of an effect on normal weight and overweight/obese populations, respectively (Brown et al., 2014). Overall, these findings add to the inconsistent theme of how Hunger influences body composition. This emphasises that a further exploration into eating behaviours in New Zealand women is required.

2.4.4 Sub-groups of Restraint, Disinhibition and Hunger

Lesdema et al. (2012) proposed that eating behaviour is multi-factorial and individuals often exhibit more than one main eating behaviour category. In addition, the level of these respective categories can also vary (Lesdema et al., 2012). For example, sub-groups of Restraint and Disinhibition can consist of: Low Restraint High Disinhibition (non-ideal behaviour combination), Low Restraint Low Disinhibition, High Restraint High Disinhibition or High Restraint Low Disinhibition (ideal behaviour combination) (Kruger et al., 2016, Lesdema et al., 2012). The evidence suggests that individuals with the sub-optimal Low Restraint High Disinhibition have significantly higher BMI and BF % (Kruger et al., 2016, Sawamoto et al., 2017, Zyriax et al., 2012, Westenhoefer et al., 1994) than individuals with the idyllic High Restraint Low Disinhibition behaviour combinations. This adverse tendency has been linked with regular over-indulgence and poor dietary control (Haynes et al., 2003) which can promote a positive energy balance (French et al., 2012). For example, Goulet et al. (2008) found women with Low Restraint High Disinhibition was linked with increased red meat intake, processed meat intake, desserts and refined grains (all $p < 0.05$) compared to High Restraint Low Disinhibition. Interestingly, this was not translated into significant differences between carbohydrate, protein, total fat intakes (all $p > 0.05$), which could be because the measurements were in percentages per energy intake. Therefore, further dietary analysis in the sub-groups of Restraint and Disinhibition is required, at a percentages and grams level, to see whether a significant difference can exist between macronutrients, their derivatives and TFEQ eating behaviour sub-groups in a New Zealand setting.

In comparison, sub-groups of Hunger and Disinhibition can consist of Low Hunger Low Disinhibition (ideal behaviour combination), Low Hunger High Disinhibition, High Hunger Low Disinhibition and High Hunger High Disinhibition (non-ideal behaviour combination). To our knowledge, no study to date has examined these combinations. However, there is a need for them to be analysed as Hirsch et al. (2016) demonstrated that frequent and excessive energy intake can override innate hunger and satiety cues. In view of this several studies have shown that both an individual high Hunger and high Disinhibition score are the most significant predictors of a high BMI and BF % (Lindroos et al., 1997, Bathalon et al., 2000, Bresch et al., 2017). This questions whether a High Hunger High Disinhibition concurrently will also exhibit high body composition, and whether the ideal behaviour combination (Low Hunger Low Disinhibition) is associated with an optimal body composition. By examining the sub-groups of eating behaviours, a deeper understanding of eating behaviour and dietary intake can be obtained.

To date, no study has examined the sub-groups of both Restraint and Disinhibition as well as Hunger and Disinhibition in relation to NZE, Māori and Pacific women with different body composition factors and dietary intake. Therefore, there is a unique opportunity to shed light on this area in attempt to optimise eating behaviour, body composition and dietary intake.

2.5 Conclusion

To combat the obesity epidemic, particularly in Māori and Pacific women, drastic measures must be taken. Examining BMI and BF % independently and concurrently (as BCP's) can provide a more accurate picture of the health. It is well regarded that eating behaviour and dietary intake can be a significant influencer of energy homeostasis and body composition (Bathalon et al., 2000, Bellanger and Bray, 2005, Emilien and Hollis, 2017, French et al., 2012), however there is no consensus, as to which TFEQ category, sub-category or sub-group is the most prominent factor contributing to body composition, let alone amongst young NZE, Māori and Pacific women with differing body compositions (particularly BCP's). Therefore, by exploring the all the three TFEQ categories, sub-categories and sub-groups of eating behaviour, in relation to ethnicity, body composition factors, and dietary intake behaviour-based interventions could be devised to improve/support weight management in young New Zealand women.

Chapter 3

Research Study Manuscript

Abstract

Many international studies have shown eating behaviour to be a modifiable risk-factor associated with an optimal and adverse body composition in women. However, no study has examined eating behaviour in New Zealand women with different ethnicities and body compositions. Therefore, the aim was to investigate eating behaviour as predictors of different body composition factors and dietary intake in New Zealand European, Māori and Pacific women, aged 16-45 years, participating in the women's EXPLORE study. Women (N=368) were assessed for basic anthropometry, total adiposity, regional adipose distribution and lean mass using height, weight, circumferences, air-displacement plethysmography (ADP) and dual-energy X-ray absorptiometry (DXA). Body composition profiles (normal-fat, hidden-fat and apparent-fat) were devised from parameters of body mass indices and body fat percentages. Eating behaviour categories (Restraint, Disinhibition and Hunger) and respective sub-categories were assessed using the validated Three Factor Eating Questionnaire. Combinations of behaviour (sub-groups) were devised from the three main categories and explored. Dietary intake was assessed using a validated New Zealand Women's Food Frequency Questionnaire.

Restraint was significantly higher in NZE than Pacific women ($p = 0.015$). Disinhibition) was significantly higher in the apparent-fat profile than normal-fat profile ($p < 0.001$). Likewise, Hunger was significantly higher in Pacific ($p < 0.001$) and apparent-fat profiles ($p = 0.034$) than NZE women and women with normal-fat profile, respectively. Sub-categories of Habitual Disinhibition and External Hunger were significantly higher in Pacific versus NZE women, and apparent-fat versus normal-fat profiles, respectively (all $p < 0.05$). External Hunger was significantly higher in the hidden-fat versus normal-fat profiles ($p = 0.001$). Restraint, Disinhibition, Habitual Disinhibition and Emotional Disinhibition were the most significant predictors of BMI ($p = 0.007$, p < 0.001, p < 0.001 and p < 0.001, respectively) and BF % ($p = 0.005$, $p < 0.001$, $p < 0.001$ and $p < 0.001$, respectively), when accounting for age and ethnicity. Adverse tendencies of Low Restraint High Disinhibition and High Hunger High Disinhibition were generally related to significantly higher body composition markers and dietary intakes ($p < 0.05$). Pacific women were three times more likely to have High Hunger High Disinhibition than NZE women ($p = 0.004$). Tendencies of Low Restraint High Disinhibition and High Hunger High Disinhibition significantly increased by 12% and 11%, respectively from the normal-fat to hidden-fat profile (both $p < 0.001$).

Designing strategies to enhance Restraint (particularly Flexible Restraint) and combat Disinhibition (particularly Habitual Disinhibition and Emotional Disinhibition), Hunger (particularly External Hunger, Low Restraint High Disinhibition and High Hunger High Disinhibition could optimise eating behaviour and dietary intake, which could potentially improve and/or support weight management in young New Zealand women.

3.1 Introduction

Obesity is a dynamic and multi-factorial metabolic dysfunction that affects 390 million women worldwide (Non-Communicable Disease Risk Factor Collaboration, 2017). In New Zealand 63.8% of women are obese or overweight (Ministry of Health, 2018a), with the highest rates being observed in Māori and Pacific ethnicities (78.7% and 91.1%, respectively) (Ministry of Health, 2018a).

Body Mass Index (BMI) is an inexpensive and effective weight screening tool that is commonly used in clinical and research settings (Lee and Nieman, 2007). Historically, a normal BMI (≥ 18.5; < 25 kg/m^2) has implied good metabolic health and reduced risk of morbidity, whilst high and low BMI categorisation implied heightened health risk (Lee and Nieman, 2007, World Health Organisation, 1995). In view of this old adage, researchers have recently identified "normal weight obesity" (NWO) whereby individuals have a high body fat percentage (BF %) (≥ 30%) masked by a normal BMI (Oliveros et al., 2014). The NWO profile exists in approximately 28% of women aged 34-73 (Hwang et al., 2015) and has been linked with low muscularity, dyslipidaemia and impaired glycaemic markers (Oliveros et al., 2014) which are typically observed in individuals with a high BMI (≥ 25 kg/m^2) and high BF % (≥ 30%). NWO can be one of the first indicators of metabolic dysregulation and an early identification could assist preventing future obesity (Oliveros et al., 2014). Therefore, examining BMI and BF % individually and concurrently (termed "body composition profiles (BCP)" is paramount for obtaining a more accurate picture of metabolic health.

Eating behaviour is a modifiable, psychological factor that can affect BMI and BF % (French et al., 2012). The Three-Factor Eating Questionnaire (TFEQ) is a 51-item psychometric tool that examines three constructs of eating behaviour: Restraint (the conscious and consistent ability to restrict unnecessary energy intake), Disinhibition (the lack of self-regulation when eating), Hunger (a physiological or psychological response that promotes energy intake) (Stunkard and Messick, 1985), and their respective sub-categories (Bond et al., 2001, Westenhoefer et al., 1999). The TFEQ has been widely validated across BMI groups (Lindroos et al., 1997, Karlsson et al., 2000, Di Renzo et al., 2006) and ethnicities (Rosnah et al., 2015, Jauregui-Lobera et al., 2014, Schlundt et al., 2003) and is well regarded.

Internationally, there is a mixed consensus as to which TFEQ category, sub-category or combination of categories/sub-groups (e.g. low Restraint and high Disinhibition) is the most related to an optimal and at risk BMI and BF %. Some studies have demonstrated that low Restraint and high Disinhibition is positively associated with BMI (Sawamoto et al., 2017, Zyriax et al., 2012, Westenhoefer et al., 1994), whereas others have shown it to be Hunger and Disinhibition (Lindroos et al., 1997, Bathalon et al., 2000, Bresch et al., 2017). At present, few studies have examined BF % (Kruger et al., 2015, Mailloux et al., 2014, Bathalon et al., 2000, de Lauzon-Guillain et al., 2006) and no eating behaviour study has examined BCP's.

To date, only two New Zealand-based studies have examined the TFEQ in relation to body composition (Brown et al., 2014, Kruger et al., 2016). However, neither study fully encompassed the relationship between the TFEQ categories, sub-categories, sub-groups in New Zealand European (NZE), Māori and Pacific women with differing body composition markers and dietary intake. Therefore, the aim of this study was to investigate eating behaviour as predictors of different body composition factors and dietary intake in post-menarche and pre-menopausal NZE, Māori and Pacific women, aged 16-45 years.

3.2 Materials and methods

3.2.1 EXPLORE Study design

This sub-analysis from the cross-sectional Examining Predictors Linking Obesity Related Elements (EXPLORE) study of New Zealand women (Kruger et al., 2015), which examined the relationship between predictive factors of metabolic dysregulation in relation to body composition profiles. The EXPLORE study obtained ethical approval from the Massey University Human Ethics Committee in 2013: Southern A, Application 13/13 (Kruger et al., 2015). Recruitment took place at the Human Nutrition Research Institute (HNRU) at Massey University's Albany Campus and across Auckland between August 2013 and December 2014. All participants provided written informed consent. Supplementary information regarding the study protocol can be obtained elsewhere (Kruger et al., 2015).

3.2.2 Study participants and screening procedures

408 healthy post-menarcheal and pre-menopausal (defined as having continuous and regular menstrual cycles for at least one year) NZE, Māori and Pacific women (defined by self-identification and having at least one parent from the given ethnicity) were recruited (Kruger et al., 2015). Sample size and power calculations were conducted to provide 80% power at a significance level $p < 0.05$ to detect a medium effect size f of 0.25. Exclusion criteria included women actively seeking weight

gain/loss, being pregnant or breastfeeding, or having any chronic illness that could jeopardise metabolic health (Kruger et al., 2015). Women demonstrating interest were given an information sheet and completed a screening questionnaire based on eligibility criteria (Appendix A). Eligible women were screened for their height, weight and body fat percentage to ensure they met the specific BCP criteria for the EXPLORE study: normal-low fat group (BMI < 25 kg/m^2; BF % ≥ 22%, < 30%) normal-fat group (BMI < 25 kg/m^2; BF % ≥ 22%, < 30%); hidden-fat group (BMI < 25 kg/m^2; BF % ≥ 30%, previously referred to as NWO), apparent-fat group (BMI ≥ 25 kg/m^2; BF % ≥ 30%) and high-low group (BMI ≥ 25 kg/m^2; BF % < 30%) (Kruger et al., 2015). Screening occurred at the Human Nutrition Research Unit (HNRU) and at suitable community locations (Kruger et al., 2015). Height was measured using a portable stadiometer, and weight and BF % was measured using a portable bioelectrical impedance analysis machine (BIA) (Biospace, Inbody 230, Cerritos, CA, USA). For the purpose of this sub-analysis, eligibility involved women fitting into the normal-fat, hidden-fat or apparent-fat profiles, specified by the EXPLORE protocol, and completing the TFEQ and New Zealand Women's Food Frequency Questionnaire (NZWFFQ).

3.2.3 Measures

Women were invited to attend the HNRU within 14 days from the start of their last menstrual period (to reduce the potential effects of menstruation altering body composition, eating behaviour, or dietary intake) (Kruger et al., 2015). The assessments relevant to this sub-study were undertaken by trained research assistants. Waist and hip circumference measurements were conducted using a Lufkin tape and in accordance with the International Society for the Advancement of Kinanthropometry (ISAK) protocol (Marfell-Jones and Stewart, 2012). Air displacement plethysmography (ADP) (BodPod Life Measurement Inc, Concord CA with software V4.2+ as supplied by the manufacturer) measurements were used to assess total adiposity and fat free mass, and dual x-ray absorptiometry (DXA) (Hologic QDR Discovery A, Hologic Inc, Bedford, MA using APEX V.3.2 software) (Kruger et al., 2015) measurements were used to assess regional adiposity and non-adipose mass. The ADP BF % was used for the BCP's as its measurement concept is similar to the gold-standard underwater weighting (Lee and Nieman, 2007).

Women completed a validated, 220 item, semi-quantitative New Zealand Women's Food Frequency Questionnaire (NZWFFQ) (Beck et al., 2018) on SurveyMonkey to assess diet quality and energy and macronutrient intakes and distribution (Appendix B). Data were entered into FoodWorks 7 (Foodworks Professional, 2013, Xyris Software, QLD Australia) by trained registered nutritionists using a pre-designed template. Women also completed the validated, 51-item, self-administered TFEQ, including questions pertaining to Restraint (21-items), Disinhibition (16-items) and Susceptibility of Hunger (Hunger) (14-items) and their respective sub-categories (Stunkard and Messick, 1985)

(Appendix C). Responses were scored 0 or 1, with higher scores of ≥ 8, ≥ 8 and ≥ 6 indicating higher levels of Restrained, Disinhibited or Hunger-based eating, respectively (Stunkard and Messick, 1985). Supplementary information regarding the TFEQ coding can be found in Appendix C.1 to Appendix C.3.

Restraint is the conscious and frequent restriction of one's food intake to achieve weight control (Stunkard and Messick, 1985). The sub-categories of Restraint include Flexible Restraint, referring to a neutral mind set to food control that is neither obsessive nor compulsive, and Rigid restraint referring to a stern "all or nothing" approach to food control to reduce weight gain (Bond et al., 2001, Westenhoefer et al., 1999).

Disinhibition is the lack of self-regulation when eating resulting in excessive energy intake (Stunkard and Messick, 1985). The sub-categories include Habitual Disinhibition referring to particular circumstances and attitudes that regularly trigger disinhibition; Emotional Disinhibition referring to over-indulging secondary to an adverse mental state and Situational Disinhibition referring to situational/environmental cues that exacerbate lack of food control (e.g. social events, celebrations), respectively (Bond et al., 2001).

Lastly, Hunger is a physiological or psychological response that often promotes energy intake (Stunkard and Messick, 1985). Sub-categories include Internal Hunger, referring to self-translated and controlled inner hunger and External Hunger, referring to hunger derived from external rather than physiological cues, such as attending buffets or eating delicacies (Bond et al., 2001). A summary of the study participants, screening procedures and measurements are presented in Figure 3.1.

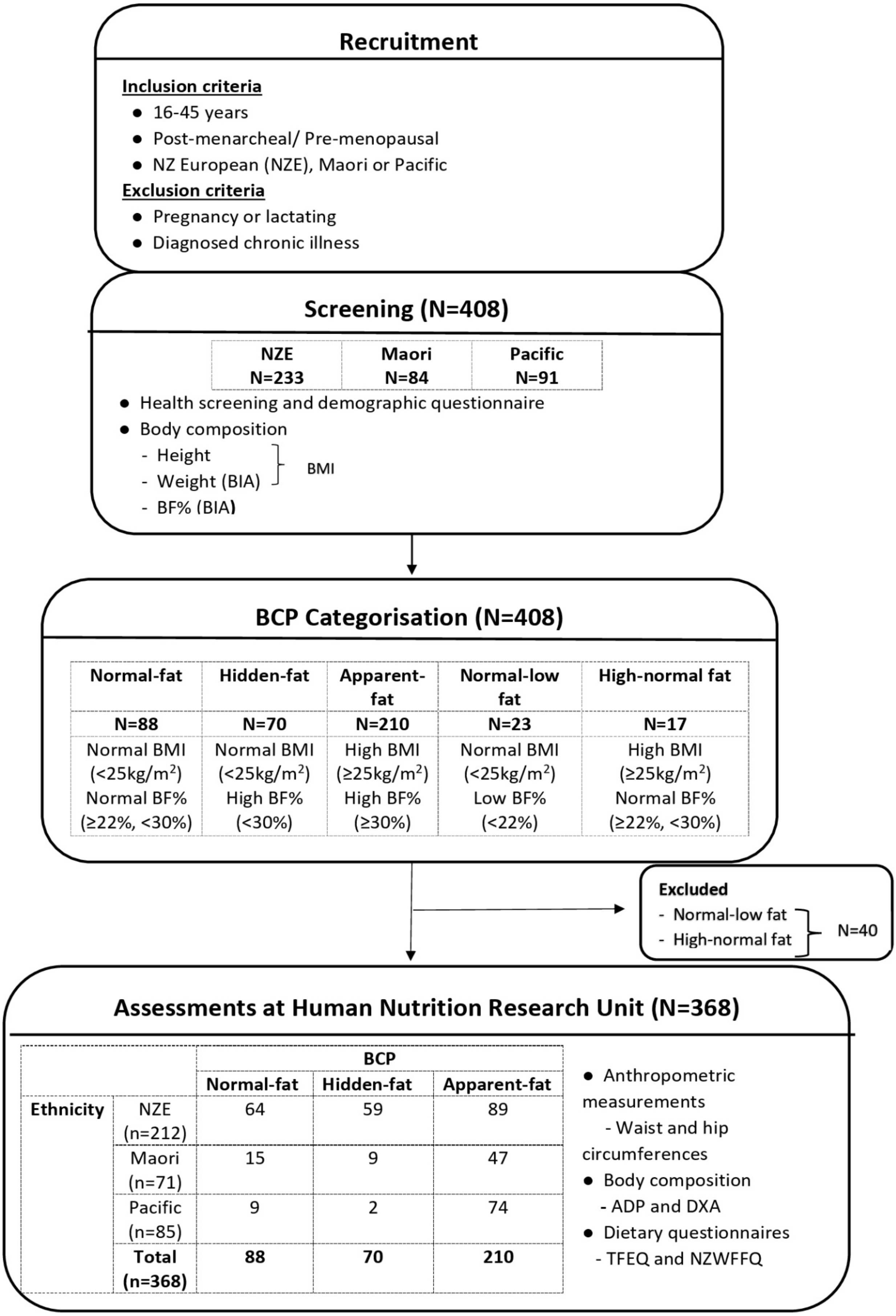


Figure 3.1 Flow diagram of the EXPLORE sub-study participants, procedures and measures

3.2.4 Statistical analysis

Statistical analysis was conducted using IBM SPSS 24 (SPSS Inc., Chicago, IL, USA). The Kolmogorov-Smirnov test and Shapiro-Wilk tests, box plots and histograms were used to assess the data for normality. Homogeneity of variance was examined using the Levene's test. Non-normally distributed data were log transformed and retested for normality. Scale data that remained non-normally distributed, such as body composition and dietary intake data, was presented as mean ± SD in agreement with the central limit theorem (Field, 2013). TFEQ scores were presented as median (25th and 75th percentile) to show a score range, however the data were treated as normal. Categorical data were presented as percentages.

TFEQ category and sub-category scores were ranked low and high according to the guidelines of Westenhoefer et al. (1999), Bond et al. (2001) and Lesdema et al. (2012). Restraint was ranked low (≤ 7) or high (> 7); Disinhibition was ranked low (≤ 7) or high (> 7) and Hunger was ranked low (≤ 5) or high (> 5) (Lesdema et al., 2012). This prompted the division of sub-groups for Restraint and Disinhibition (High Restraint Low Disinhibition, Low Restraint Low Disinhibition, High Restraint High Disinhibition and Low Restraint High Disinhibition) (Kruger et al., 2016) and Hunger and Disinhibition (Low Hunger Low Disinhibition, Low Hunger High Disinhibition, High Hunger Low Disinhibition, High Hunger High Disinhibition).

Demographic data were analysed using an ANOVA test (for scale data such as age) or chi-square analysis (for categorical data such as smoking status, hormonal contraception and having children). When a significant difference was observed in a demographic ANOVA ($p < 0.05$), a post-hoc Tukey analysis and Bonferroni correction were completed to identify which groups were statistically different. Subsequently, the Pearson's r value was calculated for effect sizes, ranging from small (r = 0.1), medium (r = 0.3) to large (r = 0.5) (Field, 2013). When a significant difference ($p < 0.05$) was observed in a demographic chi-square, an odds ratio and effect sizes were calculated when. Effect sizes of the odds-ratios ranged from small (1.5), medium (3.5) to large (9.0) (Field, 2013). Any demographic variables that were significantly different in their ANOVA or chi-square test were controlled for in an ANCOVA analysis (for scale data) when examining body composition, TFEQ scores or dietary intake data in relation to ethnicity, BCP or sub-groups. A significant ANCOVA test was followed by a post-hoc Tukey analysis and a Bonferroni correction to identify which groups were statistically different. Pearson's r value was calculated for effect sizes, as specified above. For categorical data (e.g. BMI groups) a chi-square was completed. When there was a significant difference ($p < 0.05$) was observed an odds ratio and effect sizes were calculated, as specified above. In addition, a Pearson's bivariate and partial correlation was conducted to assess the correlation between the DXA and ADP fat mass (kg) and BF %.

Multiple linear regressions (step-wise enter method) were used to identify significant TFEQ category and sub-category predictors of BMI and BF %. Assumptions regarding auto-correlation, multi-collinearity, homoscedasticity, linearity, and normality were met and log transformed variables were not used when normality worsened. All TFEQ categories and sub-categories were included in the model due to previous research highlighting a mixed consensus as to which TFEQ factor is the most significant predictor of BMI and BF %. Age, ethnicity and energy were also included in the model as controls.

3.3 Results

3.3.1 Participant characteristics in relation to ethnicity and BCP

A total of 408 women were recruited, to which 368 women met the BCP criteria for this sub-study. All demographic data were significantly associated with ethnicity. NZE women were 4 and 5.7 times, respectively, more likely to take hormonal contraception ($p < 0.001$) and drink alcohol ($p < 0.001$) than Pacific women, respectively (medium effect sizes) (Table 3.1). In addition, Māori women were 4.6 and 2.1 times more likely to smoke ($p < 0.001$) and have children ($p = 0.015$) than NZE women (small to medium effect sizes). In terms of BCP, women with apparent-fat were 3.5 times more likely to use hormonal contraception than normal-fat women (medium effect size), whereas women with hidden-fat were 1.8 times more likely to use it than normal-fat women ($p < 0.001$) (small effect size). Additionally, women with apparent-fat were 9.7 times more likely to smoke than their hidden-fat counterparts (large effect size), whereas hidden-fat women were 2.7 times more likely to smoke than normal-fat women ($p = 0.010$) (small effect size). Having children and drinking alcohol were not significant predictors of BCP ($p = 0.166$ and $p = 0.077$, respectively).

Māori women had significantly higher weight, BMI, ADP fat mass (kg), WC, HC, WHR, WTHR, android fat (kg and %), FFM (kg) and lean mass (kg) than NZE women (medium effect sizes) (Table 3.1). Comparably, Pacific women had significantly higher weight, BMI, ADP fat mass (kg), DXA fat mass (kg), ADP BF %, DXA BF %, WC, HC, WTHR, android fat (kg and %), gynoid fat (kg) than Māori and NZE women (small to medium effect sizes) and significantly lower FFM (%) and lean mass (kg and %) (small to medium effect sizes). For BCP groups, women with apparent-fat had significantly higher weight, BMI, ADP fat mass (kg); DXA fat mass (kg), ADP BF %, DXA BF %, WC, HC , WHR, WTHR, android fat (kg and %) , gynoid fat (kg and %) and FFM (kg and %) than normal-fat and hidden-fat women (large effect sizes). Additionally, women with hidden-fat had significantly higher android fat (%) and gynoid fat (kg and %) and significantly lower lean mass (%) than their normal-fat counterparts (large effect sizes).

Table 3.1 Participant characteristics in terms of demographic, anthropometric and body composition data.

	Total	Ethnicity			*P*-value	BCP			*P*-value
		NZE	**Māori**	**Pacific**		**Normal-fat**	**Hidden-fat**	**Apparent-fat**	
	N=368	**N=212**	**N=71**	**N=85**		**N=88**	**N=70**	**N=210**	
Demographic data									
Age (years)	30.9 ± 8.67	32.1 ± 8.30 [a]	29.8 ± 9.20	29.1 ± 8.90 [a]	0.006† *r* = 0.37	28.8 ± 8.20	32.0 ± 8.90	31.5 ± 8.70	0.049† *r* = 0.39
Actively uses hormonal contraception (%)	28.0	72.8	16.5	10.7	< 0.001*	37.9	20.4	41.7 [d]	< 0.001*
Active smoker (%)	8.40	29.0	35.5	35.5	0.001*	12.9	3.20	83.9	0.001*
Have children (%)	37.2	51.1	26.3	22.6	0.015*	18.2	17.5	64.3	0.166*
Drinks alcohol (%)	71.8	65.5 [d]	20.5	14.0 [d]	< 0.001*	25.8	20.4	53.8	0.077*
Body composition data									
Basic									
Weight (kg)	77.6 ± 18.6	71.0 ± 14.5 [a, c]	80.0 ± 17.4 [a, b]	92.0 ± 20.1 [b, c]	< 0.001** *r* = 0.48	61.8 ± 6.7 [a]	65.3 ± 5.5 [b]	88.3 ± 17.5 [a, b]	< 0.001*** *r* = 0.67
Height (cm)	167 ± 6.30	167 ± 6.70	167 ± 6.20	167 ± 5.60	0.734**	168 ± 6.00	168 ± 6.10	166 ± 6.30	0.051***
BMI	27.8 ± 6.60	25.4 ± 5.30 [a, c]	28.9 ± 6.30 [a, b]	32.9 ± 6.80 [b, c]	< 0.001** *r* = 0.49	21.8 ± 1.70 [a]	23.2 ± 1.20 [b]	31.9 ±6.00 [a, b]	< 0.001*** *r* = 0.71
Normal BMI 18.5-24.9 kg/m² (%)	43.2	77.4	15.7	6.9	< 0.001*	50.0	50.0	0.00	< 0.001*
High BMI > 25 kg/m² (%)	56.8	42.6	22.0	35.4		0.00	0.00	100	
Abdominal adiposity									
WC (cm) *High WC > 80 cm*	83.7 ± 13.7	79.1 ± 11.2 [a, c]	85.7 ± 12.5 [a, b]	93.7 ± 14.6 [b, c]	<0.001** *r* = 0.47	70.8 ± 4.5 [a]	74.6 ± 3.8 [b]	92.1 ± 12.1 [a, b]	< 0.001*** *r* = 0.72
HC (cm) *High HC > 100 cm*	108 ± 11.8	105 ± 9.80 [a, c]	109 ± 11.6 [a, b]	116 ± 12.5 [b, c]	< 0.001** *r* = 0.41	98.0 ± 4.8 [a]	101 ± 4.1 [b]	115 ± 11.2 [a, b]	< 0.001*** *r* = 0.65
WHR *High WHR > 0.80*	0.77 ± 0.06	0.70 ± 0.10 [a, b]	0.80 ± 0.10 [a]	0.90 ± 0.10 [b]	< 0.001** *r* = 0.38	0.70 ± 0.00 [a]	0.70 ± 0.00 [b]	0.80 ± 0.10 [a, b]	< 0.001*** *r* = 0.56
WTHR *High WTHR >0.50*	0.50 ± 0.08	0.40 ± 0.05 [a, c]	0.50 ± 0.10 [a, b]	0.60 ± 0.10 [b, c]	< 0.001** *r* = 0.46	0.40 ± 0.00 [a]	0.40 ± 0.00 [b]	0.60 ± 0.10 [a, b]	< 0.001*** *r* = 0.72

	Total	Ethnicity			*P*-value	BCP			*P*-value
		NZE	Māori	Pacific		Normal-fat	Hidden-fat	Apparent-fat	
	N=368	N=212	N=71	N=85		N=88	N=70	N=210	
Total adiposity									
ADP Fat mass (kg)	28.7 ± 13.1	24.8 ± 10.9 [a, c]	30.1 ± 12.7 [b, c]	37.3 ± 14.3 [a, b]	< 0.001** r = 0.42	16.1 ± 2.30 [a, b]	21.8 ± 2.4 [a, c]	36.3 ± 12.6 [b, c]	< 0.001*** r = 0.67
ADP BF (%)	35.5 ± 7.70	33.8 ± 7.40[a]	36.4 ± 7.50 [b]	39.3 ± 7.20 [a, b]	< 0.001** r = 0.36	26.1 ± 2.30 [a, b]	33.5 ± 2.90 [a, c]	40.2 ± 6.00 [b, c]	< 0.001*** r = 0.76
Normal BF <30% (%)	24.2	71.9	18.0	10.1	0.002*	100	0.00	0.00	< 0.001*
High BF ≥30% (%)	75.8	53.0	19.7	27.2		0.00 [a]	25.1	74.9	
DXA WB Total fat (kg)	27.2 ± 10.4	24.3 ± 8.80 [a, c]	28.3 ± 10.3 [b, c]	33.9 ± 11.2 [a, b]	< 0.001** r = 0.27	17.3 ± 2.30 [a, b]	21.7 ± 2.70 [a, c]	33.2 ± 9.9 [b, c]	< 0.001*** r = 0.65
DXA WB Total fat *(%)*	34.0 ± 6.00	33.0 ± 5.42 [a]	34.2 ± 5.90	36.2 ± 5.16 [a]	< 0.001** r = 0.27	27.6 ± 2.66 [a, b]	32.7 ± 3.00 [a, c]	37.0 ± 4.75 [b, c]	< 0.001*** r = 0.69
Adiposity distribution									
DXA Android fat (kg)	1.97 ± 1.08	1.63 ± 0.87 [a, b]	2.23 ± 1.13 [a]	2.62 ± 1.17 [b]	< 0.001** r = 0.40	1.00 ± 0.29 [a, b]	1.36 ± 0.30 [a, c]	2.60 ± 1.04 [b, c]	< 0.001*** r = 0.67
DXA Android fat (%) [1]	34.7 ± 7.43	32.7 ± 7.20 [a, b]	36.2 ± 7.50 [a]	38.8 ± 5.90 [b]	< 0.001** r = 0.35	26.4 ± 4.30 [a, b]	31.9 ± 4.40 [a, c]	39.3 ± 5.50 [b, c]	< 0.001*** r = 0.75
DXA Gynoid fat (kg)	4.93 ± 1.59	4.55 ± 1.32 [a]	5.07 ± 1.73 [b]	5.80 ± 1.74 [a, b]	< 0.001** r = 0.34	3.53 ± 0.53 [a, b]	4.23 ± 0.57 [a, c]	5.77 ± 1.60 [b, c]	< 0.001*** r = 0.62
DXA Gynoid fat (%) [1]	38.1 ± 4.59	38.0 ± 4.50	37.5 ± 5.10	38.8 ± 4.40	0.135**	34.0 ± 3.40 [a, b]	38.5 ± 3.20[a]	39.7 ± 4.40 [b]	< 0.001*** r = 0.52
Non-adipose mass									
ADP FFM (kg)	48.9 ± 7.16	46.2 ± 5.70 [a, c]	49.9 ± 6.50 [a, b]	54.7 ± 7.20 [b, c]	< 0.001** r = 0.48	45.7 ± 5.00 [a]	43.5 ± 4.30 [b]	52.4 ± 7.0 [a, b]	< 0.001*** r = 0.53
ADP FFM (%)	64.5 ± 7.71	66.2 ± 7.40 [a, b]	63.7 ± 7.50 [a]	60.7 ± 7.20 [b]	< 0.001** r = 0.36	73.9 ± 2.30 [a, b]	66.5 ± 2.90 [a, c]	59.8 ± 6.20 [b, c]	< 0.001*** r = 0.76
DXA WB total lean mass (kg)	50.8 ± 8.61	47.6 ± 6.90 [a, c]	52.4 ± 7.80 [a, b]	57.8 ± 9.00 [b, c]	< 0.001** r = 0.49	45.4 ± 5.40 [a]	44.6 ± 4.30 [b]	55.2 ± 8.20 [a, b]	< 0.001*** r = 0.58
DXA WB total lean mass (%)	66.0 ± 5.59	67.0 ± 5.42 [a]	65.8 ± 5.90	63.8 ± 5.16 [a]	< 0.001** r = 0.27	72.3 ± 2.70 [a, b]	67.2 ± 3.00 [a, c]	63.0 ± 4.70 [b, c]	< 0.001*** r = 0.69

Values are mean±SD. [1]Derived from a percentage of total android or gynoid mass. †*P*-value determined by one-way ANOVA. **P*-value determined by Chi-Square ***P*-value determined by ANOCVA analysis controlling for age, use of hormonal contraception, smoking status and having children. ****P*-value determined by ANCOVA analysis controlling for age, use of hormonal contraception and smoking status. [a-c] Values with the same superscript letters are significantly different according to the Tukey post-hoc test and Bonferroni correction when $p < 0.05$. WB Whole body; BMI Body mass index; ADP Air displacement plethysmography; WC Waist circumference; HC Hip circumference; WTHR Waist to hip ratio; BF Body fat; FFM Fat free mass; DXA Dual x-ray absorptiometry; WB Whole body. High WC, HC, WHR and WTHR based on female cut-offs (Mahan and Raymond, 2017, Lee and Nieman, 2007). r = 0.1 (small effect), r = 0.3 (medium effect), r = 0.5 (large effect). r values are non-existent for Chi-square, however odds-ratio effect size are determined as small (1.5), medium (3.5) or large (9.0) when $p < 0.05$.

The DXA data were used to assess regional fat distribution. To ensure accuracy, a correlation between the DXA and ADP fat mass (kg) and BF % was conducted (Appendix D). A positive linear relationship was demonstrated between the two apparatuses for both a normal and high BMI and BF % (Appendix E to Appendix H, thus showing excellent reliability between both measurements. Therefore, the regional data was trust worthy.

Table 3.2 shows the TFEQ scores (median 25th and 75th percentile) and dietary intake (mean± SD) in relation to ethnicity and BCP. NZE women had significantly higher Restraint than Pacific women and significantly higher Rigid Restraint compared to Pacific and Māori women (small effect sizes). Interestingly, Disinhibition, Emotional Disinhibition and Situational Disinhibition were not significantly associated with ethnicity, however Habitual Disinhibition, Hunger, Internal Hunger and External Hunger were significantly higher in Pacific women than NZE women (small effect sizes). In terms of BCP's, Disinhibition, Habitual Disinhibition and External Hunger were significantly higher in apparent-fat women compared to normal-fat and hidden-fat women (small to medium effect sizes). Moreover, Flexible Restraint, Emotional Disinhibition and Hunger were significantly higher in apparent-fat women compared to normal-fat women (small effect sizes). External Hunger was the only TFEQ eating behaviour that was significantly higher in hidden-fat women compared to normal-fat women (small effect size). In contrast, Restraint, Rigid Restraint Situational Disinhibition, and Internal Hunger were not significantly different between the BCP groups.

In terms of dietary intake (Table 3.2), Pacific women had significantly higher energy, carbohydrate (g), starch (g), monounsaturated fat (g) and polyunsaturated fat (g) than NZE women and Māori women (small to medium effect sizes). In addition, Pacific women had significantly higher protein (g), total fat (g) and saturated fat (g) than NZE women alone (small effect sizes). There was no significant difference observed between NZE and Māori women for any dietary intake. In terms of BCP's, women with the apparent-fat profile had significantly higher carbohydrate (g) and starch (g) intake than women with hidden-fat and normal-fat profiles (small effect sizes). Moreover, women with apparent-fat had significantly higher energy, protein (g), total fat (g), saturated fat (g) and monounsaturated fat (g) intake than normal-fat women (small effect sizes). There was no significant difference between normal-fat and hidden-fat women for any dietary intake.

Table 3.2 Participant characteristics in terms of dietary intake and TFEQ scores.

	Total N=368	Ethnicity			*P*-value*	BCP			*P*-value**
		NZE	Māori	Pacific		Normal-fat	Hidden-fat	Apparent-fat	
		N=212	N=71	N=85		N=88	N=70	N=210	
TFEQ scores									
Restraint (21 questions)[2]	9 (6,12)	10 (6,12)[a]	8 (5,10)	7 (5,11)[a]	0.015 *r* = 0.15	9 (6,12)	9 (6,12)	8 (5,11)	0.148
Flexible[2]	3 (2,4)	3 (2,4)	3 (2,4)	2 (1,4)	0.054	3 (2,5)[a]	3 (2,4)	2 (1,4)[a]	0.005 *r* = 0.17
Rigid[2]	3 (1,4)	3 (2,4)[a, b]	2 (1,3)[a]	2 (1,3)[b]	< 0.001 *r* = 0.23	3 (2,4)	3 (1,4)	2 (1,4)	0.082
Disinhibition (16 questions)[2]	8 (5,11)	8 (5,10)	7 (5,11)	8 (5,10)	0.778	5 (3,8)[a]	7 (4,10)[b]	9 (6,11)[a, b]	< 0.001 *r* = 0.33
Habitual[2]	1 (0,2)	1 (0,2)[a]	1 (0,2)	2 (1,3)[a]	0.023 *r* = 0.18	1 (0,1)[a]	1 (0,2)[b]	2 (1,3)[a, b]	< 0.001 *r* = 0.34
Emotional[2]	1 (0,2)	1 (0,3)	1 (0,2)	1 (0,2)	0.122	0 (0,2)[a]	1 (0,2)	2 (0,3)[a]	< 0.001 *r* = 0.29
Situational[2]	3 (2,4)	3 (2,4)	3 (2,4)	3 (2,4)	0.961	3 (2,4)	3 (2,4)	3 (2,4)	0.060
Hunger (14 questions)[2]	6 (4,8)	5 (3,7)[a]	6 (3,8)	7 (5,9)[a]	0.001 *r* = 0.20	5 (3,7)[a]	5 (3,8)	6 (4,8)[a]	0.034 *r* = 0.14
Internal[1]	2 (1,4)	2 (1,3)[a]	2 (1,4)	3 (2,4)[a]	0.040 *r* = 0.17	2 (1,3)	2 (1,4)	2 (1,4)	0.295
External[1]	2 (1,3)	2 (1,3)[a]	2 (1,4)	3 (2,4)[a]	< 0.001 *r* = 0.20	1 (1,3)[a, b]	2 (1,3)[a]	2 (1,4)[b]	0.001 *r* = 0.20
Dietary intake									
Energy (kJ)	9,6343 ± 3,767	9,018 ±3,008[a]	9,766 ± 3,773[b]	11,588 ± 5,301[a, b]	< 0.001 *r* = 0.28	8,887 ± 2,814[a]	9,106 ± 3,301	10,241 ± 4,317[a]	0.003 *r* = 0.23
Protein (g)	102 ± 40.5	95.1 ± 33.7[a]	106 ± 43.1	121 ± 51.8[a]	< 0.001 *r* = 0.26	92.5 ± 31.3[a]	96.2 ± 38.6	109 ± 44.4[a]	0.001 *r* = 0.22
Protein (%)[1]	18.1 ± 3.53	17.9 ± 3.36	18.4 ± 3.89	18.0 ± 3.62	0.568	17.6 ± 2.80	18.0 ± 3.70	18.3 ± 3.70	0.401
Carbohydrate (g)	244 ± 112	227 ± 88.9[a]	242 ± 113[b]	300 ± 164[a, b]	< 0.001 *r* = 0.30	232 ± 82.0[a]	225 ± 90.0[b]	260 ± 134[a, b]	0.018 *r* = 0.25

	Total	Ethnicity			P-value*	Ethnicity			P-value**
		NZE	Māori	Pacific		Normal-fat	Hidden-fat	Apparent-fat	
	N=368	N=212	N=71	N=85		N=88	N=70	N=210	
Carbohydrate (%) [1]	42.1 ± 7.60	42.2 ± 7.60	41.0 ± 7.12	42.8 ± 7.51	0.288	43.7 ± 6.30	41.3 ± 7.30	41.6 ± 8.0	0.183
Starch (g)	119 ± 66.6	107 ± 47.0 [a]	116 ± 66.8 [b]	159 ± 101 [a, b]	< 0.001 *r* = 0.34	108 ± 46.3 [a]	109 ± 54.0 [b]	128 ± 79.2 [a, b]	0.007 *r* = 0.27
Sugar (g)	125 ± 61.0	120 ± 55.2	125 ± 63.0	141 ± 80.6	0.112	123 ± 50.0	115 ± 50.3	130 ± 71.4	0.165
Total fat (g)	92.2 ± 39.9	84.6 ± 33.7 [a]	93.4 ± 36.7	111 ± 51.6 [a]	< 0.001 *r* = 0.24	82.4 ± 30.1 [a]	88.3 ± 36.5	99.0 ± 43.1 [a]	0.002 *r* = 0.19
Total fat (%) [1]	36.1 ± 6.67	36.1 ± 6.55	36.6 ± 6.70	36.5 ± 6.43	0.520	34.9 ± 5.62	36.5 ± 6.35	36.8 ± 6.93	0.205
Saturated fat (g)	35.7 ± 17.5	34.9 ± 16.6 [a]	34.6 ± 12.0	44.2 ± 23.7 [a]	0.004 *r* = 0.19	32.0 ± 14.0 [a]	33.6 ± 15.6	39.3 ± 19.1 [a]	0.005 *r* = 0.18
Saturated fat (%) [1]	14.3 ± 3.70	14.3 ± 3.70	14.9 ± 3.49	14.8 ± 3.68	0.466	13.7 ± 3.40	14.2 ± 3.60	14.9 ± 3.70	0.116
Monounsaturated fat (g)	30.6 ± 12.8	29.4 ± 11.2 [a]	30.1 ± 11.1 [b]	38.6 ± 18.5 [a, b]	< 0.001 *r* = 0.25	27.1 ± 9.10 [a]	29.3 ± 10.8	33.2 ± 14.6 [a]	0.001 *r* = 0.20
Polyunsaturated fat (g)	13.0 ± 5.32	12.6 ± 4.80 [a]	12.5 ± 5.20 [b]	15.6 ± 6.90 [a, b]	0.003 *r* = 0.20	12.2 ± 4.10	12.8 ± 5.00	13.5 ± 5.90	0.163

Values are mean ± SD. [1] Values are a percentage of total energy intake. [2] Values are Median (25th and 75th percentile). **P*-value determined by ANOCVA analysis controlling for age, use of hormonal contraception, smoking status and having children) ***P*-value determined by ANCOVA analysis controlling for age, use of hormonal contraception and smoking status . [a-c] Values with the same superscript letters are significantly different according to the Tukey post-hoc test and Bonferroni correction when $p < 0.05$. [d] largest odds-ratio using Chi-square values. [e] Chi-Square used to determine significance value. TFEQ scores interpretation: Restraint (Low= 0-7, High= 8-21); Flexible Restraint (Low= 0-3, High 4-7); Rigid restraint (Low= 0-3, High= 4-7); Disinhibition (Low= 0-7, High=8-16); Habitual Disinhibition (Low= 0-2, High= 3-5); Emotional Disinhibition (Low= 0-1, High= 2-3); Situational Disinhibition (Low= 0-2, High=3-5); Hunger (Low=0-5, High= 6-14); Internal Hunger (Low= 0-3, High 4-6); External Hunger (Low= 0-3, High= 4-6). $r = 0.1$ (small effect size), $r = 0.3$ (medium effect size), $r = 0.5$ (large effect size) when $p < 0.05$.

3.3.2 TFEQ categories and sub-categories influence on body mass index and body fat percentage

Table 3.3 demonstrates the main TFEQ categories that influence BMI and BF %. The first part of the BMI step-wise regression controlled for age (Model 1 for BMI). Subsequently, when age and ethnicity were considered (Model 2 for BMI) the behaviour scores accounted for 33% of BMI (a 21% increase from Model 1). In this model Disinhibition and Restraint were significant predictors of BMI ($p < 0.001$ and $p = 0.007$, respectively). For every point increase in Disinhibition and Restraint, the BMI increased by 0.66 kg/m^2 and decreased by 0.20 kg/m^2 respectively. For the typical woman in this study (1.67 m and 77.6 kg) having high Restraint or Disinhibition would result in a 0.07 kg decrease or 0.24 kg increase in weight, respectively.

The first part of the BF % step-wise regression controlled for age (Table 3.3, Model 1 for BF %). When both age and ethnicity were considered (Model 2 for BF %) the behaviour scores accounted for approximately 23% of the BF % (a 7% increase from Model 1). Model 2 highlights that Disinhibition ($p < 0.001$) and Restraint ($p = 0.005$) were significant predictors of BF %. For every point increase in Restraint and Disinhibition BF % would reduce by 0.26% and increase by 0.82%, respectively. For the typical woman in the study (with a BF % of 35.5%, as per the ADP result) every increase in point for Restraint or Disinhibition would result in BF % decreasing to 35.2% or increasing to 36.3%, respectively. Hunger was not a significant predictor of BMI nor BF % when considering age and age/ethnicity.

Table 3.3 Linear regression for Three Factor Eating Questionnaire main categories correlation to body mass index and body fat percentage.

Model for BMI[a]		B	Std error β	95% CI β	Std'ised β	*P*-value
1	Intercept	24.8	1.58	21.7 27.9		< 0.001
	Disinhibition	0.60	0.11	0.38 0.83	0.33	< 0.001
	Restraint	-0.28	0.08	-0.45 -0.19	-0.17	0.003
	Hunger	0.07	0.13	-0.18 0.31	0.03	0.602
	Age	0.02	0.04	-0.06 0.09	0.02	0.655
	[a]F ratio 13.7 (4, 359), adjusted R^2 0.12, $p < 0.001$					
2	Intercept	17.3	1.56	14.2 20.3		< 0.001
	Disinhibition	0.66	0.10	0.46 0.85	0.36	< 0.001
	Restraint	-0.20	0.07	-0.34 -0.05	-0.12	0.007
	Hunger	-0.14	0.12	-0.36 0.08	-0.07	0.223
	Ethnicity	3.72	0.36	3.02 4.42	0.47	< 0.001
	Age	0.06	0.03	-0.00 0.13	0.08	0.066
	F ratio 36.0 (5, 358), adjusted R^2 0.33, $p < 0.001$					
Model for BF %[a]		**B**	**Std error β**	**95% CI β**	**Std'ised β**	***P*-value**
1	Intercept	29.4	1.82	25.9 33.0		< 0.001
	Disinhibition	0.78	0.13	0.52 1.34	0.36	< 0.001
	Restraint	-0.32	0.10	-0.51 -0.13	-0.17	0.001
	Hunger	-0.07	0.15	-0.36 0.21	-0.03	0.621
	Age	0.11	0.05	0.02 0.20	0.12	0.013
	[a]F ratio 15.8 (4, 363) adjusted R^2 0.14, $p < 0.001$					

Model for BF %[a]		B	Std error β	95% CI β	Std'ised β	*P*-value
2	Intercept	23.6	1.94	19.8 27.5		< 0.001
	Disinhibition	0.82	0.12	0.57 1.06	0.40	< 0.001
	Restraint	-0.26	0.09	-0.44 -0.08	-0.14	0.005
	Hunger	-0.23	0.14	-0.50 0.05	-0.09	0.103
	Age	0.14	0.04	0.06 0.23	0.16	0.001
	Ethnicity	2.88	0.44	2.01 3.75	0.31	< 0.001
	F ratio 22.8 (5, 363) adjusted R^2 0.23 $p < 0.001$					

Table 3.4 demonstrates the TFEQ sub-categories that can predict BMI and BF %. The first step-wise entry, for BMI, adjusted for age (Model 1 for BMI). Subsequently, when adjusting for both age and ethnicity (Model 2 of BMI) the sub-category scores accounted for approximately 34% of BMI (a 16% increase from Model 1). Moreover, Model 2 illustrated that Habitual Disinhibition and Emotional Disinhibition were the most significant predictors of BMI (both $p < 0.001$). For every point increase in Habitual Disinhibition and Emotional Disinhibition BMI increased by approximately 1.0 kg/m^2 and 1.1 kg/m^2, respectively. For the typical woman in this study this would result in a 0.36 kg and 0.39 kg weight increase for someone with Habitual Disinhibition and Emotional Disinhibition, respectively.

The first entry in the step-wise regression, for BF %, adjusted for age alone (Table 3.4, Model 1 for BMI). Following this, when adjusting for age and ethnicity (Model 2 for BF %), the behaviour scores accounted for approximately 24% of the BF % variance (a 7% increase from Model 1). Age ($p = 0.003$), ethnicity ($p < 0.001$), Habitual Disinhibition ($p < 0.001$) and Emotional Disinhibition ($p < 0.001$) were significant predictors of BF %. In terms of BF %, for every point increase in Habitual Disinhibition and Emotional Disinhibition BF % would increase by approximately 1.0% and 1.5%. For the typical woman in this study, every point increase in Habitual Disinhibition or Emotional Disinhibition would lead to BF % increasing from 35.5% to 36.5% and 37%, respectively. Energy intake was not a significant predictor of BMI or BF % for the TFEQ categories and sub-categories, and did not change and/or increase the adjusted R^2 value when added to the regression model (Appendix I and Appendix J).

Table 3.4 Linear regression for Three Factor Eating Questionnaire sub-categories correlation to body mass index and body fat percentage.

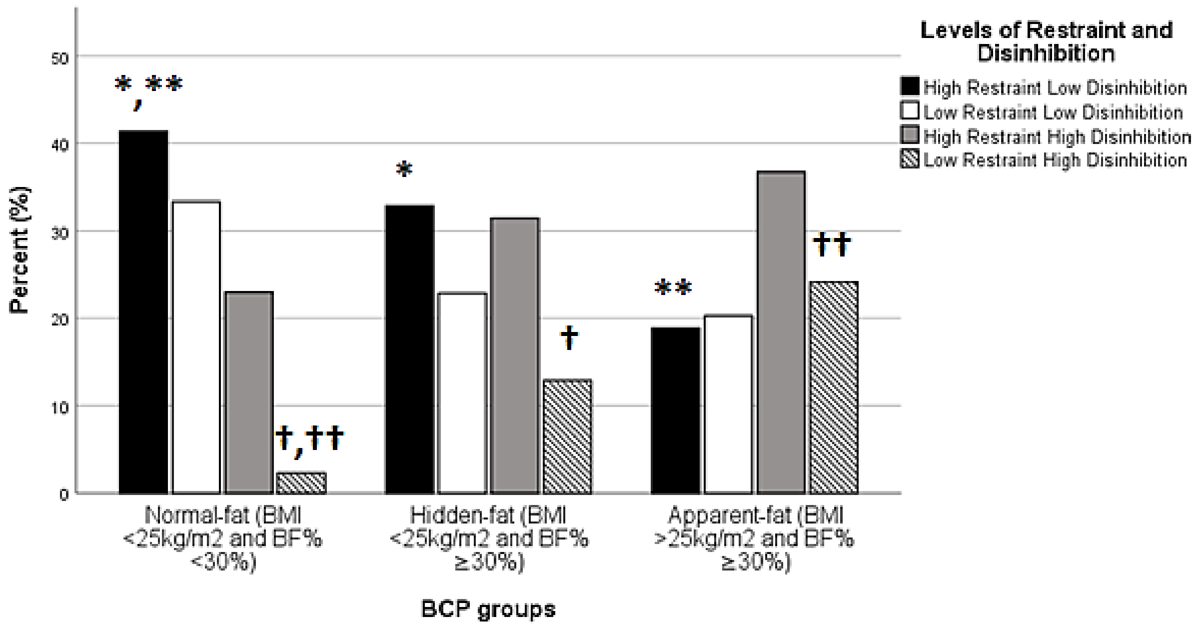
Model for BMI [a]		B	Std error β	95% CI β	Std'ised β	*P*-value
1	Intercept	27.9	1.56	24.8 31.0		< 0.001
	Habitual Disinhibition	1.43	0.27	0.90 1.96	0.32	< 0.001
	Emotional Disinhibition	0.60	0.32	-0.04 1.23	0.11	0.009
	Rigid Restraint	-0.50	0.23	-0.95 0.05	-0.13	0.030
	External Hunger	0.47	0.28	-0.08 1.02	-0.11	0.096
	Flexible Restraint	-0.35	0.23	-0.80 0.10	-0.09	0.128
	Situational Disinhibition	-0.45	0.30	-1.04 0.14	-0.09	0.132
	Internal Hunger	-0.14	0.22	-0.56 0.29	-0.04	0.523

Model for BMI [a]		B	Std error β	95% CI β	Std'ised β	*P*-value
	Age	-0.00	0.04	-0.08 0.07	-0.00	0.959
		[a] F ratio 10.2 (8, 363) adjusted R^2 0.19, $p < 0.001$				
2	Intercept	19.9	1.62	16.7 23.1		< 0.001
	Habitual Disinhibition	1.00	0.24	0.53 1.49	0.23	< 0.001
	Emotional Disinhibition	1.08	0.29	0.50 1.65	0.20	< 0.001
	Flexible Restraint	-0.34	0.20	-0.75 0.06	-0.09	0.093
	Situational Disinhibition	-0.26	0.27	-0.78 0.27	-0.05	0.336
	Internal Hunger	-0.15	0.19	-0.53 0.23	-0.04	0.450
	External Hunger	0.11	0.25	-0.39 0.60	0.25	0.673
	Rigid Restraint	-0.17	0.21	-0.58 0.24	-0.21	0.417
	Age	0.05	0.03	-0.02 0.11	0.03	0.180
	Ethnicity	3.55	0.37	2.83 4.27	0.37	< 0.001
		[a] F ratio 23.2 (9, 378) adjusted R^2 0.34, $p < 0.001$				
Model for BF % [b]		**B**	**Std error β**	**95% CI β**	**Std'ised β**	***P*-value**
1	Intercept	32.5	1.82	28.9 36.0		< 0.001
	Habitual Disinhibition	1.33	0.31	0.71 1.95	0.26	< 0.001
	Emotional Disinhibition	1.14	0.38	0.40 1.88	-0.13	0.003
	Rigid Restraint	-0.60	0.27	-1.12 -0.07	-0.13	0.027
	Flexible Restraint	-0.34	0.27	-0.86 0.19	-0.07	0.207
	Internal Hunger	-0.27	0.25	-0.77 0.23	-0.06	0.288
	External Hunger	0.35	0.33	-0.07 1.27	0.07	0.291
	Situational Disinhibition	-0.27	0.35	-0.95 0.41	-0.05	0.437
	Age	0.09	0.04	0.00 0.18	0.10	0.040
		[b] F ratio 10.1 (8, 363) adjusted R^2 0.17, $p < 0.001$				
2						
	Intercept	26.3	2.03	22.3 30.3		< 0.001
	Habitual Disinhibition	1.00	0.30	0.40 1.60	0.19	< 0.001
	Emotional Disinhibition	1.51	0.37	0.79 2.23	-0.08	< 0.001
	Rigid Restraint	-0.34	0.26	-0.85 0.17	-0.08	0.192
	Flexible Restraint	-0.33	0.25	-0.83 0.17	-0.07	0.193
	Internal Hunger	-0.27	0.24	-0.75 0.20	-0.06	0.256
	Situational Disinhibition	-0.12	0.33	-0.78 0.53	-0.02	0.713
	External Hunger	0.07	0.32	-0.55 0.69	0.01	0.828
	Age	0.13	0.04	0.04 0.21	0.14	0.003
	Ethnicity	2.72	0.50	1.82 3.62	0.29	< 0.001
		[b] F ratio 13.8 (9, 363) adjusted R^2 0.24, $p < 0.001$				

3.3.3 Sub-groups of Restraint and Disinhibition

The four sub-groups of Restraint and Disinhibition ranged High Restraint Low Disinhibition (ideal behaviour combination) to Low Restraint High Disinhibition (non-ideal behaviour combination). There was no significant difference between the sub-groups in terms of ethnicity (Appendix K.1), smoking status, having children nor drinking alcohol (Appendix K.2). However, women with High Restraint Low Disinhibition (ideal behaviour combination) were 3.5 times more likely to use hormonal contraception (p = 0.004, medium effect size) than those with Low Restraint High Disinhibition (non-ideal behaviour combination) (Appendix K.2).

Figure 3.2 shows the difference between the BCP groups in regards to the sub-groups of Restraint and Disinhibition. Women with normal-fat were 1.3 and 2.2 times more likely to have the idyllic High Restraint Low Disinhibition (41.5%) than those with hidden-fat (32.2%) or apparent-fat (19%) BCP's (p = 0.010, small effect sizes). In contrast, women with the apparent-fat profile were 1.7 and 12 times more likely to have adverse Low Restraint High Disinhibition (24%) than those with hidden-fat (13.5%) or normal-fat profiles (2.2%), respectively (p < 0.001, small to medium effect sizes), Overall, ideal tendencies of High Restraint Low Disinhibition and the non-ideal Low Restraint High Disinhibition significantly decreased and increased between normal-fat and hidden-fat profiles, respectively.



P-value determined by Chi-Square. *,**p = 0.010, $^{\dagger,\dagger\dagger}p$ < 0.001. BCP = Body composition profiles. High Restraint Low Disinhibition (ideal behaviour combination). Low Restraint High Disinhibition (non-ideal behaviour combination). Odds-ratio effect size are determined as small (1.5), medium (3.5) or large (9.0) when p < 0.05.

Figure 3.2 Sub-groups of Restraint and Disinhibition in relation to body composition profiles.

Table 3.5 shows women with High Restraint Low Disinhibition (ideal behaviour combination) were significantly younger ($p < 0.001$, small effect size) than their non-ideal behaviour counterpart. Moreover, a further analysis of body composition revealed that women with Low Restraint High Disinhibition (non-ideal behaviour combination) had significantly higher weight, WC, HC, WHR, WTHR, android fat (kg and %), gynoid fat (kg and %), and lower FFM (%) and lean mass (kg and %) than women with the ideal High Restraint Low Disinhibition behaviour combination (small to medium effect sizes) (Table 3.5). Likewise, women with Low Restraint High Disinhibition had significantly higher energy, protein (g), carbohydrate (g), starch, sugar, total fat (g), saturated fat (g and %), and monounsaturated fat (g) than those with High Restraint Low Disinhibition (small to medium effect sizes).

Table 3.5 Sub-groups of Restraint and Disinhibition in relation to participant characteristics.

Participant characteristic	High Restraint Low Disinhibition	Low Restraint Low Disinhibition	High Restraint High Disinhibition	Low Restraint High Disinhibition	*P*-value*
	N=88	N=99	N=62	N=119	
Age	28.9 ± 8.90^{a}	29.7 ± 9.36	30.7 ± 8.20	32.1 ± 7.60^{a}	< 0.001† *r* = 0.48
Body composition					
Basic					
Weight (kg)	71.3 ± 16.4$^{a, b}$	74.1 ± 16.7^{c}	80.0 ± 18.3^{a}	88.3 ± 20.3$^{b, c}$	< 0.001 *r* = 0.32
Height (cm)	166 ± 6.60	167 ± 6.10	167 ± 6.20	167 ± 6.80	0.676
BMI *High BMI ≥ 25 kg/m²*	25.7 ± 5.90$^{a, b}$	26.5 ± 6.10^{c}	28.6 ± 6.10$^{a, d}$	31.7 ± 7.60$^{b, c, d}$	< 0.001 *r* = 0.31
Abdominal adiposity					
WC (cm) *High WC > 80 cm*	78.9 ± 12.4$^{a, b}$	80.5 ± 12.6^{c}	85.3 ± 12.5$^{a, d}$	93.0 ± 14.7$^{b, c, d}$	< 0.001 *r* = 0.36
HC (cm) *High HC > 100 cm*	104 ± 11.0$^{a, b}$	106 ± 10.6^{c}	109 ± 11.9^{a}	114 ± 12.3$^{b, c}$	< 0.001 *r* = 0.29
WHR *High WHR > 0.80*	0.59 ± 0.10$^{a, b}$	0.62 ± 0.10^{c}	0.70 ± 0.10$^{b, d}$	0.80 ± 0.10$^{a, c, d}$	< 0.001 *r* = 0.33
WTHR *High WTHR > 0.50*	0.40 ± 0.10$^{a, b}$	0.50 ± 0.10^{c}	0.54 ± 0.10$^{b, d}$	0.60 ± 0.10$^{a, c, d}$	< 0.001 *r* = 0.35
Total adiposity					
ADP Fat mass (kg)	24.4 ± 12.1$^{a, b}$	25.9 ± 11.5^{c}	30.3 ± 12.9$^{a, d}$	36.7 ± 13.8$^{b, c, d}$	0.001 *r* = 0.33
ADP BF (%) *High BF % ≥30%*	32.9 ± 7.60$^{a, b}$	33.7 ± 7.20^{c}	36.6 ± 7.30^{a}	40.4 ± 6.90$^{b, c}$	< 0.001 *r* = 0.37
Adipose distribution					
Android fat (kg)	1.63 ± 1.01$^{a, b}$	1.79 ± 0.99^{c}	2.06 ± 1.00$^{a, d}$	2.63 ± 1.20$^{b, c, d}$	< 0.001 *r* = 0.31
Android fat (%)[1]	32.7 ± 7.90^{a}	34.0 ± 6.90^{b}	34.9 ± 6.90^{c}	38.8 ± 7.20$^{a, b, c}$	< 0.001 *r* = 0.27
Gynoid fat (kg)	4.46 ± 1.52$^{a, b}$	4.68 ± 1.44^{c}	5.09 ± 1.55$^{a, d}$	5.76 ± 1.68$^{b, c, d}$	< 0.001 *r* = 0.28
Gynoid fat (%)[1]	37.4 ± 4.90^{a}	37.7 ± 4.50	38.2 ± 4.40	39.9 ± 4.30^{a}	0.016 *r* = 0.21
Non-adipose mass					

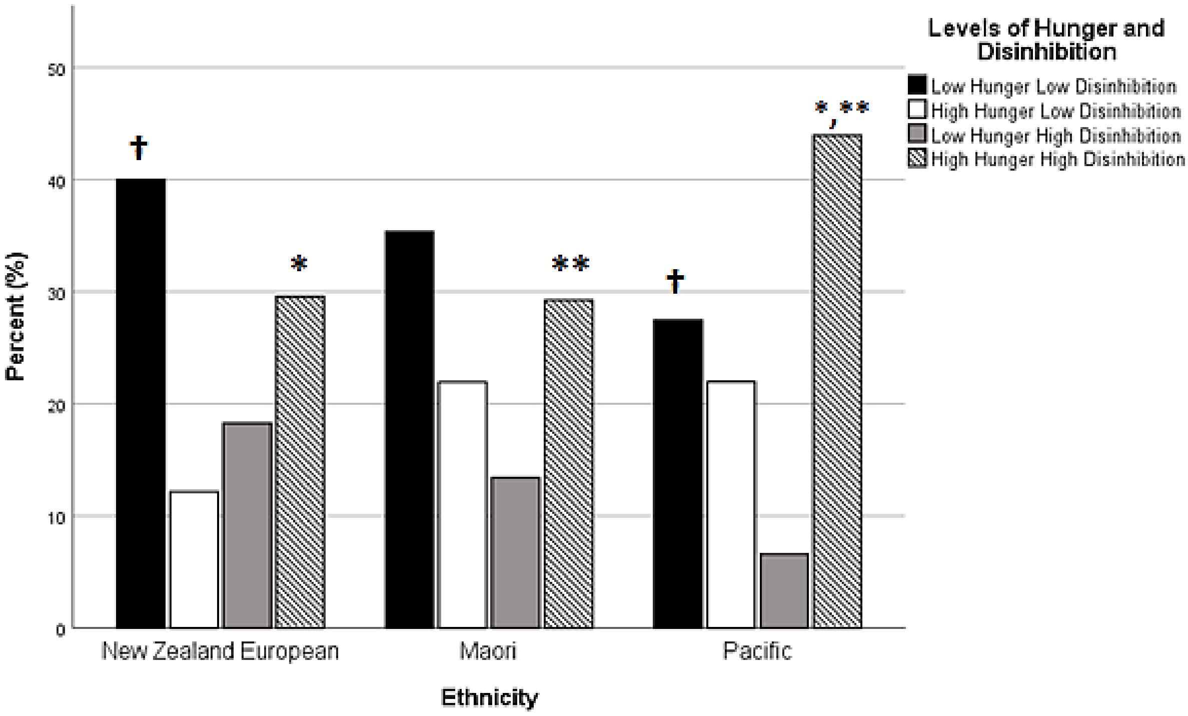
Participant characteristic	High Restraint Low Disinhibition	Low Restraint Low Disinhibition	High Restraint High Disinhibition	Low Restraint High Disinhibition	*P*-value*
	N=88	N=99	N=62	N=119	
ADP FFM (kg)	46.9 ± 6.70 [a]	48.2 ± 6.70 [b]	49.7 ± 7.10	51.6 ± 8.10 [a, b]	< 0.001 *r* = 0.24
ADP FFM (%)	67.1 ± 7.60 [a, b]	66.3. ± 7.20 [c]	63.4 ± 7.30 [a, d]	59.6 ± 6.90 [b, c, d]	< 0.001 *r* = 0.37
DXA WB total lean mass (kg)	48.0 ± 7.60 [a, b]	49.5 ± 8.10 [c]	52.0 ± 8.60 [a]	54.9 ± 9.30 [b, c]	< 0.001 *r* = 0.28
DXA WB total lean mass (%)	67.5 ± 5.93 [a, b]	66.9 ± 5.32 [c]	65.6 ± 5.21 [b]	63.1 ± 5.11 [a, c]	< 0.001 *r* = 0.28
Dietary intake					
Energy (kJ)	8,486 ± 3,157 [a]	9,634 ± 3,17 [b]	9,890 ± 4,145 [c]	11,478 ± 4,515 [a, b, c]	< 0.001 *r* = 0.30
Protein (g)	92.6 ± 37.5 [a]	99.5 ± 36.8	106 ± 42.0	116 ± 47.0 [a]	0.003 *r* = 0.23
Protein (%)[2]	18.6 ± 3.80	17.4 ± 2.92	18.3 ± 3.32	17.4 ± 3.79	0.287
Carbohydrate (g)	216 ± 92.8 [a]	251 ± 100	245 ± 131 [b]	290 ± 128 [a, b]	0.001 *r* = 0.30
Carbohydrate (%)[2]	42.5 ± 7.47	43.7 ± 6.67	40.8 ± 8.38	42.1 ± 6.47	0.229
Starch (g)	102 ± 52.8 [a]	123 ± 58.4	120.7 ± 83.0	143 ± 64.3 [a]	0.001 *r* = 0.31
Sugar (g)	114 ± 53.8 [a]	128 ± 60.5	124 ± 62.6	147 ± 78.4 [a]	0.011 *r* = 0.22
Total fat (g)	78.9 ± 30.3 [a, b]	89.6 ± 30.7 [c]	96.1 ± 42.1 [b, d]	115 ± 49.2 [a, c, d]	< 0.001 *r* = 0.31
Total fat (%)[2]	35.2 ± 6.58 [a]	35.3 ± 5.57	37.0 ± 7.44	37.9 ± 5.61 [a]	0.079
Saturated fat (g)	29.8 ± 12.2 [a]	34.9 ± 12.2 [b]	36.6 ± 18.1 [c]	49.1 ± 23.0 [a, b, c]	< 0.001 *r* = 0.35
Saturated fat (%)[2]	13.4 ± 3.60 [a]	14.2 ± 2.76	14.7 ± 4.20	16.2 ± 3.47 [a]	0.001 *r* = 0.27
Monounsaturated fat (g)	26.7 ± 10.3 [a]	29.8 ± 9.90 [b]	31.5 ± 13.0	38.4 ± 17.1 [a, b]	< 0.001 *r* = 0.29
Polyunsaturated fat (g)	12.8 ± 5.60	12.2 ± 4.40	13.1 ± 5.00	14.7 ± 6.70	0.096

Presented as Mean±SD. [1] Derived from a percentage of total android or gynoid mass. [2] Derived from a percentage of total energy intake. †*P*-value determined by one-way ANOVA analysis. BMI Body mass index; WB Whole body; ADP Air displacement plethysmography; WC Waist circumference; HC Hip circumference; WTHR Waist to hip ratio; BF % Body fat percentage; DXA Dual x-ray absorptiometry. High WC, HC, WHR and WTHR based on female cut-offs (Mahan and Raymond, 2017, Lee and Nieman, 2007). **P*-value determined by ANOCVA analysis (controlling for age and use of hormonal contraception). [a-d] Values with the same superscript letters are significantly different according to the Tukey post-hoc test and Bonferroni correction when $p < 0.05$. $r = 0.1$ (small effect size), $r = 0.3$ (medium effect size), $r = 0.5$ (large effect size) when $p < 0.05$.

3.3.4 Sub-groups of Hunger and Disinhibition

The four sub-groups of Hunger and Disinhibition ranged from Low Hunger Low Disinhibition (ideal behaviour combination) to High Hunger High Disinhibition (non-ideal behaviour combination). Women who used hormonal contraception were 2.3 times more likely to have Low Hunger Low Disinhibition (ideal behaviour combination) than those with High Hunger High Disinhibition (non-ideal behaviour combination) ($p = 0.015$, small effect size) (Appendix L). In contrast smoking status, drinking alcohol and having children were not significantly associated with levels of Hunger and Disinhibition (Appendix L).

Figure 3.3 shows the difference between the ethnic groups in regards to the sub-groups of Hunger and Disinhibition. In particular, NZE women were 1.4 times more likely to have significantly higher Low Hunger Low Disinhibition (ideal behaviour combination) (40%) than Pacific women (27.8%) ($p < 0.001$, small effect size). Likewise, Pacific women were 1.4 times more likely to have High Hunger High Disinhibition (non-ideal behaviour combination) (43.5%) than either NZE or Māori women (30% and 29.9% respectively) ($p = 0.023$, small effect size). Overall, Pacific women had the lowest rates of the idyllic Low Hunger Low Disinhibition combination and the highest rates of the non-ideal behaviour combination High Hunger High Disinhibition, whereas NZE women had the opposite.

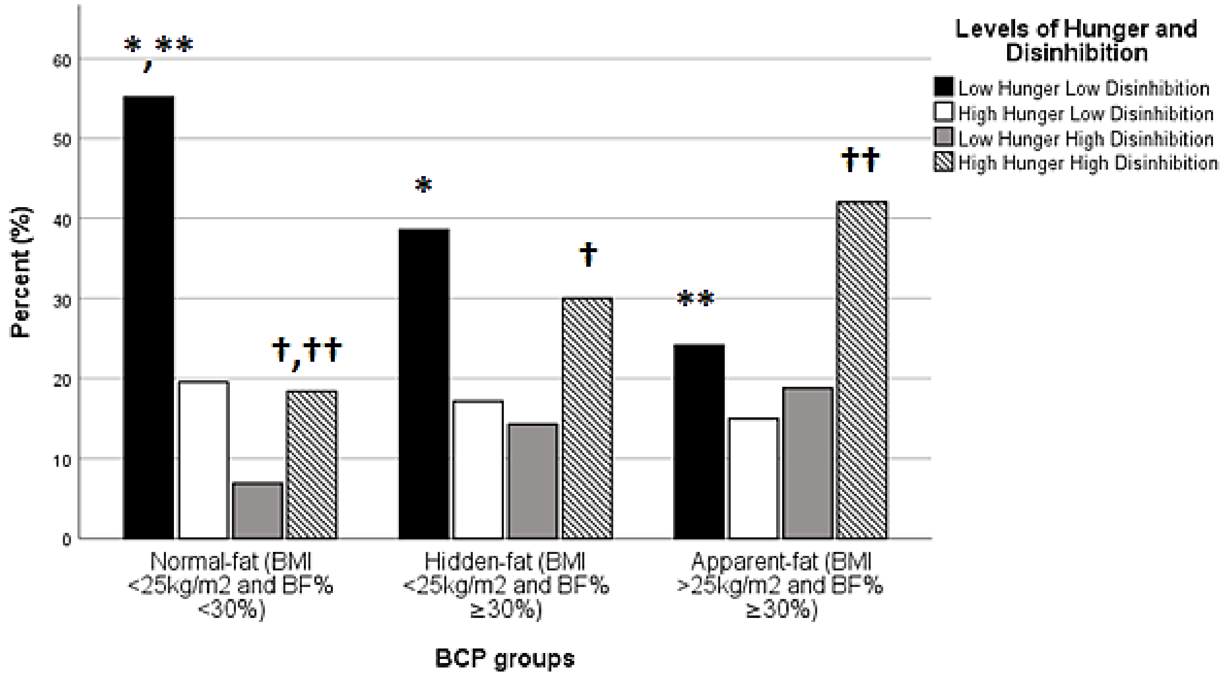


P-value determined by Chi-Square. † $p < 0.001$, *, ** $p = 0.023$. Low Hunger Low Disinhibition (ideal behaviour combination. High Hunger High Disinhibition (non-ideal behaviour combination. Odds-ratio effect size are determined as small (1.5), medium (3.5) or large (9.0) when $p < 0.05$.

Figure 3.3 Sub-groups of Hunger and Disinhibition in relation to ethnicity.

Figure 3.4 shows the different Hunger and Disinhibition sub-groups in relation to BCP's. Women with normal-fat were 1.4 and 2.3 times more likely to have higher Low Hunger Low Disinhibition (ideal behaviour combination) (55%) compared to hidden-fat (39%) and apparent-fat profiles (24%), respectively ($p < 0.001$, small effect sizes). Likewise, women with apparent-fat were 1.4 and 2.2 times more likely to have High Hunger High Disinhibition (non-ideal behaviour combination) (42%) than hidden-fat (30%) or normal-fat (19%), respectively. Moreover, ideal tendencies of Low Hunger Low

Disinhibition and non-ideal tendencies High Hunger High Disinhibition significantly decreased ($p < 0.001$) and increased ($p = 0.004$), respectively, between normal-fat and hidden-fat profiles.



P-value determined by Chi-Square. *,** $p < 0.001$, † $p = 0.004$. BCP = Body composition profiles. Low Hunger Low Disinhibition (ideal behaviour combination). High Hunger High Disinhibition (non-ideal behaviour combination). Odds-ratio effect size are determined as small (1.5), medium (3.5) or large (9.0) when $p < 0.05$.

Figure 3.4 Sub-groups of Hunger and Disinhibition in relation to body composition profiles.

Table 3.6 shows that women with High Hunger High Disinhibition (non-ideal behaviour combination) were significantly older that their ideal behaviour combination counterpart ($p < 0.001$, medium effect size). Furthermore, an analysis of anthropometric and body composition measures (Table 3.6) showed that women with High Hunger High Disinhibition (non-ideal behaviour combination) had significantly higher weight, WC, HC, WHR, WTHR, android fat (kg and %), gynoid fat (kg) and significantly lower FFM (%) and lean mass (%) than those with Low Hunger Low Disinhibition (ideal behaviour combination) (small to large effect sizes). Likewise, women with the non-ideal tendencies of High Hunger High Disinhibition had significantly higher energy, protein (g), carbohydrate (g), starch, sugar, total fat (g), saturated fat (g and %), monounsaturated fat and polyunsaturated fat than women with the optimal tendency of Low Hunger Low Disinhibition (small to medium effect sizes) (Table 3.6).

Table 3.6 Sub-groups of Hunger and Disinhibition in relation to participant characteristics.

Participant characteristics	Low Hunger Low Disinhibition	High Hunger Low Disinhibition	Low Hunger High Disinhibition	High Hunger High Disinhibition	*P*-value*
	N= 126	N= 61	N= 56	N=125	
Age (years)	27.2 ± 6.84 [a, b]	29.1 ± 9.36	30.9 ± 8.20 [a]	32.0 ± 9.20 [b]	< 0.001† *r* = 0.39
Body composition					
Basic					
Weight (kg)	70.7 ± 16.4 [a, b]	76.6 ± 16.2 [c]	78.7 ± 13.5 [b]	84.6 ± 21.2 [a, c]	< 0.001 *r* = 0.31
Height (cm)	166 ± 6.30	168 ± 6.30	168 ± 5.80	167 ± 6.60	0.070
BMI *High BMI ≥25kg/m²*	25.7 ± 6.30 [a]	26.9 ± 5.20 [b]	27.9 ± 5.20	30.4 ± 7.30 [a, b]	< 0.001 *r* = 0.30
Abdominal adiposity					
WC (cm) *High WC >80cm*	78.6 ± 12.9 [a]	81.9 ± 11.3 [b]	84.7 ± 10.6	89.3 ± 14.7 [a, b]	< 0.001 *r* = 0.34
HC (cm) *High HC >100cm*	104 ± 11.3 [a]	108 ± 9.50	109 ± 9.10	112 ± 13.4 [a]	< 0.001 *r* = 0.28
WHR *High WHR >0.80*	0.64 ± 0.09 [a]	0.71 ± 0.10 [b]	0.77 ± 0.08	0.80 ± 0.10 [a, b]	< 0.001 *r* = 0.32
WTHR *High WTHR >0.50*	0.31 ± 0.07 [a]	0.37 ± 0.10 [b]	0.42 ± 0.09	0.50 ± 0.10 [a, b]	< 0.001 *r* = 0.33
Total adiposity					
ADP Fat mass (kg)	24.2 ± 12.3 [a, b]	26.8 ± 10.7 [c]	29.9 ± 10.0 [b]	33.7 ± 14.7 [a, c]	< 0.001 *r* = 0.32
ADP BF (%) *High BF % ≥30%*	32.9 ± 7.70 [a, b]	34.0 ± 6.8 [c]	37.1± 6.60 [a]	38.3 ± 7.60 [b, c]	< 0.001 *r* = 0.33
Adipose distribution					
Android fat (kg)	1.66 ± 1.06 [a]	1.80 ± 0.87 [b]	2.09 ± 0.85	2.33 ± 1.19 [a, b]	< 0.001 *r* = 0.27
Android fat (%)[1]	33.0 ± 7.70 [a]	34.0 ± 6.8	35.7 ± 6.70	36.4 ± 7.40 [a]	0.003 *r* = 0.20
Gynoid fat (kg)	4.45 ± 1.48 [a]	4.82 ± 1.47	5.05 ± 1.29	5.44 ± 1.75 [a]	< 0.001 *r* = 0.25
Gynoid fat (%)[1]	37.5 ± 4.60 [a]	37.6 ± 4.90	38.5 ± 4.90	38.9 ± 4.20 [a]	0.165
Non-adipose mass					
ADP FFM (kg)	46.4 ± 6.30 [a]	49.8 ± 7.00	48.9 ± 5.40	51.0 ± 8.10 [a]	< 0.001 *r* = 0.28
ADP FFM (%)	67.1 ± 7.70 [a, b]	66.0 ± 6.80 [c]	62.9 ± 6.60 [a]	61.7 ± 7.7 [b, c]	< 0.001 *r* = 0.33
DXA WB total lean mass (kg)	47.5 ± 7.20 [a, b]	51.4 ± 8.50	51.8 ± 7.00 [a]	53.5 ± 9.70 [b]	< 0.001 *r* = 0.30
DXA WB total lean mass (%)	67.3 ± 5.84 [a]	66.0 ± 5.24	65.5 ± 5.00	64.4 ± 5.42 [a]	0.001 *r* = 0.50
Dietary intake					
Energy (kJ)	8,554 ± 3,120 [a]	10,113 ± 3,171	8,540 ± 2,825 [b]	11,284 ± 4,622 [a, b]	< 0.001 *r* = 0.36
Protein (g)	92.0 ± 36.9 [a]	105 ± 36.9	94.6 ± 39.4 [b]	116 ± 44.3 [a, b]	0.001 *r* = 0.28
Protein (%)[2]	18.2 ± 3.66	17.5 ± 2.63	18.5 ± 3.40	17.7 ± 3.48	0.343

Participant characteristics	Low Hunger Low Disinhibition	High Hunger Low Disinhibition	Low Hunger High Disinhibition	High Hunger High Disinhibition	*P*-value*
	N= 126	N= 61	N= 56	N=125	
Carbohydrate (g)	218 ± 93.5 [a]	267 ± 99.6	200 ± 70.3 [b]	288 ± 144 [a, b]	< 0.001 *r* = 0.37
Carbohydrate (%)[2]	42.5 ± 7.80	44.1 ± 4.99 [a]	39.9 ± 8.90 [a]	41.9 ± 7.20	0.096
Starch (g)	102 ± 50.1 [a]	137 ± 62.3 [b]	95.4 ± 37.9 [b]	143 ± 86.7 [a, b]	< 0.001 *r* = 0.38
Sugar (g)	116 ± 56.9 [a]	130 ± 55.6	104 ± 45.5 [b]	144 ± 74.3 [a, b]	< 0.001 *r* = 0.24
Total fat (g)	79.6 ± 31.0 [a]	92.0 ± 28.4	86.5 ± 40.5 [b]	110 ± 45.7 [a, b]	< 0.001 *r* = 0.33
Total fat (%)[2]	35.2 ± 6.68	35.4 ± 4.58	37.8 ± 8.46	37.1 ± 6.06	0.086
Saturated fat (g)	30.3 ± 12.8 [a]	37.1 ± 9.70	35.3 ± 20.2	43.3 ± 20.4 [a]	< 0.001 *r* = 0.31
Saturated fat (%)[2]	13.5 ± 3.31 [a]	14.7 ± 2.65	15.8 ± 5.02 [a]	15.1 ± 3.40	0.014 *r* = 0.25
Monounsaturated fat (g)	27.0 ± 10.8 [a]	31.6 ± 7.40	30.0 ± 14.5	35.6 ± 14.5 [a]	< 0.001 *r* = 0.28
Polyunsaturated fat (g)	12.1 ± 5.30 [a]	13.8 ± 4.10	11.9 ± 5.2	14.5 ± 5.50 [a]	0.004 *r* = 0.21

Presented as Mean±SD. [1] Derived from a percentage of total android or gynoid mass. [2] Derived from a percentage of total energy intake. WC Waist circumference; HC Hip circumference; WTHR Waist to hip ratio; BF Body fat; FFM Fat free mass; DXA Dual x-ray absorptiometry; WB Whole body. High WC, HC, WHR and WTHR based on female cuts offs (Mahan and Raymond, 2017, Lee and Nieman, 2007). †*P*-value determined by one-way ANOVA analysis. WB Whole body; BMI Body mass index; ADP Air displacement plethysmography; **P*-value determined by ANOCVA analysis (controlling for age, ethnicity and use of hormonal contraception) within each level of Restraint and Hunger. [a-c] Values with the same superscript letters are significantly different according to the Tukey post-hoc test and Bonferroni correction when $p < 0.05$. $r = 0.1$ (small effect size), $r = 0.3$ (medium effect size), $r = 0.5$ (large effect size) when $p < 0.05$.

3.4 Discussion

The aim of this sub-study was to investigate eating behaviour as predictors of different body composition factors and dietary intake in post-menarche and pre-menopausal New Zealand European, Māori and Pacific women, aged 16-45 years participating in the women's EXPLORE study.

3.4.1 Restraint

The total Restraint score for all women was high (score of 9 (6, 12)). This was similar to other New Zealand based (Kruger et al., 2016) and international studies (Provencher et al., 2003, Drapeau et al., 2005) examining young women with both normal and high BMI (scores of 9 (6, 12); 8.4±4.7 and 9.3 (3, 16), respectively). Significantly higher Restraint was observed in NZE compared to Pacific women (p = 0.015), which was supported by NZE women having significantly lower energy, protein (g), carbohydrate (g), starch (g), total fat (g), and saturated fat (g) intake than Pacific women (all $p < 0.05$). The high dietary intakes of Pacific women has been a common theme in other New Zealand ethnic dietary studies (Beck et al., 2017, Schrijvers et al., 2016). Restraint scores were high across all BCP groups and not significantly different (p = 0.148). This finding was similar to the relationship between normal and high BMI (p = 0.845) and BF % (p = 0.128) groups in Kruger et al. (2016). Some studies have suggested that Restraint can be an insensitive predictor of body composition in overweight and obese individuals (Provencher et al., 2003, French et al., 2014, Kruger et al., 2016, de Lauzon-Guillain et al., 2006), which could suggest the lack of significance observed between BCP groups in this study. In view of this, our study showed that Restraint was a significant, inverse predictor of BMI (B = -0.20, $ß$ = 0.07, [95% CI -0.34, -0.05], p = 0.007) and BF % (B = -0.26, $ß$ = 0.09, [95% CI -0.44, -0.08], p = 0.015), when accounting for age and ethnicity. Studies that found similar, inverse BMI results (Bellisle et al., 2004, Lesdema et al., 2012, Park et al., 2016, Zhao et al., 2017, Brown et al., 2014), attributed their findings to low levels of eating impulsivity (Coffino et al., 2016); slower eating rates that reflect lower energy intake (Shah et al., 2014) and a generally healthy diet (Goulet et al., 2008). Comparably, our findings were dissimilar to Kruger et al. (2016), who found Restraint was not a significant predictor of BMI (p = 0.340) nor BF % (p = 0.110). However, this could be due to their smaller sample size (N=116) and lack of ethnic diversity (87% NZE women).

Flexible Restraint was low across all women (3 (2, 4)). This aligned with previous studies, with similar gender and body composition parameters, reporting scores of (3 (2, 4)) (Kruger et al., 2016); 3.0±1.8 (Provencher et al., 2003) and 2.9±0.1 (Lesdema et al., 2012). There was no significant difference between Flexible Restraint and ethnicity (p = 0.507), which implies that it is not increased Flexible Restraint that caused the general decreased dietary intake in certain ethnic groups, such as NZE. Furthermore, Flexible Restraint was significantly higher in those with normal-fat versus apparent-fat profiles (p = 0.005). Although this aligns with the notion that Flexible Restraint is more common in healthier body compositions, typically seen in German studies (Westenhoefer et al., 2013, Zyriax et al., 2012), all scores were low across the three BCP's (scores of 2-3). Therefore, this questions whether the normal-fat profile individuals (with the highest of the low score) were in fact exhibiting a healthy diet pattern, which is commonly associated with this trait (Berg et al., 2018, Westenhoefer et al., 2013). The low scores across the total, ethnic and BCP groups could explain why Flexible Restraint was not considered a significant predictor of BMI (p = 0.093, respectively), nor BF % (p = 0.193, respectively) when accounting for age and ethnicity. These findings were similar to Kruger et al. (2016) (BMI p = 0.064 and BF % p = 0.079), which suggest Flexible Restraint is not prominent in New Zealand women.

The average Rigid Restraint score was low (3 (1, 4)) in this study. Other studies with women of similar body composition, also reported low scores; 3 (2, 4) (Kruger et al., 2016); 2.3±1.8 (Provencher et al., 2003) and 1.9±0.1 (Lesdema et al., 2012). From an ethnic perspective, NZE women had significantly higher Rigid Restraint than Māori and Pacific women (p < 0.001). This heightened level of restriction was also represented in the dietary data with NZE women having significantly lower intakes of energy, protein (g), carbohydrate (g), starch (g), total fat (g) and saturated fat (g) than Pacific women. This notion has been supported by Metcalf et al. (2008) who found portion sizes and serving sizes in NZE were significantly lower than Pacific counterparts, and Beck et al. (2017) who showed that a "healthy eating pattern" was associated with being of NZE ethnicity. However, neither of these studies demonstrated whether it was due to Rigid Restraint. In our study, no significant difference was observed between the BCP groups and Rigid Restraint (p = 0.082), contrary to previous German research showing that Rigid Restraint has been linked with an adverse BMI and BF % (Westenhoefer et al., 1999, Westenhoefer et al., 2013, Zyriax et al., 2012). When accounting for both age and ethnicity, Rigid Restraint was not a significant predictor of BMI (p = 0.417) nor BF % (p = 0.192) in our study. This was a similar finding to Kruger et al. (2016) (BMI p = 0.661, BF % p = 0.970) and could suggest why there was no significant difference between the BCP's either.

3.4.2 Disinhibition

The overall Disinhibition score for the women in this study was high (8 (5, 11)); considerably higher than previous studies with similar gender and body composition parameters, reporting lower scores of 5.8±3.3 (Provencher et al., 2003); 6 (4, 9) (Kruger et al., 2016); 6.7±0.2 (Lesdema et al., 2012) and 7.6 (2, 13) (Drapeau et al., 2005). There was no significant difference between ethnic groups for Disinhibition (moderately high/high scores of 7-8, p = 0.778), which implies that it is not increased Disinhibition that caused the general increased dietary intake in certain ethnic groups, such as Pacific. Moreover, Disinhibition scores increased with the increase in BMI and BF % in BCPs, from the normal-fat to apparent-fat profile ($p < 0.001$), which was similar to relationship between the normal and high BMI ($p < 0.001$) and BF % groups (p = 0.003) in Kruger et al. (2016). This trend could explain why Disinhibition was the most significant TFEQ category predictor of BMI (B = 0.66, *ß* = 0.10 [95% CI 0.46, 0.85], $p < 0.001$) and BF % (B = 0.82, *ß* = 0.12 [95% CI 0.57, 1.06], $p < 0.001$) when accounting for age and ethnicity. In particular, our findings were very similar to Kruger et al. (2016) who also found Disinhibition to be a significant predictor of BMI (B = 0.40, *ß* = 0.10 [95% CI 0.21, -0.59], $p < 0.001$) and BF % (B = 0.82, *ß* = 0.12 [95% CI 0.57, 1.06], $p < 0.001$) in young NZ women, however their regressions did not adjust for age or ethnicity. Other studies from England, Switzerland, Prague, the United States of America and Canada have also demonstrated that Disinhibition was the most significant predictor of BMI (Dykes et al., 2004, Ernst et al., 2015, Painchaud Guerard et al., 2016, Wagenknecht et al., 2007) and BF % (Mailloux et al., 2014, Lawson et al., 1995). Some of which have likened the increase in Disinhibition and body composition to individuals having large portion sizes and rapid eating rates (Smith et al., 1998) and excessive consumption of high-caloric, nutrient-poor foods (Bryant et al., 2008). Although this study did not explore these factors, some similarity could be resembled to the energy and dietary intake, which was generally higher in the apparent-fat profile compared to the normal-fat profile.

Women in this study had a generally low Habitual Disinhibition score (1 (0, 2)), similar to previous studies with scores of 1 (0, 2) (Kruger et al., 2016); 1.1±1.3 (Provencher et al., 2003) and 1.2±0.1 (Lesdema et al., 2012). Both Pacific and apparent-fat profile women had significantly higher Habitual Disinhibition than NZE and normal-fat profile women ($p < 0.001$ and $p = 0.023$, respectively), however all score were considered low. This therefore questions whether the generally higher dietary intake and body composition, associated with Pacific and apparent-fat profile women, was in fact secondary to Habitual Disinhibition. In addition, Kruger et al. (2016) did not show a significant difference between normal and high BMI ($p = 0.071$) and BF % ($p = 0.336$). Despite the low scores across ethnic and BCP groups, Habitual Disinhibition was a significant predictor of BMI (B = 1.00, $ß = 0.24$ [95% CI 0.53, 1.49], $p < 0.001$) and BF % (B = 1.00, $ß = 0.30$, [95% CI 0.40, 1.60], $p < 0.001$) when accounting for age and ethnicity. This means that although the scores were low, Habitual Disinhibition should be monitored closely. This BMI and BF% findings were dissimilar to Kruger et al. (2016) ($p = 0.108$ and $p = 0.266$, respectively) but aligned with other international studies with similar gender/body composition parameters (Barkeling et al., 2007, Hays and Roberts, 2008, Lesdema et al., 2012), indicating that Habitual Disinhibition is an important predictor of a high body composition.

Emotional Disinhibition was generally low in women (1 (0, 2), which aligned with previous studies (Kruger et al., 2016, Lesdema et al., 2012, Provencher et al., 2003) with low scores (1 (0, 2); 1.6±0.1; 1.4±1.3, respectively). Moreover, there was no ethnic differences between Emotional Disinhibition scores ($p = 0.122$), suggesting that Emotional Disinhibition was equally low across ethnic groups. Women had significantly higher scores in the apparent-fat (2 (0, 3) versus normal-fat (0 (0, 2) profiles ($p < 0.001$). Although this finding aligns with previous British and American studies (Hays and Roberts, 2008, Hootman et al., 2018) (who examined women aged 55-65 and 18-24, respectively) the nature of the low scores questions whether the apparent-fat profile individuals (with the highest of the low scores) were in fact exhibiting eating secondary to heightened stress, depression, sadness and loneliness (Kim et al., 2016, Loffler et al., 2015a). Similarly, Kruger et al. (2016) also found Emotional Disinhibition was significantly higher in groups with a high BMI ($p = 0.003$) and high BF % ($p = 0.023$) despite low scores. With this in mind, Emotional Disinhibition was a significant predictor of BMI when accounting for age and ethnicity (B = 1.08, $ß = 0.29$, [95% CI 0.50, 1.65], $p < 0.001$). This aligned with other international studies with similar gender/BMI parameters (Hootman et al., 2018, Hays and Roberts, 2008), but was dissimilar to Kruger et al. (2016) ($p = 0.061$). This could be because of their small sample size (N=116) or the fact that their sample size comprised of 87% NZE women (who, in this study, have lower Emotional Disinhibition). Moreover, this study showed that Emotional

Disinhibition was a significant predictor of BF % when accounting for age and ethnicity (B = 1.51, *ß* = 0.37, [95% CI 0.79 2.23], $p < 0.001$), which aligned with Kruger et al. (2016) (B = 1.59, *ß* = 0.71, [95% CI 0.18, -3.00], $p = 0.028$) and could be because the average BF % in their study was similar to ours (30.5% and 35.5%, respectively).

Situational Disinhibition was high across women in this study (3 (2, 4), which was similar to Kruger et al. (2016) (3 (1.3, 4) Lesdema et al. (2012) (2.3±0.1), yet differed from Provencher et al. (2003) (1.9±1.5). The high scores were consistent across ethnic and BCP groups and there was no significant difference observed ($p = 0.961$ and $p = 0.060$, respectively). This implies that social gatherings and the food micro-environment can exacerbate adverse eating behaviour (Egger and Swinburn, 1997, Michimi and Wimberly, 2015, Bond et al., 2001) regardless of ethnicity or BCP. In contrast, Kruger et al. (2016) found women with a high BMI and BF % had significantly higher Situational Disinhibition scores than their normal counterparts ($p = 0.006$ and $p = 0.003$, respectively). This could be because more of a significant difference was detected amongst their smaller sample size. Because Situational Disinhibition was high throughout BCP groups, this may explain why it was not considered a significant predictor of BMI or BF % when accounting for age and ethnicity ($p = 0.336$ and $p = 0.713$). These findings align with those of Kruger et al. (2016) who also reported that it was not a significant predictor of BMI ($p = 0.250$) or BF % ($p = 0.506$).

3.4.3 Hunger

The average Hunger score for the women in this study was high (6 (4, 8)), compared to previous studies with similar gender and BMI parameters, with lower scores5 (3, 7.8) (Kruger et al., 2016); 5±0.2 (Lesdema et al., 2012) and 3.9±3.1 (Provencher et al., 2003). From an ethnic perspective, Pacific women had significantly higher Hunger scores (7 (5, 7) than NZE (5 (3, 7) ($p < 0.001$). This may explain why Pacific women had significantly higher protein (g), carbohydrate (g), starch (g), total fat (g), saturated fat (g), monounsaturated fat (g) and polyunsaturated fat (g) intake than NZE women (all $p < 0.001$). A similar intake vs ethnicity pattern comparison has also been observed in previous New Zealand based studies (Metcalf et al., 2008, Metcalf et al., 2014), but has not yet been linked with TFEQ Hunger scores. Women with the apparent-fat profile had significantly higher Hunger scores than women with the normal-fat profile ($p < 0.001$). Thomas et al. (2013) obtained similar Hunger results in American men and women, with a high BMI, and attributed this to higher food cravings and increased food appeal than their normal BMI counterparts. However, Hunger was not a significant predictor of individual BMI or BF % in our study, when controlling for age ($p = 0.602$ and $p = 0.621$, respectively) nor both age and ethnicity ($p = 0.223$ and $p = 0.103$, respectively). This is in contrast to previous British and American studies (Yeomans and McCrickerd, 2017, Bathalon et al., 2000) that found Hunger to be a significant predictor of BMI ($p < 0.001$ and $p < 0.05$, respectively) in women.

However, our results aligned with those of Kruger et al. (2016) who also found that Hunger was not significantly associated with BMI (p = 0.360) nor BF % (p = 0.720) in New Zealand women.

Internal Hunger was low (2 (1, 4)) across all women in this study, similar to previous studies reporting low scores of 2 (1, 3) (Kruger et al., 2016); 1.8±0.1 (Lesdema et al., 2012) and 1.4±1.7 (Provencher et al., 2003) in women. Pacific women (3 (2, 4) had significantly higher Internal Hunger than NZE women (2 (1, 3) (p = 0.040). However, because both scores are considered low there is uncertainty as to whether the generally higher dietary intake and body composition measures, observed in these Pacific women, was due to increased Internal Hunger cues. All BCP groups had low scores (scores of 2) and no significant difference was observed (p = 0.295). Similarly, Kruger et al. (2016) also found Internal Hunger to be low and insignificant between normal and high BMI groups (p = 0.063) and BF % groups (p = 0.554). This indicates that Internal Huger is consistently low across body compositions, which aligns with Brown et al. (2014) who demonstrated that ghrelin levels (a hunger stimulating hormone) did not differ between normal BMI and high BMI groups (p = 0.319). Likewise, this could explain why Internal Hunger was not considered a significant predictor of BMI or BF % when adjusting for age and ethnicity (p = 0.450 and p = 0.256, respectively), similar to Kruger et al. (2016) (p = 0.526 and p = 0.368, respectively).

External Hunger was generally low across all women (2 (1, 3)), which was similar to Kruger et al. (2016) (2 (1, 3)); Lesdema et al. (2012) (2.3±0.1) and Provencher et al. (2003) (1.7±1.5). Pacific women had significantly higher External Hunger than NZE women (p < 0.001), however both scores were considered low (2(1, 3) and 3(2, 4), respectively). Therefore, we cannot conclude that the general heightened body composition and dietary intake, generally observed in the Pacific women, was entirely due to increased External Hunger. Moreover, women with hidden-fat and apparent-fat profiles had significantly higher scores than women with normal-fat profiles (p < 0.001), suggesting hunger from external cues (e.g. delicacies, buffets) can vary across BCP's. Although this aligns with previous studies (Dykes et al., 2004, Yeomans and McCrickerd, 2017) (who examined N=1,470 British women aged 45-68 and N=507 British women, respectively), our scores were low across all BCP groups. Comparably, Kruger et al. (2016), who had a smaller sample size, found no significant difference between normal and high BMI (p = 0.058) and BF % groups (p = 0.586) and their scores were also low across the board. This questions whether sample size could affect the significance (or lack thereof) of External Hunger between body composition groups. Moreover, the low scores of External Hunger could suggest why it was not a significant predictor of BMI (p = 0.673) or BF % (p = 0.828) when accounting for age and ethnicity. These findings were similar to Kruger et al. (2016) (BMI p = 0.722, BF % p = 0.822), which implies that External Hunger is a poor indicator of body composition in New Zealand women.

3.4.4 *Sub-groups of Restraint and Disinhibition*

Maintaining a normal body weight has been shown in those who exhibit an ideal combination of eating behaviours, particularly High Restraint Low Disinhibition (Borg et al., 2004, Goulet et al., 2008). This was reinforced in our study with women from the normal-fat profile having the highest rates of the idyllic High Restraint Low Disinhibition combination, which could be secondary to normal-fat women also generally having the lowest rates of BMI, BF %, abdominal adiposity, total adiposity and adipose distribution. Comparably, women with the apparent-fat profile had the highest rates of Low Restraint High Disinhibition (non-ideal behaviour combination), which could be linked with this sub-group also having increased body composition markers (abdominal adiposity, total adiposity and adipose distribution), particularly BMI (31.7 ± 7.60 kg/m^2) and BF % (40.4 + 6.90%) which were considered outside of their respective parameters for a healthy body composition, and were higher Kruger et al. (2016) (BMI 26.2 ± 5.1 kg/m^2 and BF % 36.6 ± 8.9%, respectively). Moreover, women with the sub-optimal Low Restraint High Disinhibition behaviour combination had had significantly higher energy, protein (g), carbohydrate (g), starch (g), sugar (g), total fat (g), saturated fat (g and %) than individuals with the ideal High Restraint Low Disinhibition combination. This notion aligned with previous female based Canadian and Portuguese studies (Goulet et al., 2008, Moreira et al., 2005), however their significances were observed with mostly energy and protein, carbohydrate and fat percentages rather than the grams of intake measurement. This means their significant differences were relative to total energy intake, whereas our significant differences were more seen in absolute values, which should be considered when interpreting the results. Other studies who have also demonstrated a higher dietary intake in men and women with Low Restraint and/or High Disinhibition, linked this with increased impulsivity and binge eating episodes (Mailloux et al., 2014, Sawamoto et al., 2017); reduced vegetable intake (Moreira et al., 2005); increased sugary snacks/beverages (Haynes et al., 2003, Goulet et al., 2008) and increased high-fat snacks (Wardle et al., 2000) in women. Moreover, Sawamoto et al. (2017) found food addiction scores were significantly higher Japanese women in those who practised High Restraint Low Disinhibition than the opposite (p = 0.022). However, a further analysis would be required to see whether any of these patterns exist in a New Zealand setting of women alone.

3.4.5 *Sub-groups of Hunger and Disinhibition*

Loeber et al. (2013) identified that heightened Hunger is associated with an impaired inhibition response and an adverse body composition, which prompted the assessment of combined Hunger and Disinhibition assessment in this study. Pacific women were 1.4 times more likely to have High Hunger High Disinhibition than NZE women, which was in line with both Hunger and general dietary intake being significantly higher in Pacific women compared to NZE women, as previously discussed.

From a non-ethnic perspective, tendencies of High Hunger High Disinhibition were associated with increased abdominal adiposity, total adiposity, adipose distribution and general dietary intake (energy, protein (g), carbohydrate (g), starch (g), total fat (g), saturated fat (g and %)) than their Low Hunger Low Disinhibition counterparts. To date, there is no study to compare these findings to, however other international that have also shown high body composition and high dietary intake in those with High Disinhibition and/or High Hunger, in women, have linked this with increased high-fat/processed foods (Green et al., 2000, Lahteenmaki and Tuorila, 1995); reduced vegetable intake (Moreira et al., 2005); increased sugar sweetened beverages (Goulet et al., 2008); increased food cravings (Burton et al., 2007, Thomas et al., 2013) and increased food appeal (Loeber et al., 2013) when compared to the Low Hunger and/or Low Disinhibition counterparts. However, a further examination into the food group intake, of this behaviour sub-group in a New Zealand setting, is required before assumptions can be made. Moreover, Barkeling et al. (2007) proposed that Disinhibition could partially impair the appetite and satiety regulation at a peptide level, as obese individuals who ate unrelated to hunger had high tendencies of High Hunger and High Disinhibition versus those who ate in relation to hunger. Additionally, this could also be true on a smaller scale for women with the hidden-fat profile, as they had significantly higher tendencies of High Hunger High Disinhibition than their normal-fat counterparts. Therefore, there could be a possibility that early dysfunction of appetite and satiety regulation can occur when BF % is high, irrespective of a normal BMI, however further research is required to solidify this theory.

3.4.6 Recommendations, strengths and weaknesses

Overall, it is clear that there is a disconnection between eating because one *has* to versus eating because one *wants* to. Therefore, obesity prevention strategies should be aimed at rebuilding this connection. A comprehensive literature review by Van Dyke and Drinkwater (2014) that consisted of 17 cross-sectional studies and 9 clinical trials showed that intuitive eating and mindful eating is inversely associated with BMI and health markers (e.g. blood pressure and cholesterol) and positively associated with improved dietary intake. This notion has been supported by other academic literature (Mantzios and Wilson, 2015, Dunn et al., 2018) and in a New Zealand setting (Madden et al., 2012), which implores the question: could the obesity prevalence be reduced by re-training eating behaviour? Perhaps creative, government funded community and/or individual interventions to support/maintain eating behaviour, for Māori and Pacific women, should be considered.

This study contributes to understanding predictors of obesity in New Zealand women in terms of TFEQ categories and sub-categories. Not only was it the first study to explore an extensive array of body composition measurements and use of BCP groups, but it was also the first to shed light on the eating behaviour of NZE, Māori and Pacific women. However, there were several limitations to this study that must be considered when interpreting the results. Firstly, the nature of a cross-sectional study design is limited in terms of causality and reproducibility. Secondly, the study did not adjust for other confounding factors (e.g. physical activity or socioeconomic status) that could have influenced body composition, dietary intake or TFEQ data. Thirdly, there was a disproportionately higher number of NZE than Māori and Pacific women used in this sub-study (N=212 versus N=71 and N=85, respectively), due to inability to recruit higher numbers within the strict EXPLORE study inclusion parameters. Likewise, there was a disproportionately higher number of women with the apparent-fat profile than normal-fat and hidden-fat profiles (N=210 versus N=88 and N=70, respectively). Therefore, ethnic and BCP eating behaviour and dietary intake generalisations should not be drawn from this study alone.

3.5 Conclusion

New interventions should be explored to reduce and prevent obesity in New Zealand women, particularly for Māori and Pacific. This could involve government funded community and/or individual health promotion programmes on supporting/maintaining optimal eating behaviour. Despite some scores being low, Habitual Disinhibition, Hunger and External Hunger, as well as rates of Low Restraint High Disinhibition and High Hunger High Disinhibition were significantly higher in Pacific women and apparent-fat profiles than NZE and normal-fat profiles, respectively. Likewise, Restraint, Disinhibition, Habitual Disinhibition and Emotional Disinhibition were predictors of BMI and BF % and adverse tendencies of Low Restraint High Disinhibition and High Hunger High Disinhibition were more prominent in the hidden-fat profile than the normal-fat profile. This means having a normal BMI alone does not assume eating behaviour is always optimal. Tailored behaviour-based interventions that can resolve poor self-regulation, particularly around routine eating/circumstantial eating/emotional eating, while enhancing the conscious ability to restrict unnecessary energy intake, should be considered for improving/supporting weight-management in young New Zealand women. Future research should examine the motivating factors that underpin the TFEQ categories and sub-categories, as well as the relationship between metabolic bio-markers and TFEQ scores in a larger/equal sample size of New Zealand ethnic groups and BCP's.

Chapter 4

Conclusions and Recommendations

4.1 Overview

Many New Zealand women have an overweight and/or obese BMI (63.8%), with the highest rates being observed in Māori and Pacific women (Ministry of Health, 2018a). The old adage that a normal BMI is preventative against adverse metabolic health (e.g. impaired glucose tolerance and dyslipidaemia) (World Health Organisation, 1995) has recently been challenged by the identification of the normal-weight obesity profile (Oliveros et al., 2014) (termed hidden-fat profile in this study). This has prompted BMI and BF % to be examined independently and concurrently, as BCP's, to help better predict weight-related metabolic disease risk (Kruger et al., 2015). It is well regarded that eating behaviour (assessed by the TFEQ) and dietary intake (assessed by the NZWFFQ) can be key modifiable factors that can positively or negatively affect body composition (Stunkard and Messick, 1985, Yannakoulia et al., 2007, Schlundt et al., 2003, Ezquerro et al., 2017). No study to date has examined eating behaviour in relation to BCP, let alone in a New Zealand setting. Moreover, the studies that *have* examined different elements of body composition (e.g. BMI and/or BF %), have a mixed consensus as to which TFEQ category, sub-category, or mix of categories (sub-groups) play the biggest role in body composition outcomes (Barkeling et al., 2007, Berg et al., 2018, Blumfield et al., 2018, Bresch et al., 2017, Burton et al., 2007). This could be due to the respective studies assessing different age, gender and ethnic groups. Although eating behaviour has been examined in the New Zealand setting (Brown et al., 2014, Kruger et al., 2016) neither one of these studies fully explored eating behaviours (TFEQ categories, sub-categories and sub-groups) in New Zealand European, Māori and Pacific women with different body composition factors (particularly BCP's) and dietary intake into one study. Therefore, the purpose of this women's EXPLORE sub-study (N=368) was to examine the body composition (particularly BMI, BF % and BCP's), eating behaviour (using TFEQ categories, sub-categories and mixed sub-groups) and dietary intake (using the NZWFFQ) of post-menarcheal and pre-menopausal NZ European, Māori and Pacific women, aged between 16 and 45 years.

4.2 Aims and objectives

The overall aim of the study was to investigate eating behaviour as predictors of different body composition factors and dietary intake in post-menarche and pre-menopausal New Zealand European, Māori and Pacific women, aged 16-45 years participating in the women's EXPLORE study. This aim was met through several objectives:

Objective 1: To investigate three eating behaviour categories (TFEQ categories: Restraint, Disinhibition and Hunger) in NZ European, Māori and Pacific women within three body composition profiles (normal-fat, hidden-fat and apparent-fat groups).

Restraint, Disinhibition and Hunger were examined within the three ethnic groups and the three BCP groups independently, using an ANCOVA analysis (Table 3.2). The ANCOVA analysis adjusted for any demographic information (e.g. age, use of hormonal contraception, smoking status, having children) that was significantly related to the given ethnic/BCP groups, and proven to influence eating behaviour previously. In terms of ethnicity Restraint was significantly higher in NZE women (high score) than Pacific women (low score) ($p = 0.015$, small effect size). Additionally, Pacific women had a significantly higher Hunger (high score) than NZE women (low score) ($p = 0.001$, small effect size).

In terms of BCP's (Table 3.2) we hypothesised that Restraint would be significantly lower in both the hidden-fat and apparent-fat profiles compared to the normal-fat profile (H1.1). However, there were no significant difference between Restraint and the three BCP's, therefore H1.1 is rejected. Similarly, we hypothesised that Disinhibition would be significantly higher in both the hidden-fat and apparent-fat profiles (H1.2). Our findings showed women with the apparent-fat profile had significantly higher Disinhibition (high score) than those with normal-fat profile and hidden-fat profile (low scores) ($p < 0.001$, medium effect size). Likewise, women with the apparent-fat profile had significantly higher simple anthropometric measurements than those with the normal-fat profile (Table 3.2). Although Disinhibition was higher in the apparent-fat profile (which technically accepts H1.2), there was no significant difference between scores of the normal-fat profile and hidden-fat profiles. Therefore, that part of H1.2 is rejected. Women with the apparent-fat profile had significantly higher Hunger (high score) than the normal-fat profile (low score) ($p = 0.034$, small effect size). There was no significant difference between the normal-fat profile and the hidden-fat profile for any main TFEQ category, contrary to our hypotheses (H1.1 and H1.2). Likewise, there was no significant difference between the normal-fat profile and hidden-fat profile for any anthropometric measurements. Overall, these findings suggest that optimal TFEQ eating behaviour category (e.g. high Restraint) was more prominent in NZE women, whereas sub-optimal TFEQ eating behaviour categories (e.g. high Disinhibition and high Hunger) were more prominent in Pacific women, and in any women with the apparent-fat profile.

Objective 2: To investigate the seven TFEQ sub-categories of Restraint (Flexible and Rigid); Disinhibition (Habitual, Emotional and Situational) and Hunger (Internal and External) in New Zealand European, Māori and Pacific women within three BCP's.

Similar to the main TFEQ categories, their sub-categories were examined within the three ethnic groups and the three BCP groups independently, using an ANCOVA analysis (Table 3.2). The ANCOVA analysis adjusted for any demographic information (e.g. age, use of hormonal contraception, smoking status, having children) that was significantly related to the given ethnic/BCP groups and has also been shown to influence eating behaviour in previous studies. In terms of ethnicity Rigid Restraint was significantly higher in NZE (low score) compared to Pacific women (lower score) ($p < 0.001$, small effect size). Habitual Disinhibition ($p = 0.023$, small effect size), Internal Hunger ($p = 0.040$, small effect size) and External Hunger ($p < 0.001$, small effect size) were significantly higher in Pacific (all low scores except for Internal Hunger) than NZE women (all lower scores). Overall, more of the adverse TFEQ eating behaviour sub-categories were significantly higher in Pacific women, however most scores were low.

In terms of BCP's (Table 3.2) we hypothesised that Flexible Restraint would be significantly lower in the hidden-fat and apparent-fat profiles compared to the normal-fat profile (H2.1). Women with the apparent-fat profile had significantly lower Flexible Restraint (low score) than the normal-fat counterpart (lower score) ($p = 0.005$, small effect size), therefore that part of H2.1 can be accepted. However, there was no significant difference between Flexible Restraint and normal-fat and hidden-fat profiles, therefore that part of H2.1 is rejected. Furthermore, we hypothesised that Emotional Disinhibition would be significantly higher in the hidden-fat/apparent-fat profile compared to the normal-fat profile (H2.2). Women with the apparent-fat profile had significantly higher Emotional Disinhibition (high score) compared to normal-fat women (low score) ($p < 0.001$, medium effect size), therefore that part of H2.2 can be accepted. However, there was no significant difference between Flexible Restraint and normal-fat and hidden-fat profiles, therefore that part of H2.2 is rejected. In addition, Habitual Disinhibition ($p < 0.001$, medium effect size) and External Hunger ($p < 0.001$, small effect size) were significantly higher in the apparent-fat profile (all low scores) than the normal-fat profile (all lower scores) (Table 3.2). Moreover, External Hunger was the only eating behaviour sub-category that was significantly higher in the hidden-fat profile (low score) when compared to the normal-fat profile (low score) ($p = 0.001$, small effect size). In summary, optimal TFEQ sub-category eating behaviours (e.g. Flexible Restraint) were more prominent in women with a normal-fat profile. Comparably, sub-optimal eating behaviours (e.g. Rigid Restraint, Habitual Disinhibition, Emotional Disinhibition and External Hunger) were generally more prominent in Pacific women (excluding Rigid Restraint which was higher in NZE and Emotional Disinhibition which had no effect, respectively) and women with an apparent-fat profile (excluding Rigid Restraint).

Objective 3: To investigate which TFEQ categories and sub-categories are significant predictors of BMI and BF % in NZE, Māori and Pacific women, collectively.

Four multiple linear regressions, using a step-wise enter method, were conducted to assess firstly the TFEQ eating behaviour categories in relation to BMI (1st regression adjusted for age then age plus ethnicity) and BF % (2nd regression adjusted for age then age plus ethnicity) (Table 3.3), and secondly, the TFEQ sub-categories in relation to BMI (3rd regression adjusted for age then age plus ethnicity) and BF % (4th regression adjusted for age then age plus ethnicity) (Table 3.4). Energy intake was also included as a third factor in the TFEQ category and sub-category step-wise models (age, ethnicity and energy) for BMI and BF %, however it did not change or improve any of the model's significance or the amount that be behaviour scores accounted for (compared to age and ethnicity). Therefore, it was not illustrated in the Tables (see Appendix I and Appendix J).

In terms of the TFEQ categories, we hypothesised that Restraint would be an inverse predictor of both BMI and BF % (H3.1). This hypothesis was accepted as Restraint proved to be an inverse predictor of BMI (B = -0.20, *ß* = 0.07, [95% CI -0.34, -0.05], $p = 0.007$) and BF % (B = -0.26, *ß* = 0.09, [95% CI -0.44, -0.08], $p = 0.015$). Additionally, we hypothesised that Disinhibition would be a positive predictor of both BMI and BF % (H3.2). This hypothesis was also accepted as Disinhibition proved to be a positive predictor of BMI (B = 0.66, *ß* = 0.10 [95% CI 0.46, 0.85], $p < 0.001$) and BF % (B = 0.82, *ß* = 0.12 [95% CI 0.57, 1.06], $p < 0.001$) (all when accounting for age and ethnicity) (Table 3.3).

In terms of the TFEQ sub-categories (Table 3.4) we hypothesised that Flexible Restraint would be an inverse predictor of both BMI and BF % (H3.3). This hypothesis was rejected as Flexible Restraint was not significantly associated with BMI or BF % when accounting for age ($p = 0.128$ and $p = 0.207$, respectively) nor age and ethnicity ($p = 0.093$ and $p = 0.0193$, respectively). Moreover, we hypothesised that Emotional Disinhibition would be a positive predictor of both BMI and BF % (H3.4). This hypothesis was accepted as Emotional Disinhibition was a positive predictor of BMI (B = 1.08, *ß* = 0.29, [95% CI 0.50, 1.65], $p < 0.001$) and BF % (B = 1.51, *ß* = 0.37, [95% CI 0.79, 2.23], $p < 0.001$) when accounting for age and ethnicity (Table 3.4). In addition, Habitual Disinhibition was also a positive predictor for both BMI (B = 1.00, *ß* = 0.24 [95% CI 0.53, 1.49], $p < 0.001$) and BF % (B = 1.00, *ß* = 0.30, [95% CI 0.40, 1.60], $p < 0.001$) when accounting for age and ethnicity (Table 3.4), which we did not foresee. Interestingly, Rigid Restraint was a significant, inverse predictor of BMI, however this was just when age only was accounted for (B = -0.50, *ß* = 0.23 [95% CI -0.95, 0.05], $p = 0.030$); significance disappeared when ethnicity and energy intake was entered into the model. Overall, these findings suggest the higher the Restraint, the lower the BMI and BF % (which can be optimal for health if BMI < 25 kg/m^2 and BF % < 30%). Additionally, the higher the Disinhibition, Habitual Disinhibition, Emotional Disinhibition and External Hunger, the higher BMI and BF % are (which can be sub-optimal for health if BMI ≥ 25 kg/m^2 and BF % ≥ 30%).

Objective 4: To investigate the TFEQ sub-groupings in NZ European, Māori and Pacific women in relation to the different BCP's, markers of adiposity and dietary intake.

To meet this objective, TFEQ sub-groups of Restraint and Disinhibition and Hunger and Disinhibition were examined in NZ European, Māori and Pacific women in relation to the different BCP's, markers of adiposity and dietary intake.

Sub-objective 4.1: TFEQ sub-grouping of Restraint and Disinhibition categories

Individual scores of Restraint and Disinhibition were ranked high or low according to the recommendations of Lesdema et al. (2012) to allow for subsequent analysis of four sub-groupings: Low Restraint High Disinhibition (non-ideal behaviour combination), Low Restraint Low Disinhibition, High Restraint High Disinhibition and High Restraint Low Disinhibition (ideal behaviour combination). We hypothesised that Low Restraint High Disinhibition (non-ideal behaviour combination) would have an adverse body composition (e.g. (e.g. higher markers of adiposity and a hidden-fat and apparent-fat profile) and an adverse dietary intake (e.g. high energy and nutrient intake) (H4.1). The findings showed individuals with Low Restraint High Disinhibition had higher total adiposity, abdominal adiposity, adipose distribution and dietary intake than their High Restraint Low Disinhibition counterparts (generally all $p < 0.05$ and small to medium effect sizes) (Table 3.5). In addition, a chi-square odds-ratio analysis showed women with apparent-fat were 1.7 and 12 times more likely to have Low Restraint High Disinhibition (non-idea behaviour combination) than those with hidden-fat and normal-fat profiles, respectively ($p < 0.001$) (Figure 3.2). Moreover, women with the hidden-fat profile had higher tendencies of the adverse Low Restraint High Disinhibition and lower tendencies of the optimal High Restraint Low Disinhibition than the normal-fat profile ($p < 0.001$ and $p = 0.010$). Therefore, we can accept H4.1. In summary, having Low Restraint High Disinhibition was significantly associated with higher markers of adiposity/body composition markers and higher dietary intake, which could be pre-cursors for adverse metabolic health.

Sub-objective 4.2: TFEQ sub-grouping of Hunger and Disinhibition categories

Similar to the sub-groups of Restraint and Disinhibition, individual scores of Hunger and Disinhibition were ranked high or low (Lesdema et al., 2012) to allow for a subsequent analysis of four sub-groupings: Low Hunger Low Disinhibition (ideal behaviour combination), Low Hunger High Disinhibition, High Hunger Low Disinhibition and High Hunger High Disinhibition (non-ideal behaviour combination). We hypothesised that High Hunger High Disinhibition would have an adverse body composition (e.g. higher markers of adiposity and hidden-fat and apparent fat profile) and an adverse dietary intake (H4.2). A chi-square analysis revealed that Pacific women were approximately 1.4 times more likely to have significantly higher tendencies of High Hunger High Disinhibition (43.5%) compared to Māori and NZE women (30% and 29.9%, respectively) (p = 0.023, small effect size) (Figure 3.3). Moreover, women with High Hunger High Disinhibition (non-ideal behaviour combination) generally had a higher total adiposity, abdominal adiposity, adipose distribution and dietary intake than their Low Hunger Low Disinhibition counterparts (generally all p < 0.05, small to large effect sizes) (Table 3.6). In addition, women with the apparent-fat profile were 1.4 and 2.2 times more likely to have High Hunger High Disinhibition (non-ideal behaviour combination) (42%) compared to hidden-fat (30%) and apparent-fat (19%) profiles, respectively (Figure 3.4). Moreover women with the hidden-fat profile had significantly lower rates of the optimal Low Hunger Low Disinhibition behaviours and higher rates of the adverse High Hunger High Disinhibition behaviours than the normal-fat profile, respectively (p < 0.001 and p = 0.004, respectively). Therefore, we can accept H4.2. Overall, these findings suggest that High Hunger High Disinhibition is associated with higher markers of adiposity, higher body composition markers, particularly the hidden-fat profile and the apparent-fat profile, and higher dietary intake, which could be pre-cursors for adverse metabolic health.

4.3 Strengths and weaknesses of the study

There were several strengths to this study. Firstly, the EXPLORE study employed strict inclusion and exclusion criteria. This enabled a specific and unique cohort of women to be examined; they were post-menarcheal, pre-menopausal, not pregnant/lactating, not disease ridden, not seeking weight loss and of NZE, Māori and Pacific ethnicities. In addition, careful steps were taken to control variables. For example, women were invited to attend HNRU within 14 days of their last menstruation to account for potential hormonal differences that could affect body composition, eating behaviour, or dietary intake.

Secondly, a variety of anthropometric measurements (e.g. BMI, waist and hip circumferences, ratios) and laboratory based measurements (e.g. ADP and DXA) were undertaken to assess total adiposity, abdominal adiposity, adipose distribution and non-adipose mass. Using a variety of measurements in an epidemiological setting provides a clear picture of body composition, however in a clinical setting clinicians might not have access to ADP and DXA. Therefore, this study used anthropometric measurements, as well as laboratory-based measures to examine whether there were ethnic, BCP, and eating behaviour differences between the women.

Thirdly, to date, only two New Zealand based studies have examined eating behaviour using the TFEQ (Kruger et al., 2016, Brown et al., 2014). Brown et al. (2014) examined eating behaviour in BMI-defined normal weight and overweight men and women, however they did not examine BF %, nor the sub-categories of the TFEQ. Moreover, Kruger et al. (2016) assessed BMI and BF %, however not in a collaborative BCP sense, and their study was not ethnic specific (Kruger et al., 2016). In view of these studies, this was the first study to not only compare eating behaviour categories, but also sub-categories and levels of eating behaviour, among selected NZ ethnicities and BCP's in women. Subsequently, the findings showed that singular and combined eating behaviour are in fact significantly different between some ethnicities and BCP groups. This information could be used to assist with eating behaviour related weight management issues, at an ethnic or body composition level.

In light of these strengths, the study also had several weaknesses. Firstly, the cross-sectional study design is limited in terms of strength of causality. There was a chance of non-response bias whereby participants who did *not* participate may have answered differently to those who did participate. In addition, the data only represents a snap-shot of eating behaviour in specific women at a specific time. Therefore, the results may not apply to all NZE, Māori or Pacific women. Moreover, there is also a chance of voluntary-response bias whereby the results were only applicable to those who participated in the study (e.g. women living in Auckland) or those who had a pre-existing interest on health. In addition, the NZWFFQ and TFEQ were completed retrospectively, therefore there is a possibility that recall bias may have occurred. Overall, caution must be taken when interpreting the results and ethnic and BCP eating behaviour generalisations should not be made based on this study alone.

Secondly, the sample size for this sub-study was N=368. The limitations of a small sample size are the reliability and reproducibility of results, as well as non-response bias and voluntary-response bias, as specified above. Despite attempts to recruit a diverse population, there was an unintentional and uneven distribution of participants in terms of ethnicity (NZE N=212; Māori N=71; Pacific N=85) and BCP's (normal-fat profile N=88; hidden-fat profile N=70; apparent-fat profile N=210). Having a larger sample size, and more even distribution of ethnicities and BCP's, may have reduced or alleviated some of the existing limitations and optimised the reliability and reproducibility of the findings. This could be achieved in the future by perhaps utilising both Māori and Pacific recruiters, which could potentially improve participant interest and sample size.

4.4 Recommendations

4.4.1 Recommendations for improving eating behaviour

Eating behaviour of each ethnicity and BCP needs to be managed in a different or unique way, as their eating behaviour (as well as overall body composition) was different. Table 4.1 presents the recommendations for respective ethnicities and BCP's. These were determined when a score was adversely low (e.g. Restraint) or high (e.g. Disinhibition), or when it was significantly higher in the given ethnicity/BCP. In terms of ethnicity all women should aim to increase their Flexible Restraint and decrease their Situational Disinhibition, regardless of their ethnicity. Moreover, NZE and Pacific women should attempt to decrease their Disinhibition. Likewise, Māori and Pacific women should aim to decrease their Hunger. In addition, Pacific women alone should also try and increase their Restraint, while decreasing their Habitual Disinhibition, Internal Hunger and External Hunger. In terms of BCP's all women should aim to increase their Flexible Restraint and decrease their Situational Disinhibition, regardless of their BCP. Furthermore, women with hidden-fat and apparent-fat profiles should try to decrease their External Hunger. Finally, women with apparent-fat alone should also aim to reduce their Disinhibition, Habitual Disinhibition, Emotional Disinhibition and Hunger.

Table 4.1 Recommendations for improving eating behaviour in relation to ethnicity and body composition profiles

	Ethnicity	
NZE	**Māori**	**Pacific**
• ↑ Flexible Restraint • ↓ Situational Disinhibition • ↓ Disinhibition	• ↑ Flexible Restraint • ↓ Situational Disinhibition • ↓ Hunger	• ↑ Flexible Restraint • ↓ Situational Disinhibition • ↓ Disinhibition • ↓ Hunger • ↑ Restraint • ↓ Habitual Disinhibition • ↓ Internal Hunger • ↓ External Hunger
	Body composition profiles	
Normal-fat	**Hidden-fat**	**Apparent-fat**
• ↑ Flexible Restraint • ↓ Situational Disinhibition	• ↑ Flexible Restraint • ↓ Situational Disinhibition • ↓ External Hunger	• ↑ Flexible Restraint • ↓ Situational Disinhibition • ↓ External Hunger • ↓ Disinhibition • ↓ Habitual Disinhibition • ↓ Emotional Disinhibition • ↓ Hunger

The direction of the arrow indicates whether the eating behaviour should be increased (↑) or decreased (↓) in the given ethnicity and body composition profile (BCP). Yellow highlighting = exists in all three ethnicities or BCP's, green highlighting = exists in two ethnicities or BCP's, blue highlighting = exists in only one ethnicity or BCP.

There are several methods that could be employed meet these eating behaviour recommendations. Firstly, Restraint and Flexible Restraint can be optimised by achieving energy equilibrium through a balanced diet and regular exercise (Stunkard and Messick, 1985, Riesco et al., 2009). This could be done through a public health campaign that reinforces the basic requirements of a healthy diet. In addition, practising mindfulness and intuitive have been shown to increase both Restraint and Flexible

Restraint, having beneficial effects on body composition (Dunn et al., 2018, Mantzios and Wilson, 2015). Mindfulness and intuitive eating could be achieved through culturally-appropriate online series on the Ministry of Health website. Moreover, studies have shown that Disinhibition and Emotional Disinhibition were successfully counteracted in a randomised-control trial using Acceptance-Based Behavioural Interventions (ABBI) (Lillis et al., 2016, Lillis et al., 2015). Similarly, Habitual Disinhibition has been shown to be significantly reduced during individual and group Cognitive Behaviour Therapy (CBT) sessions (Brownley et al., 2007). Overall, the ABBI and CBT interventions, at an individual or community level, could be tailored specifically for each ethnic group and should focus on how to decline unnecessary food/beverage intake, or how to cope with emotional situations without excessive eating. Moreover, no study to date has discussed ways of overcoming Situational Disinhibition per se, however researchers have expressed supressing external environmental factors (e.g. eating out) would be useful in weight management (Egger and Swinburn, 1997).

A randomised-control trial demonstrated that group interventions (e.g. counselling, weekly diet histories/food reflections) have been shown to counteract excessive Hunger (Batra et al., 2013). These could be funded by the Ministry of Health and set up at local community groups (e.g. churches, schools, maraes, and workplaces) in an attempt to combat unnecessary Hunger. Likewise, Internal Hunger and External Hunger has been shown to be supressed with education regarding slowing down energy intake (Shah et al., 2014) and practising mindfulness (Brownley et al., 2007, Dunn et al., 2018). With these factors in mind, community or e-learning courses on mindful/intuitive eating (e.g. what does hunger feel like, food and mood recording, ranking hunger scores in a day) from the Ministry of Health could be beneficial to target changes in those with adverse eating behaviours.

4.4.2 Recommendations for future research

- Investigate eating behaviour, in relation to BCP's, within a different cross section on NZE, Māori and Pacific women (e.g. outside of Auckland) and a with a larger/equal sample size.
- Conduct a randomised-control trial to assess eating behaviour changes before and after eating behaviour education in NZE, Māori and Pacific women.
- Conduct a longitudinal study to assess potential eating behaviour changes from post-menarcheal stage to post-menopausal stage in NZE, Māori and Pacific women.
- Assess nutrition knowledge, deprivation scores, and physical activity levels in NZE, Māori and Pacific women in relation to eating behaviour and body composition.

- Compare visual sensory responses to food with eating behaviour scores to see whether high stimulation to high-caloric, nutrient-poor food (e.g. cakes, biscuits) is associated with any adverse eating behaviour in NZE, Māori and Pacific women.
- Compare metabolic biomarkers (e.g. cholesterol, fasting glucose) with eating behaviour scores to see if any significantly predict/correlate to eating behaviour in NZE, Māori and Pacific women.

References

AFSHIN, A., FOROUZANFAR, M. H., REITSMA, M. B., SUR, P., ESTEP, K., LEE, A., MARCZAK, L., MOKDAD, A. H., MORADI-LAKEH, M., NAGHAVI, M., SALAMA, J. S., VOS, T., ABATE, K. H., ABBAFATI, C., AHMED, M. B., AL-ALY, Z., ALKERWI, A., AL-RADDADI, R., AMARE, A. T., AMBERBIR, A., AMEGAH, A. K., AMINI, E., AMROCK, S. M., ANJANA, R. M., ARNLOV, J., ASAYESH, H., BANERJEE, A., BARAC, A., BAYE, E., BENNETT, D. A., BEYENE, A. S., BIADGILIGN, S., BIRYUKOV, S., BJERTNESS, E., BONEYA, D. J., CAMPOS-NONATO, I., CARRERO, J. J., CECILIO, P., CERCY, K., CIOBANU, L. G., CORNABY, L., DAMTEW, S. A., DANDONA, L., DANDONA, R., DHARMARATNE, S. D., DUNCAN, B. B., ESHRATI, B., ESTEGHAMATI, A., FEIGIN, V. L., FERNANDES, J. C., FURST, T., GEBREHIWOT, T. T., GOLD, A., GONA, P. N., GOTO, A., HABTEWOLD, T. D., HADUSH, K. T., HAFEZI-NEJAD, N., HAY, S. I., HORINO, M., ISLAMI, F., KAMAL, R., KASAEIAN, A., KATIKIREDDI, S. V., KENGNE, A. P., KESAVACHANDRAN, C. N., KHADER, Y. S., KHANG, Y. H., KHUBCHANDANI, J., KIM, D., KIM, Y. J., KINFU, Y., KOSEN, S., KU, T., DEFO, B. K., KUMAR, G. A., LARSON, H. J., LEINSALU, M., LIANG, X., LIM, S. S., LIU, P., LOPEZ, A. D., LOZANO, R., MAJEED, A., MALEKZADEH, R., MALTA, D. C., MAZIDI, M., MCALINDEN, C., MCGARVEY, S. T., MENGISTU, D. T., MENSAH, G. A., MENSINK, G. B. M., MEZGEBE, H. B., MIRRAKHIMOV, E. M., MUELLER, U. O., NOUBIAP, J. J., OBERMEYER, C. M., OGBO, F. A., OWOLABI, M. O., PATTON, G. C., et al. 2017. Health Effects of Overweight and Obesity in 195 Countries over 25 Years. *N Engl J Med,* 377**,** 13-27.

ANDERSON, L. M., REILLY, E. E., SCHAUMBERG, K., DMOCHOWSKI, S. & ANDERSON, D. A. 2016. Contributions of mindful eating, intuitive eating, and restraint to BMI, disordered eating, and meal consumption in college students. *Eat Weight Disord,* 21**,** 83-90.

BACHMAN, J. L. & RAYNOR, H. A. 2012. Effects of manipulating eating frequency during a behavioral weight loss intervention: a pilot randomized controlled trial. *Obesity (Silver Spring),* 20**,** 985-92.

BARKELING, B., KING, N. A., NASLUND, E. & BLUNDELL, J. E. 2007. Characterization of obese individuals who claim to detect no relationship between their eating pattern and sensations of hunger or fullness. *Int J Obes (Lond),* 31**,** 435-9.

BARRENA, R., GARCIA, T. & SANCHEZ, M. 2015. Analysis of personal and cultural values as key determinants of novel food acceptance. Application to an ethnic product. *Appetite,* 87**,** 205-14.

BASTIEN, M., POIRIER, P., LEMIEUX, I. & DESPRES, J. P. 2014. Overview of epidemiology and contribution of obesity to cardiovascular disease. *Prog Cardiovasc Dis,* 56**,** 369-81.

BATHALON, G. P., TUCKER, K. L., HAYS, N. P., VINKEN, A. G., GREENBERG, A. S., MCCRORY, M. A. & ROBERTS, S. B. 2000. Psychological measures of eating behavior and the accuracy of 3 common dietary assessment methods in healthy postmenopausal women. *Am J Clin Nutr,* 71**,** 739-45.

BATRA, P., DAS, S. K., SALINARDI, T., ROBINSON, L., SALTZMAN, E., SCOTT, T., PITTAS, A. G. & ROBERTS, S. B. 2013. Eating behaviors as predictors of weight loss in a 6 month weight loss intervention. *Obesity (Silver Spring),* 21**,** 2256-63.

BAYS, H. E., GONZALEZ-CAMPOY, J. M., BRAY, G. A., KITABCHI, A. E., BERGMAN, D. A., SCHORR, A. B., RODBARD, H. W. & HENRY, R. R. 2008. Pathogenic potential of adipose tissue and metabolic consequences of adipocyte hypertrophy and increased visceral adiposity. *Expert Rev Cardiovasc Ther,* 6**,** 343-68.

BECK, K. L., HOUSTON, Z. L., MCNAUGHTON, S. A. & KRUGER, R. 2018. Development and evaluation of a food frequency questionnaire to assess nutrient intakes of adult women in New Zealand. *Nutr Diet*.

BECK, K. L., JONES, B., ULLAH, I., MCNAUGHTON, S. A., HASLETT, S. J. & STONEHOUSE, W. 2017. Associations between dietary patterns, socio-demographic factors and anthropometric

measurements in adult New Zealanders: an analysis of data from the 2008/09 New Zealand Adult Nutrition Survey. *Eur J Nutr*.
BELLANGER, T. M. & BRAY, G. A. 2005. Obesity related morbidity and mortality. *J La State Med Soc,* 157 Spec No 1**,** S42-9; quiz 49.
BELLISLE, F., CLEMENT, K., LE BARZIC, M., LE GALL, A., GUY-GRAND, B. & BASDEVANT, A. 2004. The Eating Inventory and body adiposity from leanness to massive obesity: a study of 2509 adults. *Obes Res,* 12**,** 2023-30.
BELLOU, E., MARAKI, M., MAGKOS, F., BOTONAKI, H., PANAGIOTAKOS, D. B., KAVOURAS, S. A. & SIDOSSIS, L. S. 2013. Effect of acute negative and positive energy balance on basal very-low density lipoprotein triglyceride metabolism in women. *PLoS One,* 8**,** e60251.
BERG, A. C., JOHNSON, K. B., STRAIGHT, C. R., REED, R. A., O'CONNOR, P. J., EVANS, E. M. & JOHNSON, M. A. 2018. Flexible Eating Behavior Predicts Greater Weight Loss Following a Diet and Exercise Intervention in Older Women. *Journal of nutrition in gerontology and geriatrics***,** 1-16.
BLUMFIELD, M. L., BEI, B., ZIMBERG, I. Z. & CAIN, S. W. 2018. Dietary disinhibition mediates the relationship between poor sleep quality and body weight. *Appetite,* 120**,** 602-608.
BOND, M. J., MCDOWELL, A. J. & WILKINSON, J. Y. 2001. The measurement of dietary restraint, disinhibition and hunger: an examination of the factor structure of the Three Factor Eating Questionnaire (TFEQ). *Int J Obes Relat Metab Disord,* 25**,** 900-6.
BORG, P., FOGELHOLM, M. & KUKKONEN-HARJULA, K. 2004. Food selection and eating behaviour during weight maintenance intervention and 2-y follow-up in obese men. *Int J Obes Relat Metab Disord,* 28**,** 1548-54.
BRESCH, A., RULLMANN, M., LUTHARDT, J., BECKER, G. A., PATT, M., DING, Y. S., HILBERT, A., SABRI, O. & HESSE, S. 2017. Hunger and disinhibition but not cognitive restraint are associated with central norepinephrine transporter availability. *Appetite,* 117**,** 270-274.
BROWN, R. C., MCLAY-COOKE, R. T., RICHARDSON, S. L., WILLIAMS, S. M., GRATTAN, D. R. & CHISHOLM, A. W. 2014. Appetite Response among Those Susceptible or Resistant to Obesity. *Int J Endocrinol,* 2014**,** 512013.
BROWNLEY, K. A., BERKMAN, N. D., SEDWAY, J. A., LOHR, K. N. & BULIK, C. M. 2007. Binge eating disorder treatment: a systematic review of randomized controlled trials. *Int J Eat Disord,* 40**,** 337-48.
BRYANT, E. J., KING, N. A. & BLUNDELL, J. E. 2008. Disinhibition: its effects on appetite and weight regulation. *Obes Rev,* 9**,** 409-19.
BURTON, P., SMIT, H. J. & LIGHTOWLER, H. J. 2007. The influence of restrained and external eating patterns on overeating. *Appetite,* 49**,** 191-7.
CANUTO, R., DA SILVA GARCEZ, A., KAC, G., DE LIRA, P. I. C. & OLINTO, M. T. A. 2017. Eating frequency and weight and body composition: a systematic review of observational studies. *Public Health Nutr,* 20**,** 2079-2095.
CAPPELLERI, J. C., BUSHMAKIN, A. G., GERBER, R. A., LEIDY, N. K., SEXTON, C. C., LOWE, M. R. & KARLSSON, J. 2009. Psychometric analysis of the Three-Factor Eating Questionnaire-R21: results from a large diverse sample of obese and non-obese participants. *Int J Obes (Lond),* 33**,** 611-20.
CAPURON, L., POITOU, C., MACHAUX-THOLLIEZ, D., FROCHOT, V., BOUILLOT, J. L., BASDEVANT, A., LAYE, S. & CLEMENT, K. 2011. Relationship between adiposity, emotional status and eating behaviour in obese women: role of inflammation. *Psychol Med,* 41**,** 1517-28.
CARR, K. A., LIN, H., FLETCHER, K. D. & EPSTEIN, L. H. 2014. Food reinforcement, dietary disinhibition and weight gain in nonobese adults. *Obesity (Silver Spring),* 22**,** 254-9.
CHONG, M. F., AYOB, M. N., CHONG, K. J., TAI, E. S., KHOO, C. M., LEOW, M. K., LEE, Y. S., THAM, K. W., VENKATARAMAN, K., MEANEY, M. J., WEE, H. L. & KHOO, E. Y. 2016. Psychometric analysis of an eating behaviour questionnaire for an overweight and obese Chinese population in Singapore. *Appetite,* 101**,** 119-24.

CHOQUETTE, A. C., BOUCHARD, L., DRAPEAU, V., LEMIEUX, S., TREMBLAY, A., BOUCHARD, C., VOHL, M. C. & PERUSSE, L. 2012. Association between olfactory receptor genes, eating behavior traits and adiposity: results from the Quebec Family Study. *Physiol Behav,* 105**,** 772-6.
CLEMENTI, C., CASU, G. & GREMIGNI, P. 2017. An Abbreviated Version of the Mindful Eating Questionnaire. *J Nutr Educ Behav,* 49**,** 352-356.e1.
COFFINO, J. A., ORLOFF, N. C. & HORMES, J. M. 2016. Dietary Restraint Partially Mediates the Relationship between Impulsivity and Binge Eating Only in Lean Individuals: The Importance of Accounting for Body Mass in Studies of Restraint. *Front Psychol,* 7**,** 1499.
COLLINS, K. H., SHARIF, B., SANMARTIN, C., REIMER, R. A., HERZOG, W., CHIN, R. & MARSHALL, D. A. 2017. Association of body mass index (BMI) and percent body fat among BMI-defined non-obese middle-aged individuals: Insights from a population-based Canadian sample. *Can J Public Health,* 107**,** e520-e525.
COX, S. & BRODE, C. 2018. Predictors of Binge Eating among Bariatric Surgery Candidates: Disinhibition as a Mediator of the Relationship Between Depressive Symptoms and Binge Eating. *Obes Surg*.
DE LAUZON-GUILLAIN, B., BASDEVANT, A., ROMON, M., KARLSSON, J., BORYS, J. M. & CHARLES, M. A. 2006. Is restrained eating a risk factor for weight gain in a general population? *Am J Clin Nutr,* 83**,** 132-8.
DE LORENZO, A., MARTINOLI, R., VAIA, F. & DI RENZO, L. 2006. Normal weight obese (NWO) women: an evaluation of a candidate new syndrome. *Nutr Metab Cardiovasc Dis,* 16**,** 513-23.
DI RENZO, L., DEL GOBBO, V., BIGIONI, M., PREMROV, M. G., CIANCI, R. & DE LORENZO, A. 2006. Body composition analyses in normal weight obese women. *Eur Rev Med Pharmacol Sci,* 10**,** 191-6.
DI RENZO, L., GALVANO, F., ORLANDI, C., BIANCHI, A., DI GIACOMO, C., LA FAUCI, L., ACQUAVIVA, R. & DE LORENZO, A. 2010. Oxidative stress in normal-weight obese syndrome. *Obesity (Silver Spring),* 18**,** 2125-30.
DI RENZO, L., TYNDALL, E., GUALTIERI, P., CARBONI, C., VALENTE, R., CIANI, A. S., TONINI, M. G. & DE LORENZO, A. 2016. Association of body composition and eating behavior in the normal weight obese syndrome. *Eat Weight Disord,* 21**,** 99-106.
DING, C., CHAN, Z. & MAGKOS, F. 2016. Lean, but not healthy: the 'metabolically obese, normal-weight' phenotype. *Curr Opin Clin Nutr Metab Care,* 19**,** 408-417.
DOBSON, R., BURGESS, M. I., SPRUNG, V. S., IRWIN, A., HAMER, M., JONES, J., DAOUSI, C., ADAMS, V., KEMP, G. J., SHOJAEE-MORADIE, F., UMPLEBY, M. & CUTHBERTSON, D. J. 2016. Metabolically healthy and unhealthy obesity: differential effects on myocardial function according to metabolic syndrome, rather than obesity. *Int J Obes (Lond),* 40**,** 153-61.
DRAPEAU, V., BLUNDELL, J., THERRIEN, F., LAWTON, C., RICHARD, D. & TREMBLAY, A. 2005. Appetite sensations as a marker of overall intake. *Br J Nutr,* 93**,** 273-80.
DUNN, C., HAUBENREISER, M., JOHNSON, M., NORDBY, K., AGGARWAL, S., MYER, S. & THOMAS, C. 2018. Mindfulness Approaches and Weight Loss, Weight Maintenance, and Weight Regain. *Curr Obes Rep,* 7**,** 37-49.
DUTTON, E. & DOVEY, T. M. 2016. Validation of the Dutch Eating Behaviour Questionnaire (DEBQ) among Maltese women. *Appetite,* 107**,** 9-14.
DYKES, J., BRUNNER, E. J., MARTIKAINEN, P. T. & WARDLE, J. 2004. Socioeconomic gradient in body size and obesity among women: the role of dietary restraint, disinhibition and hunger in the Whitehall II study. *Int J Obes Relat Metab Disord,* 28**,** 262-8.
EGGER, G. & SWINBURN, B. 1997. An "ecological" approach to the obesity pandemic. *Bmj,* 315**,** 477-80.
ELFHAG, K. & LINNE, Y. 2005. Gender differences in associations of eating pathology between mothers and their adolescent offspring. *Obes Res,* 13**,** 1070-6.
EMILIEN, C. & HOLLIS, J. H. 2017. A brief review of salient factors influencing adult eating behaviour. *Nutr Res Rev,* 30**,** 233-246.

ERNST, B., WILMS, B., THURNHEER, M. & SCHULTES, B. 2015. Eating behaviour in treatment-seeking obese subjects - Influence of sex and BMI classes. *Appetite,* 95**,** 96-100.
EZQUERRO, S., RODRIGUEZ, A., PORTINCASA, P. & FRUHBECK, G. 2017. Effects of diets on adipose tissue. *Curr Med Chem*.
FEIG, E. H., PIERS, A. D., KRAL, T. V. E. & LOWE, M. R. 2018. Eating in the absence of hunger is related to loss-of-control eating, hedonic hunger, and short-term weight gain in normal-weight women. *Appetite,* 123**,** 317-324.
FIELD, A. 2013. *Discovering Statistics Using IBM SPSS Statistics,* Los Angeles, CA, Sage.
FRAMSON, C., KRISTAL, A. R., SCHENK, J. M., LITTMAN, A. J., ZELIADT, S. & BENITEZ, D. 2009. Development and validation of the mindful eating questionnaire. *J Am Diet Assoc,* 109**,** 1439-44.
FREITAS, A., ALBUQUERQUE, G., SILVA, C. & OLIVEIRA, A. 2018. Appetite-Related Eating Behaviours: An Overview of Assessment Methods, Determinants and Effects on Children's Weight. *Ann Nutr Metab,* 73**,** 19-29.
FRENCH, S. A., EPSTEIN, L. H., JEFFERY, R. W., BLUNDELL, J. E. & WARDLE, J. 2012. Eating behavior dimensions. Associations with energy intake and body weight. A review. *Appetite,* 59**,** 541-9.
FRENCH, S. A., MITCHELL, N. R., WOLFSON, J., FINLAYSON, G., BLUNDELL, J. E. & JEFFERY, R. W. 2014. Questionnaire and laboratory measures of eating behavior. Associations with energy intake and BMI in a community sample of working adults. *Appetite,* 72**,** 50-8.
GALLANT, A. R., TREMBLAY, A., PERUSSE, L., BOUCHARD, C., DESPRES, J. P. & DRAPEAU, V. 2010. The Three-Factor Eating Questionnaire and BMI in adolescents: results from the Quebec family study. *Br J Nutr,* 104**,** 1074-9.
GALLANT, A. R., TREMBLAY, A., PERUSSE, L., DESPRES, J. P., BOUCHARD, C. & DRAPEAU, V. 2012. Past dieting is related to rigid control and disinhibition in adolescents from the Quebec Family Study. *Br J Nutr,* 108**,** 1976-9.
GASPAR, T., DE MATOS, M. G., LUSZCZYNSKA, A., BABAN, A. & WIT, J. 2014. The impact of a rural or urban context in eating awareness and self-regulation strategies in children and adolescents from eight European countries. *Int J Psychol,* 49**,** 158-66.
GEARY, N. 2014. A physiological perspective on the neuroscience of eating. *Physiol Behav,* 136**,** 3-14.
GIBSON, R. S. 2005. *Principles of Nutritional Assessment,* Oxford, New York, Oxford University Press.
GOOSSENS, G. H. 2017. The Metabolic Phenotype in Obesity: Fat Mass, Body Fat Distribution, and Adipose Tissue Function. *Obes Facts,* 10**,** 207-215.
GORAN, M. I. & ALDERETE, T. L. 2012. Targeting adipose tissue inflammation to treat the underlying basis of the metabolic complications of obesity. *Nestle Nutr Inst Workshop Ser,* 73**,** 49-60; discussion p61-6.
GORMALLY, J., BLACK, S., DASTON, S. & RARDIN, D. 1982. The assessment of binge eating severity among obese persons. *Addict Behav,* 7**,** 47-55.
GOULET, J., PROVENCHER, V., PICHE, M. E., LAPOINTE, A., JOHN WEISNAGEL, S., NADEAU, A., BERGERON, J. & LEMIEUX, S. 2008. Relationship between eating behaviours and food and drink consumption in healthy postmenopausal women in a real-life context. *Br J Nutr,* 100**,** 910-7.
GREEN, S. M., WALES, J. K., LAWTON, C. L. & BLUNDELL, J. E. 2000. Comparison of high-fat and high-carbohydrate foods in a meal or snack on short-term fat and energy intakes in obese women. *Br J Nutr,* 84**,** 521-30.
GRIMM, E. R. & STEINLE, N. I. 2011. Genetics of eating behavior: established and emerging concepts. *Nutr Rev,* 69**,** 52-60.
HAYNES, C., LEE, M. D. & YEOMANS, M. R. 2003. Interactive effects of stress, dietary restraint, and disinhibition on appetite. *Eat Behav,* 4**,** 369-83.
HAYS, N. P. & ROBERTS, S. B. 2008. Aspects of eating behaviors "disinhibition" and "restraint" are related to weight gain and BMI in women. *Obesity (Silver Spring),* 16**,** 52-8.
HERMAN, C. P. & MACK, D. 1975. Restrained and unrestrained eating. *J Pers,* 43**,** 647-60.

HIRSCH, K. R., SMITH-RYAN, A. E., BLUE, M. N., MOCK, M. G., TREXLER, E. T. & ONDRAK, K. S. 2016. Metabolic characterization of overweight and obese adults. *Phys Sportsmed,* 44**,** 362-372.

HOOTMAN, K. C., GUERTIN, K. A. & CASSANO, P. A. 2018. Stress and psychological constructs related to eating behavior are associated with anthropometry and body composition in young adults. *Appetite*.

HUNOT, C., FILDES, A., CROKER, H., LLEWELLYN, C. H., WARDLE, J. & BEEKEN, R. J. 2016. Appetitive traits and relationships with BMI in adults: Development of the Adult Eating Behaviour Questionnaire. *Appetite,* 105**,** 356-63.

HUSSAIN, Z., JAFAR, T., ZAMAN, M. U., PARVEEN, R. & SAEED, F. 2014. Correlations of skin fold thickness and validation of prediction equations using DEXA as the gold standard for estimation of body fat composition in Pakistani children. *BMJ Open,* 4**,** e004194.

HWANG, Y. C., HAYASHI, T., FUJIMOTO, W. Y., KAHN, S. E., LEONETTI, D. L., MCNEELY, M. J. & BOYKO, E. J. 2015. Visceral abdominal fat accumulation predicts the conversion of metabolically healthy obese subjects to an unhealthy phenotype. *Int J Obes (Lond),* 39**,** 1365-70.

JAMES, B. L., LOKEN, E., ROE, L. S. & ROLLS, B. J. 2017. The Weight-Related Eating Questionnaire offers a concise alternative to the Three-Factor Eating Questionnaire for measuring eating behaviors related to weight loss. *Appetite,* 116**,** 108-114.

JAUREGUI-LOBERA, I., GARCIA-CRUZ, P., CARBONERO-CARRENO, R., MAGALLARES, A. & RUIZ-PRIETO, I. 2014. Psychometric properties of Spanish version of the Three-Factor Eating Questionnaire-R18 (Tfeq-Sp) and its relationship with some eating- and body image-related variables. *Nutrients,* 6**,** 5619-35.

JIA, A., XU, S., MING, J., XING, Y., GUO, J., ZHAO, M., ZHANG, L. & JI, Q. 2018. Body fat percentage cutoffs for risk of cardiometabolic abnormalities in the Chinese adult population: a nationwide study. *Eur J Clin Nutr*.

JOHNSON, R. J., LANASPA, M. A., SANCHEZ-LOZADA, L. G., RIVARD, C. J., BJORNSTAD, P. S., MERRIMAN, T. & SUNDBORN, G. 2014. Fat storage syndrome in Pacific peoples: a combination of environment and genetics? *Pac Health Dialog,* 20**,** 11-6.

JOSPE, M. R., TAYLOR, R. W., ATHENS, J., ROY, M. & BROWN, R. C. 2017. Adherence to Hunger Training over 6 Months and the Effect on Weight and Eating Behaviour: Secondary Analysis of a Randomised Controlled Trial. *Nutrients,* 9.

KARLSSON, J., PERSSON, L. O., SJOSTROM, L. & SULLIVAN, M. 2000. Psychometric properties and factor structure of the Three-Factor Eating Questionnaire (TFEQ) in obese men and women. Results from the Swedish Obese Subjects (SOS) study. *Int J Obes Relat Metab Disord,* 24**,** 1715-25.

KEYS, A., FIDANZA, F., KARVONEN, M. J., KIMURA, N. & TAYLOR, H. L. 2014. Indices of relative weight and obesity. *Int J Epidemiol,* 43**,** 655-65.

KIM, J., CHOUE, R. & LIM, H. 2016. Differences of Socio-psychology, Eating Behavior, Diet Quality and Quality of Life in South Korean Women according to Their Weight Status. *Clin Nutr Res,* 5**,** 161-71.

KIM, S., KYUNG, C., PARK, J. S., LEE, S. P., KIM, H. K., AHN, C. W., KIM, K. R. & KANG, S. 2015. Normal-weight obesity is associated with increased risk of subclinical atherosclerosis. *Cardiovasc Diabetol,* 14**,** 58.

KLIEMANN, N., BEEKEN, R. J., WARDLE, J. & JOHNSON, F. 2016. Development and validation of the Self-Regulation of Eating Behaviour Questionnaire for adults. *Int J Behav Nutr Phys Act,* 13**,** 87.

KLOTING, N. & BLUHER, M. 2014. Adipocyte dysfunction, inflammation and metabolic syndrome. *Rev Endocr Metab Disord,* 15**,** 277-87.

KRUGER, R., DE BRAY, J. G., BECK, K. L., CONLON, C. A. & STONEHOUSE, W. 2016. Exploring the Relationship between Body Composition and Eating Behavior Using the Three Factor Eating Questionnaire (TFEQ) in Young New Zealand Women. *Nutrients,* 8.

KRUGER, R., SHULTZ, S. P., MCNAUGHTON, S. A., RUSSELL, A. P., FIRESTONE, R. T., GEORGE, L., BECK, K. L., CONLON, C. A., VON HURST, P. R., BREIER, B., JAYASINGHE, S. N., O'BRIEN, W. J., JONES, B. & STONEHOUSE, W. 2015. Predictors and risks of body fat profiles in young New Zealand European, Maori and Pacific women: study protocol for the women's EXPLORE study. *Springerplus,* 4**,** 128.

LABBE, D., RYTZ, A., BRUNSTROM, J. M., FORDE, C. G. & MARTIN, N. 2017. Influence of BMI and dietary restraint on self-selected portions of prepared meals in US women. *Appetite,* 111**,** 203-207.

LAFOREST, S., LABRECQUE, J., MICHAUD, A., CIANFLONE, K. & TCHERNOF, A. 2015. Adipocyte size as a determinant of metabolic disease and adipose tissue dysfunction. *Crit Rev Clin Lab Sci,* 52**,** 301-13.

LAHTEENMAKI, L. & TUORILA, H. 1995. Three-factor eating questionnaire and the use and liking of sweet and fat among dieters. *Physiol Behav,* 57**,** 81-8.

LAL, A., MOODIE, M., ASHTON, T., SIAHPUSH, M. & SWINBURN, B. 2012. Health care and lost productivity costs of overweight and obesity in New Zealand. *Aust N Z J Public Health,* 36**,** 550-6.

LAWSON, O. J., WILLIAMSON, D. A., CHAMPAGNE, C. M., DELANY, J. P., BROOKS, E. R., HOWAT, P. M., WOZNIAK, P. J., BRAY, G. A. & RYAN, D. H. 1995. The association of body weight, dietary intake, and energy expenditure with dietary restraint and disinhibition. *Obes Res,* 3**,** 153-61.

LEE, R. D. & NIEMAN, D. C. 2007. *Nutritional Assessment,* New York, McGraw-Hill.

LEGRO, R. S. 2017. Effects of obesity treatment on female reproduction: results do not match expectations. *Fertil Steril,* 107**,** 860-867.

LESDEMA, A., FROMENTIN, G., DAUDIN, J. J., ARLOTTI, A., VINOY, S., TOME, D. & MARSSET-BAGLIERI, A. 2012. Characterization of the Three-Factor Eating Questionnaire scores of a young French cohort. *Appetite,* 59**,** 385-90.

LILLIS, J., NIEMEIER, H. M., ROSS, K. M., THOMAS, J. G., LEAHEY, T., UNICK, J., KENDRA, K. E. & WING, R. R. 2015. Weight loss intervention for individuals with high internal disinhibition: design of the Acceptance Based Behavioral Intervention (ABBI) randomized controlled trial. *BMC Psychol,* 3**,** 17.

LILLIS, J., NIEMEIER, H. M., THOMAS, J. G., UNICK, J., ROSS, K. M., LEAHEY, T. M., KENDRA, K. E., DORFMAN, L. & WING, R. R. 2016. A randomized trial of an acceptance-based behavioral intervention for weight loss in people with high internal disinhibition. *Obesity (Silver Spring),* 24**,** 2509-2514.

LINDROOS, A. K., LISSNER, L., MATHIASSEN, M. E., KARLSSON, J., SULLIVAN, M., BENGTSSON, C. & SJOSTROM, L. 1997. Dietary intake in relation to restrained eating, disinhibition, and hunger in obese and nonobese Swedish women. *Obes Res,* 5**,** 175-82.

LLUCH, A., KAHN, J., STRICKER-KRONGRAD, A., ZIEGLER, O., DROUIN, P. & MEJEAN, L. 1996. Internal validation of a French version of the Dutch eating behaviour questionnaire. *Eur Psychiatry,* 11**,** 198-203.

LOEBER, S., GROSSHANS, M., HERPERTZ, S., KIEFER, F. & HERPERTZ, S. C. 2013. Hunger modulates behavioral disinhibition and attention allocation to food-associated cues in normal-weight controls. *Appetite,* 71**,** 32-9.

LOFFLER, A., LUCK, T., THEN, F. S., LUPPA, M., SIKORSKI, C., KOVACS, P., TONJES, A., BOTTCHER, Y., BREITFELD, J., HORSTMANN, A., LOFFLER, M., ENGEL, C., THIERY, J., STUMVOLL, M. & RIEDEL-HELLER, S. G. 2015a. Age- and gender-specific norms for the German version of the Three-Factor Eating-Questionnaire (TFEQ). *Appetite,* 91**,** 241-7.

LOFFLER, A., LUCK, T., THEN, F. S., SIKORSKI, C., KOVACS, P., BOTTCHER, Y., BREITFELD, J., TONJES, A., HORSTMANN, A., LOFFLER, M., ENGEL, C., THIERY, J., VILLRINGER, A., STUMVOLL, M. & RIEDEL-HELLER, S. G. 2015b. Eating Behaviour in the General Population: An Analysis of the Factor Structure of the German Version of the Three-Factor-Eating-Questionnaire (TFEQ) and Its Association with the Body Mass Index. *PLoS One,* 10**,** e0133977.

MADDEN, C. E., LEONG, S. L., GRAY, A. & HORWATH, C. C. 2012. Eating in response to hunger and satiety signals is related to BMI in a nationwide sample of 1601 mid-age New Zealand women. *Public Health Nutr,* 15**,** 2272-9.
MAHAN, K. L. & RAYMOND, J. L. 2017. *Krause's Food and the Nutrition Care Process,* St Louis, Missisouri, Elsevier.
MAILLOUX, G., BERGERON, S., MEILLEUR, D., D'ANTONO, B. & DUBE, I. 2014. Examining the associations between overeating, disinhibition, and hunger in a nonclinical sample of college women. *Int J Behav Med,* 21**,** 375-84.
MALIK, V. S., WILLETT, W. C. & HU, F. B. 2013. Global obesity: trends, risk factors and policy implications. *Nat Rev Endocrinol,* 9**,** 13-27.
MANTZIOS, M. & WILSON, J. C. 2015. Mindfulness, Eating Behaviours, and Obesity: A Review and Reflection on Current Findings. *Curr Obes Rep,* 4**,** 141-6.
MARFELL-JONES, M. J. & STEWART, A. D. 2012. *International Standards for Anthropometric Assessment,* Wellington, New Zealand, International Society for the Advancement of Kinanthropometry.
MARTIN-GARCIA, M., VILA-MALDONADO, S., RODRIGUEZ-GOMEZ, I., FAYA, F. M., PLAZA-CARMONA, M., PASTOR-VICEDO, J. C. & ARA, I. 2016. The Spanish version of the Three Factor Eating Questionnaire-R21 for children and adolescents (TFEQ-R21C): Psychometric analysis and relationships with body composition and fitness variables. *Physiol Behav,* 165**,** 350-7.
METCALF, P. A., SCRAGG, R. R., SCHAAF, D., DYALL, L., BLACK, P. N. & JACKSON, R. 2008. Dietary intakes of European, Maori, Pacific and Asian adults living in Auckland: the Diabetes, Heart and Health Study. *Aust N Z J Public Health,* 32**,** 454-60.
METCALF, P. A., SCRAGG, R. R., SUNDBORN, G. & JACKSON, R. 2014. Dietary intakes of Pacific ethnic groups and European people. *Pac Health Dialog,* 20**,** 73-80.
MEULE, A. & VOGELE, C. 2013. The psychology of eating. *Front Psychol,* 4**,** 215.
MICHIMI, A. & WIMBERLY, M. C. 2015. The food environment and adult obesity in US metropolitan areas. *Geospat Health,* 10**,** 368.
MINISTRY OF HEALTH. 2004. *Food and Nutrition Guidelines for Healthy Adults: A background paper* [Online]. Available: https://www.nzihf.co.nz/media-resources-1/articles/personal%20training-nutrition-guidelines-adults [Accessed 1st March 2018].
MINISTRY OF HEALTH. 2008. *A Portrait of Health: Key Results of the 2006/07 New Zealand Health Survey* [Online]. Available: https://www.health.govt.nz/system/files/documents/publications/portrait-of-health-june08.pdf [Accessed 2nd February 2018].
MINISTRY OF HEALTH. 2017. *Obesity statistics* [Online]. Available: http://www.health.govt.nz/nz-health-statistics/health-statistics-and-data-sets/obesity-statistics [Accessed 19th May 2017].
MINISTRY OF HEALTH. 2018a. *Annual Data Explorer: New Zealand Health Survey 2016/17* [Online]. Available: https://minhealthnz.shinyapps.io/nz-health-survey-2016-17-annual-data-explorer/_w_006e9e92/_w_b8866278/#!/explore-indicators [Accessed 3rd February 2018].
MINISTRY OF HEALTH. 2018b. *Nutrient Reference Values for Australia and New Zealand* [Online]. Available: https://www.nrv.gov.au/ [Accessed 5th January, 2018].
MOREIRA, P., DE ALMEIDA, M. D. & SAMPAIO, D. 2005. Cognitive restraint is associated with higher intake of vegetables in a sample of university students. *Eat Behav,* 6**,** 229-37.
NON-COMMUNICABLE DISEASE RISK FACTOR COLLABORATION 2017. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128.9 million children, adolescents, and adults. *Lancet,* 390**,** 2627-2642.
OLIVEIRA, J. B. 2016. Obesity and Reproduction. *JBRA Assist Reprod,* 20**,** 194.
OLIVEROS, E., SOMERS, V. K., SOCHOR, O., GOEL, K. & LOPEZ-JIMENEZ, F. 2014. The concept of normal weight obesity. *Prog Cardiovasc Dis,* 56**,** 426-33.

PAINCHAUD GUERARD, G., LEMIEUX, S., DOUCET, E., POMERLEAU, S. & PROVENCHER, V. 2016. Influence of Nutrition Claims on Appetite Sensations according to Sex, Weight Status, and Restrained Eating. *J Obes,* 2016**,** 9475476.

PARK, B. Y., SEO, J. & PARK, H. 2016. Functional brain networks associated with eating behaviors in obesity. *Sci Rep,* 6**,** 23891.

PICKETT, S. & MCCOY, T. P. 2017. Effect of Psychosocial Factors on Eating Behaviors and BMI Among African American Women. *Clin Nurs Res***,** 1054773817713420.

POINHOS, R., OLIVEIRA, B. M. & CORREIA, F. 2013. Eating behaviour patterns and BMI in Portuguese higher education students. *Appetite,* 71**,** 314-20.

POVEDA, A., KOIVULA, R. W., AHMAD, S., BARROSO, I., HALLMANS, G., JOHANSSON, I., RENSTROM, F. & FRANKS, P. W. 2016. Innate biology versus lifestyle behaviour in the aetiology of obesity and type 2 diabetes: the GLACIER Study. *Diabetologia,* 59**,** 462-71.

PROVENCHER, V., DRAPEAU, V., TREMBLAY, A., DESPRES, J. P. & LEMIEUX, S. 2003. Eating behaviors and indexes of body composition in men and women from the Quebec family study. *Obes Res,* 11**,** 783-92.

PUDEL, V., METZDORFF, M. & OETTING, M. 1975. [The personality of obese persons in psychological tests with special consideration on latent obesity]. *Z Psychosom Med Psychoanal,* 21**,** 345-61.

RAYNOR, H. A. & VADIVELOO, M. 2018. Understanding the Relationship Between Food Variety, Food Intake, and Energy Balance. *Curr Obes Rep*.

REECE, J. B., URRY, L. A., CAIN, M. L. & WASSERMAN, S. A. 2014a. *Campbell Biology,* Cambridge, England, Pearson Education.

REECE, J. B. U., LISA A, CAIN, M. L. & WASSERMAN, S. A. 2014b. *Campbell Biology,* Cambridge, England, Pearson Education.

RIESCO, E., ROSSEL, N., RUSQUES, C., MIREPOIX, M., DRAPEAU, V., SANGUIGNOL, F. & MAURIEGE, P. 2009. Impact of weight reduction on eating behaviors and quality of life: Influence of the obesity degree. *Obes Facts,* 2**,** 87-95.

ROCHESTER MEDICAL WEIGHT LOSS CENTER. 2018. *Facts of Obesity* [Online]. Available: https://www.rochestermedicalweightloss.com/news/obesity-facts/ [Accessed January 4th 2018].

ROSNAH, I., MOHD ZALI, M. N., NOOR HASSIM, I. & AZMI, M. T. 2015. A tale of two construct validation analysis: Rasch model and exploratory factor analysis approach for Three-Factor Eating Questionnaire (TFEQ-R21) among Malaysian male workers. *Med J Malaysia,* 70**,** 169-76.

RUSH, E. C., FREITAS, I. & PLANK, L. D. 2009. Body size, body composition and fat distribution: comparative analysis of European, Maori, Pacific Island and Asian Indian adults. *Br J Nutr,* 102**,** 632-41.

SAWAMOTO, R., NOZAKI, T., NISHIHARA, T., FURUKAWA, T., HATA, T., KOMAKI, G. & SUDO, N. 2017. Predictors of successful long-term weight loss maintenance: a two-year follow-up. *Biopsychosoc Med,* 11**,** 14.

SCHEMBRE, S., GREENE, G. & MELANSON, K. 2009. Development and validation of a weight-related eating questionnaire. *Eat Behav,* 10**,** 119-24.

SCHEMBRE, S. M. & GELLER, K. S. 2011. Psychometric properties and construct validity of the Weight-Related Eating Questionnaire in a diverse population. *Obesity (Silver Spring),* 19**,** 2336-44.

SCHLUNDT, D. G., HARGREAVES, M. K. & BUCHOWSKI, M. S. 2003. The Eating Behavior Patterns Questionnaire predicts dietary fat intake in African American women. *J Am Diet Assoc,* 103**,** 338-45.

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.

SCHWAB, S., TIMOTHY, X., RYAN, K. & STEINLE, N. 2016. Eating behavior disinhibition predicts insulin insensitivity in old order Amish. *Advances in Nutrition: An International Review Journal,* 7**,** 40A-40A.
SHAH, M., COPELAND, J., DART, L., ADAMS-HUET, B., JAMES, A. & RHEA, D. 2014. Slower eating speed lowers energy intake in normal-weight but not overweight/obese subjects. *J Acad Nutr Diet,* 114**,** 393-402.
SHUSTER, A., PATLAS, M., PINTHUS, J. H. & MOURTZAKIS, M. 2012. The clinical importance of visceral adiposity: a critical review of methods for visceral adipose tissue analysis. *Br J Radiol,* 85**,** 1-10.
SINGH, A., BAINS, K. & KAUR, H. 2017. Relationship of Eating Behaviors with Age, Anthropometric Measurements, and Body Composition Parameters among Professional Indian Women. *Ecol Food Nutr,* 56**,** 411-423.
SMITH, C. F., GEISELMAN, P. J., WILLIAMSON, D. A., CHAMPAGNE, C. M., BRAY, G. A. & RYAN, D. H. 1998. Association of dietary restraint and disinhibition with eating behavior, body mass, and hunger. *Eat Weight Disord,* 3**,** 7-15.
SMITH, S. R., LOVEJOY, J. C., GREENWAY, F., RYAN, D., DEJONGE, L., DE LA BRETONNE, J., VOLAFOVA, J. & BRAY, G. A. 2001. Contributions of total body fat, abdominal subcutaneous adipose tissue compartments, and visceral adipose tissue to the metabolic complications of obesity. *Metabolism,* 50**,** 425-35.
SPADARO, K. C., DAVIS, K. K., SEREIKA, S. M., GIBBS, B. B., JAKICIC, J. M. & COHEN, S. M. 2017. Effect of mindfulness meditation on short-term weight loss and eating behaviors in overweight and obese adults: A randomized controlled trial. *J Complement Integr Med*.
STUNKARD, A. J. & MESSICK, S. 1985. The three-factor eating questionnaire to measure dietary restraint, disinhibition and hunger. *J Psychosom Res,* 29**,** 71-83.
SUNDBORN, G., METCALF, P. A., GENTLES, D., SCRAGG, R., DYALL, L., BLACK, P. & JACKSON, R. 2010. Overweight and obesity prevalence among adult Pacific peoples and Europeans in the Diabetes Heart and Health Study (DHAHS) 2002-2003, Auckland New Zealand. *N Z Med J,* 123**,** 30-42.
SUNDBORN, G., METCALF, P. A., GENTLES, D., SCRAGG, R. K., SCHAAF, D., DYALL, L., BLACK, P. & JACKSON, R. 2008. Ethnic differences in cardiovascular disease risk factors and diabetes status for Pacific ethnic groups and Europeans in the Diabetes Heart and Health Survey (DHAH) 2002-2003, Auckland New Zealand. *N Z Med J,* 121**,** 28-39.
TALLROTH, K., KETTUNEN, J. A. & KUJALA, U. M. 2013. Reproducibility of regional DEXA examinations of abdominal fat and lean tissue. *Obes Facts,* 6**,** 203-10.
THOMAS, E. A., BECHTELL, J. L., VESTAL, B. E., JOHNSON, S. L., BESSESEN, D. H., TREGELLAS, J. R. & CORNIER, M. A. 2013. Eating-related behaviors and appetite during energy imbalance in obese-prone and obese-resistant individuals. *Appetite,* 65**,** 96-102.
URBANEK, J. K., METZGAR, C. J., HSIAO, P. Y., PIEHOWSKI, K. E. & NICKOLS-RICHARDSON, S. M. 2015. Increase in cognitive eating restraint predicts weight loss and change in other anthropometric measurements in overweight/obese premenopausal women. *Appetite,* 87**,** 244-50.
VAN DYKE, N. & DRINKWATER, E. J. 2014. Relationships between intuitive eating and health indicators: literature review. *Public Health Nutr,* 17**,** 1757-66.
VAN STREIN, T., FRIJTERS, J. E. R. & BERGERS, G. E. P. 1986. The Dutch Eating Behavior Questionnaire (DEBQ) for assessment of restrained, emotional, and external eating behavior. *International Journal of Eating Disorders,* 5**,** 295-315.
VON HURST, P. R., WALSH, D., CONLON, C. A., INGRAM, M., KRUGER, R. & STONEHOUSE, W. V. 2016. Validity and reliability of bioelectrical impedance analysis to estimate body fat percentage against air displacement plethysmography and dual-energy X-ray absorptiometry. *Nutr Diet,* 73**,** 197-204.

VON SECK, P., SANDER, F. M., LANZENDORF, L., VON SECK, S., SCHMIDT-LUCKE, A., ZIELONKA, M. & SCHMIDT-LUCKE, C. 2017. Persistent weight loss with a non-invasive novel medical device to change eating behaviour in obese individuals with high-risk cardiovascular risk profile. *PLoS One,* 12**,** e0174528.

WAGENKNECHT, M., HAINER, V., KUNESOVA, M., BELLISLE, F., PARIZKOVA, J., BRAUNEROVA, R., HILL, M. & LAJKA, J. 2007. [Relationships between the "eating inventory" factors, socioeconomic status, anthropometric body adiposity indexes and health risks in Czech population]. *Cas Lek Cesk,* 146**,** 284-6, 287-91.

WALL, C. L., GEARRY, R. B., PEARSON, J., PARNELL, W. & SKIDMORE, P. M. 2014. Dietary intake in midlife and associations with standard of living, education and nutrition literacy. *N Z Med J,* 127**,** 30-40.

WARDLE, J., STEPTOE, A., OLIVER, G. & LIPSEY, Z. 2000. Stress, dietary restraint and food intake. *J Psychosom Res,* 48**,** 195-202.

WELLS, J. C. 2012. The evolution of human adiposity and obesity: where did it all go wrong? *Dis Model Mech,* 5**,** 595-607.

WESTENHOEFER, J. 1991. Dietary restraint and disinhibition: is restraint a homogeneous construct? *Appetite,* 16**,** 45-55.

WESTENHOEFER, J., BROECKMANN, P., MUNCH, A. K. & PUDEL, V. 1994. Cognitive control of eating behaviour and the disinhibition effect. *Appetite,* 23**,** 27-41.

WESTENHOEFER, J., ENGEL, D., HOLST, C., LORENZ, J., PEACOCK, M., STUBBS, J., WHYBROW, S. & RAATS, M. 2013. Cognitive and weight-related correlates of flexible and rigid restrained eating behaviour. *Eat Behav,* 14**,** 69-72.

WESTENHOEFER, J., PUDEL, V. & MAUS, N. 1990. Some restrictions on dietary restraint. *Appetite,* 14**,** 137-41; discussion 142-3.

WESTENHOEFER, J., STUNKARD, A. J. & PUDEL, V. 1999. Validation of the flexible and rigid control dimensions of dietary restraint. *Int J Eat Disord,* 26**,** 53-64.

WHITAKER, K. M., SHARPE, P. A., WILCOX, S. & HUTTO, B. E. 2014. Depressive symptoms are associated with dietary intake but not physical activity among overweight and obese women from disadvantaged neighborhoods. *Nutr Res,* 34**,** 294-301.

WILLIAMS, E. P., MESIDOR, M., WINTERS, K., DUBBERT, P. M. & WYATT, S. B. 2015. Overweight and Obesity: Prevalence, Consequences, and Causes of a Growing Public Health Problem. *Curr Obes Rep,* 4**,** 363-70.

WILLIAMSON, D. A., LAWSON, O. J., BROOKS, E. R., WOZNIAK, P. J., RYAN, D. H., BRAY, G. A. & DUCHMANN, E. G. 1995. Association of body mass with dietary restraint and disinhibition. *Appetite,* 25**,** 31-41.

WORLD HEALTH ORGANISATION 1995. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser,* 854**,** 1-452.

WORLD HEALTH ORGANISATION. 2017. *Obesity and overweight* [Online]. Available: http://www.who.int/mediacentre/factsheets/fs311/en/ [Accessed 19th June 2017].

YANNAKOULIA, M., MELISTAS, L., SOLOMOU, E. & YIANNAKOURIS, N. 2007. Association of eating frequency with body fatness in pre- and postmenopausal women. *Obesity (Silver Spring),* 15**,** 100-6.

YEOMANS, M. R. & MCCRICKERD, K. 2017. Acute hunger modifies responses on the Three Factor Eating Questionnaire hunger and disinhibition, but not restraint, scales. *Appetite,* 110**,** 1-5.

ZHAO, J., LI, M., ZHANG, Y., SONG, H., VON DENEEN, K. M., SHI, Y., LIU, Y. & HE, D. 2017. Intrinsic brain subsystem associated with dietary restraint, disinhibition and hunger: an fMRI study. *Brain Imaging Behav,* 11**,** 264-277.

ZYRIAX, B. C., WOLF, C., SCHLUTER, A., KHATTAK, A. H., WESTENHOEFER, J. & WINDLER, E. 2012. Association of cognitive dietary restraint and disinhibition with prediabetes--cross-sectional and longitudinal data of a feasibility study in German employees. *Public Health Nutr,* 15**,** 860-7.

Appendix

Appendix A. Participant personal health, demographics and screening questionnaire

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

Subject Number:

Women's EXPLORE study

Personal Information, Health and Demographics Questionnaire

First name: ____________________

Family name: ____________________

Name you would like to be called by: ____________________

Medical Practitioner: ____________________

Address: ____________________

Phone: ____________________

What is your first language?

English ☐

Other ☐

If other, please state: ____________________

I would like to receive a brief report summarizing the main findings of the project:

Yes ☐ No ☐

I am willing to be contacted in future research projects within the Institute of Food, Nutrition and Human Health:

Yes ☐ No ☐

Health and Demographic information

Do you have children? Yes □ No □

- How many children do you have? ______________________

- When was your youngest child born? __ / __ / ____ (DD/MM/YYYY)

When did your last period start? (Day / month / year) ____________________

Are you pregnant? Yes □ No □

Do you have any surgical or cosmetic implants? Yes □ No □

Are you currently in paid employment? Yes □ No □

If yes,

Full time Yes □ No □

Part time Yes □ No □

If yes, specify hours per week:________________________

Describe your job or paid employment or work:

TITLE / DESCRIBE HOURS PER WEEK

____

____

____

____

____

Do you follow a specific diet for health reasons? Yes □ No □

Please explain

____

____

Do you follow any diet for cultural or religious reasons? Yes □ No □

If yes, what type of diet do you follow? ___________________________

____

____

Are you taking any form of medication, including traditional or homeopathic medicine?

Yes □ No □

Please specify the condition, the medication and the dosage in the table provided.

Condition	Medication	Dosage & Frequency

Are you taking any form of supplements, including tablets or drinks? Yes □ No □

If yes, what are the name, brand and dosage of the supplements you are taking?

Supplement	Brand	Dosage & Frequency

Will send by email Yes □ No □

Do you smoke cigarettes? Yes □ No □

If yes, approximately how many cigarettes per day:______________________________

Do you drink alcohol? Yes □ No □

If yes, approximately how many standard drinks per week:___________________

[1 standard drink = a glass of wine (120ml), 1 bottle/can of beer, I tot of spirits (45mL)]

Do you have any allergies? Yes □ No □

Please specify ____

____

Appendix B. New Zealand Women's Food Frequency Questionnaire

EXPLORE Food Frequency Questionnaire

1. Please read carefully before you begin:

Please make sure when filling out this questionnaire that you:

- Tell us what YOU usually eat (not someone else in your household!).
- Fill in the form YOURSELF.
- Are correct, but don't spend too much time on each food.
- Answer EVERY question; the asterisk symbol (*) at the beginning of each question means that you must answer before moving onto the next question.

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

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

For example:

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

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

If every day you have 2 cups of coffee with 1 tsp sugar, 4 cups of tea with 1 tsp sugar, one bowl of cereal with 1 tsp sugar and sugar on pancakes at dinner, you would choose four or more times per day = '4+ x / day'.

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

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

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

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

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

EXPLORE Food Frequency Questionnaire

2. EXPLORE Study Food Frequency Questionnaire

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

EXPLORE Food Frequency Questionnaire

3. Eating Pattern

***1. How would you describe your eating pattern? (Please choose one only)**

- ◯ Eat a variety of all foods, including animal products
- ◯ Eat eggs, dairy products, fish and chicken but avoid other meats
- ◯ Eat eggs, dairy products and fish, but avoid chicken and other red meats
- ◯ Eat eggs and dairy products, but avoid all meats, chicken and fish
- ◯ Eat eggs, but avoid dairy products, all meats and fish
- ◯ Eat dairy products, but avoid eggs, all meats and fish
- ◯ Eat no animal products
- ◯ None of the above

Other (please state)

EXPLORE Food Frequency Questionnaire

4. Dairy

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

- ◯ Yes
- ◯ No

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

- ☐ Not applicable
- ☐ Full cream milk (purple top)
- ☐ Standard milk (blue top)
- ☐ Skim milk (light blue top)
- ☐ Trim milk (green top)
- ☐ Super trim milk (light green top)
- ☐ Calcium enriched milk (yellow top) e.g. Xtra, Calci-Trim
- ☐ Calcium and vitamin enriched milk e.g. Mega, Anlene
- ☐ Calcium and protein enriched milk e.g. Sun Latte
- ☐ Standard soy milk (blue)
- ☐ Light soy milk (light blue)
- ☐ Calcium enriched soy milk (purple) e.g. Calci-Forte, Calci-Plus
- ☐ Calcium, vitamin and omega 3 enriched soy milk e.g. Essential
- ☐ Calcium and high fibre enriched soy milk e.g. Calci-Plus High Fibre
- ☐ Rice milk

Other (please state)

____

*3. On average, how many servings of milk do you have per day? (Please choose one only)
(A 'serving' = 250 mL or 1 cup/glass)
e.g. 5 cups of coffee/tea using 50 mL of milk + ½ cup of milk on cereal = 1 ½ servings per day

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

EXPLORE Food Frequency Questionnaire

*4. How often do you usually have milk?

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

*5. How often do you usually eat cheese?

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

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

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

EXPLORE Food Frequency Questionnaire

5. Bread

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

◯ No

◯ Yes

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

☐ Not applicable

☐ White

☐ White – high fibre

☐ Wholemeal or wheat meal

☐ Wholegrain

Other (please state)

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

◯ Not applicable

◯ Sandwich slice

◯ Toast slice

◯ Mixture of both sandwich and toast slices

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

◯ Not applicable

◯ Less than 1 serving

◯ 1–2 servings

◯ 3–4 servings

◯ 5–6 servings

◯ 7 or more servings

EXPLORE Food Frequency Questionnaire

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

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

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

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

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

◯ No

◯ Yes

EXPLORE Food Frequency Questionnaire

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

- ☐ Not applicable
- ☐ Butter (all varieties)
- ☐ Monounsaturated fat margarine e.g. Olive, Rice Bran, Canola Oil Spreads
- ☐ Polyunsaturated fat margarine e.g. Sunflower Oil Spreads
- ☐ Light monounsaturated fat margarine e.g. Olivio Spread Light
- ☐ Light polyunsaturated fat margarine e.g. Flora Spread Light
- ☐ Plant sterol enriched margarine e.g. Pro Active, Logical Spreads
- ☐ Light plant sterol enriched margarine e.g. Pro Active Spread Light
- ☐ Butter and margarine blend e.g. Country Soft, Butter Lea

Other (please state)

***9. On average, how many servings of butter, margarine or spreads do you have per day? (Please choose one only)**
(A 'serving' = 1 level teaspoon or 5 mL)
e.g. 1 sandwich with butter thinly spread on two pieces of bread = 2 servings

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

EXPLORE Food Frequency Questionnaire

6. Breakfast Cereals and Porridge

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

- ◯ No
- ◯ Yes

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

- ☐ Not applicable
- ☐ Weetbix
- ☐ Refined cereals e.g. Cornflakes or Rice Bubbles
- ☐ Bran based cereals including fruity varieties e.g. Special K, Muesli, All Bran
- ☐ Sweetened e.g. Nutrigrain, Cocoa Pops
- ☐ Porridge

Other (please state)

***3. On average, how many servings of breakfast cereal or porridge do you have per week? (Please choose one only)**
(A 'serving' = ½ cup porridge, muesli, cornflakes or 2 weetbix)
e.g. ½ cup of porridge 3 times per week + 2 weetbix 4 times a week = 7 servings per week

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

EXPLORE Food Frequency Questionnaire

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

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Porridge, rolled oats, oat bran, oat meal - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Muesli (all varieties) - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Weetbix (all varieties) - 2 weetbix	◯	◯	◯	◯	◯	◯	◯	◯	◯
Cornflakes or rice bubbles - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Bran cereals (All Bran, Bran Flakes) - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Bran based cereals (Sultana Bran, Sultana Bran Extra) - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Light and fruity cereals (Special K, Light and Tasty) - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Chocolate based cereals (Milo cereal, Coco Pops) - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Sweetened cereals (Nutrigrain, Fruit Loops, Honey Puffs, Frosties) - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Breakfast drinks (Up and Go) - Small carton / 250 mL	◯	◯	◯	◯	◯	◯	◯	◯	◯

EXPLORE Food Frequency Questionnaire

7. Starchy Foods

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

- No
- Yes

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

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

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

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

EXPLORE Food Frequency Questionnaire

8. Meat

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

- ◯ No
- ◯ Yes

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

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

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

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

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

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

EXPLORE Food Frequency Questionnaire

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

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

EXPLORE Food Frequency Questionnaire

9. Poultry

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

◯ No
◯ Yes

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

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

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

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

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

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

EXPLORE Food Frequency Questionnaire

10. Fish and Seafood

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

- ◯ No
- ◯ Yes

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

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

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

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

EXPLORE Food Frequency Questionnaire

*4. How often do you usually eat seafood?

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

*5. How often do you usually eat seafood?

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

EXPLORE Food Frequency Questionnaire

11. Fats and Oils

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

- ◯ No
- ◯ Yes

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

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

Other (please state)

____

***3. When you use fat or oil to cook, how many servings of fat or oil do you use per dish? (Please choose one only)**
(A 'serving' = 1 level teaspoon or 5 mL)

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

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

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

EXPLORE Food Frequency Questionnaire

12. Eggs

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

- ◯ No
- ◯ Yes

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

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

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

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

EXPLORE Food Frequency Questionnaire

13. Legumes

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

- ◯ No
- ◯ Yes

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

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

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

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

EXPLORE Food Frequency Questionnaire

14. Vegetables

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

- ◯ No
- ◯ Yes

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

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

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

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

EXPLORE Food Frequency Questionnaire

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

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Green bananas (plantain) - 1 medium / ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Sprouts (alfalfa, mung) - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Pacific Island yams - 1 medium / ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Turnips, swedes, parsnip or yams - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Onions, celery or leeks - ¼ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Cauliflower, broccoli or broccoflower - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Brussel sprouts, cabbage, red cabbage or kale - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Courgette/zucchini, marrow, eggplant, squash, kamo kamo, asparagus, cucumber - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Capsicum (peppers) - ½ medium / ¼ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Avocado - ¼ avocado	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lettuce greens (mesculin, cos, iceberg) - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯
Other green leafy vegetables (whitloof, watercress, taro leaves, puha) - ½ cup	◯	◯	◯	◯	◯	◯	◯	◯	◯

EXPLORE Food Frequency Questionnaire

15. Fruit

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

- No
- Yes

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

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

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

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

EXPLORE Food Frequency Questionnaire

16. Drinks

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

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

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

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

EXPLORE Food Frequency Questionnaire

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

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

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

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

EXPLORE Food Frequency Questionnaire

17. Dressings and Sauces

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

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

EXPLORE Food Frequency Questionnaire

18. Miscellaneous - Cakes, Biscuits and Puddings

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

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

EXPLORE Food Frequency Questionnaire

19. Miscellaneous

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

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

***2. Do you use salt in cooking?**

- ◯ Never
- ◯ Rarely
- ◯ Sometimes
- ◯ Usually
- ◯ Always

***3. Do you use salt at the table?**

- ◯ Never
- ◯ Rarely
- ◯ Sometimes
- ◯ Usually
- ◯ Always

EXPLORE Food Frequency Questionnaire

20. Miscellaneous - Takeaways

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

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

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

	Never	<1x / month	1-3x / month	1x / week	2-3x / week	4-6x / week	Once / day	2-3x / day	4+ x / day
Meat pie, sausage roll, other savouries - 1 pie / 2 small sausage rolls or savouries									
Hot potato chips, kumara chips, french fries, wedges - ½ cup									
Chinese - 1 serve									
Indian - 1 serve									
Thai - 1 serve									
Pizza - 1 medium slice									
Burgers - 1 medium burger									
Battered fish - 1 piece									
Fried chicken (KFC, Country fried chicken) - 1 medium piece									
Bread based (Kebab, sandwiches, wraps, Pita Pit, Subway) - 1 medium									

EXPLORE Food Frequency Questionnaire

21. Other

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

- ◯ No
- ◯ Yes

EXPLORE Food Frequency Questionnaire

22. Other

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

Appendix C. Three Factor Eating Questionnaire

Eating Behaviour Questionnaire

Eating Behaviour Questionnaire

*1. Please enter your study identification number again

Study identification number ____________________

Eating Behaviour Questionnaire

Please answer each question by choosing the the appropriate answer (True or False)

2. When I smell a sizzling steak or see a juicy piece of meat, I find it very difficult to keep from eating, even if I have just finished a meal

○ True

○ False

3. I usually eat too much at social occasions, like parties and picnics

○ True

○ False

4. I am usually so hungry that I eat more than three times a day

○ True

○ False

5. When I have eaten my quota of calories, I am usually good about not eating any more

○ True

○ False

6. Dieting is so hard for me because I just get too hungry

○ True

○ False

7. I deliberately take small helpings as a means of controlling my weight

○ True

○ False

8. Sometimes things just taste so good that I keep on eating even when I am no longer hungry

○ True

○ False

Eating Behaviour Questionnaire

9. Since I am often hungry, I sometimes wish that while eating, an expert would tell me that I have had enough or that I can have something more to eat

- True
- False

10. When I feel anxious, I find myself eating

- True
- False

11. Life is too short to worry about dieting

- True
- False

12. Since my weight goes up and down, I have gone on reducing diets more than on

- True
- False

13. I often feel so hungry that I just have to eat someting

- True
- False

14. When I am with someone who is overeating, I usually overeat too

- True
- False

15. I have a pretty good idea of the number of calories in common food

- True
- False

16. Sometimes when I start eating, I just can't seem to stop

- True
- False

17. It is not difficult for me to leave something on my plate

- True
- False

Eating Behaviour Questionnaire

18. At certain times of the day, I get hungry because I have gotten used to eating someting then

- True
- False

19. While on a diet, if I eat food that is not allowed, I consciously eat less for a period of time to make up for it

- True
- False

20. Being with someone who is eating often makes me hungry enough to eat also

- True
- False

21. When I feel blue, I often overeat

- True
- False

22. I enjoy eating too much to spoil it by counting calories or watching my weight

- True
- False

23. When I see a real delicacy, I often get so hungry that I have to eat right away

- True
- False

24. I often stop eating when I am not really full as a conscious means of limiting the amount that I eat

- True
- False

25. I get so hungry that my stomach often seems like a bottomless pit

- True
- False

26. My weight has hardly changed at all in the last ten years

- True
- False

Eating Behaviour Questionnaire

27. I am always hungry so it is hard for me to stop eating before I finish the food on my plate

- True
- False

28. When I feel lonely, I console myself by eating

- True
- False

29. I consciously hold back at meals in order not to gain weight

- True
- False

30. I sometimes get very hungry late in the evening or at night

- True
- False

31. I eat anything I want, any time I want

- True
- False

32. Without even thinking about it, I take a long time to eat

- True
- False

33. I count calories as a conscious means of controlling my weight

- True
- False

34. I do not eat some foods because they make me fat

- True
- False

35. I am always hungry enough to eat at any time

- True
- False

Eating Behaviour Questionnaire

36. I pay a great deal of attention to changes in my figure

- True
- False

37. While on a diet, if I eat a food that is not allowed, I often then splurge and eat other high calorie foods

- True
- False

Eating Behaviour Questionnaire

Please answer the following questions by choosing the response that is appropriate to you.

38. How often are you dieting in a conscious effort to control your weight?

- Rarely
- Sometimes
- Usually
- Always

39. Would a weight fluctuation of 2.5 kg (5 lbs) affect the way you live your life?

- Not at all
- Slightly
- Moderately
- Very much

40. How often do you feel hungry?

- Only at mealtimes
- Sometimes between meals
- Often between meals
- Almost always

41. Do your feelings of guilt about overeating help you to control your food intake?

- Never
- Rarely
- Often
- Always

Eating Behaviour Questionnaire

42. How difficult would it be for you to stop eating halfway through dinner and not eat for the next four hours?

- Easy
- Slightly difficult
- Moderately difficult
- Very difficult

43. How conscious are you of what you are eating?

- Not at all
- Slightly
- Moderately
- Exremely

44. How frequently do you avoid ‘stocking up’ on tempting foods?

- Almost never
- Seldom
- Usually
- Almost always

45. How likely are you to shop for low calorie foods?

- Unlikely
- Slightly likely
- Moderately likely
- Very likely

46. Do you eat sensibly in front of others and splurge alone?

- Never
- Rarely
- Often
- Always

47. How likely are you to consciously eat slowly in order to cut down on how much you eat?

- Unlikely
- Slightly likely
- Moderately likely
- Very Likely

48. How frequently do you skip dessert because you are no longer hungry?

- Almost never
- Seldom
- At least once a week
- Almost every day

49. How likely are you to consciously eat less than you want?

- Unlikely
- Slightly likely
- Moderately likely
- Very likely

50. Do you go on eating binges though you are not hungry?

- Never
- Rarely
- Sometimes
- At least once a week

51. On a scale of 0 to 5, where 0 means no restraint in eating (eating whatever you want, whenever you want it) and 5 means total restraint (constantly limiting food intake and never 'giving in'), what number would you give yourself?. Choose the answer which best describes you.

- 0. Eat whatever you want, whenever you want it
- 1. Usually eat whatever you want, whenever you want it
- 2. Often eat whatever you want, whenever you want it
- 3. Often limit food intake, but often 'give in'
- 4. Usually limit food intake, rarely 'give in'
- 5. Constantly limiting food intake, never 'giving in'

52. To what extent does this statement describe your eating behaviour ? 'I start dieting in the morning, but because of any number of things that happen during the day, by evening I have given up and eat what I want, promising myself to start dieting again tomorrow.'

- Not like me
- A little like me
- Pretty good description of me
- Describes me perfectly

Appendix C.1 General coding sheet for Three Factor Eating Questionnaire

Category/sub-category	Number of questions	Examples of question number items
Restraint		
R_0 Total restraint	21	**4, 6,** 10, **14, 18**, 21, 23, **28,** 30, **32,** 33, **35, 37, 38, 40, 42, 43, 44,** 46, **48,** 50
R_1 Flexible restraint	*7*	*4, 6, 18, 28, 35, 42, 48*
R_2 Rigid restraint	*7*	*14, 32, 37, 38, 40, 43, 44*
Disinhibition		
D_0 Total disinhibition	16	1, **2, 7, 9, 11, 13, 15, 16, 20,** 25, **27,** 31, **36, 45, 49, 51**
D_1 Habitual disinhibition	*5*	*11, 36, 45, 49, 51*
D_2 Emotional disinhibition	*3*	*9, 20, 27*
D_3 Situational disinhibition	*5*	*2, 7, 13, 15, 16*
Hunger		
H_0 Total hunger	14	**3, 5, 8, 12,** 17, **19, 22, 24, 26,** 29, **34, 39, 41, 47**
H_1 Internal hunger	*6*	*3, 5, 12, 24, 34, 39*
H_2 External hunger	*6*	*8, 19, 22, 26, 41, 47*

Italics = sub-category. Bold examples = the question contributes to a main category AND a sub-category (e.g. R_0 AND $R_{1 \text{ or } 2}$). Un-bolded examples = the question only contributes to a main category and NOT a sub-category (e.g. (e.g. R_0 only).

Appendix C.2 Part 1 coding sheet for the Three Factor Eating Questionnaire

PART 1				
Question	Score		Factor number	Category and/or sub-category
	True	False		
Q.1	1	0	2	D_0
Q.2	1	0	2	D_0, D_3
Q.3	1	0	3	H_0, H_1
Q.4	1	0	1	R_0, R_1
Q.5	1	0	3	H_0, H_1
Q.6	1	0	1	R_0, R1
Q.7	1	0	2	D_0, D_3
Q.8	1	0	3	H_0, H_2
Q.9	1	0	2	D_0, D_2
Q.10	0	1	1	R_0
Q.11	1	0	2	D_0, D_1
Q.12	1	0	3	H_0, H_1
Q.13	1	0	2	D_0, D_3
Q.14	1	0	1	R_0, R_2
Q.15	1	0	2	D_0, D_3
Q.16	0	1	2	D_0, D_3

PART 1				
Question	Score		Factor number	Category and/or sub-category
	True	False		
Q.17	1	0	3	H_0
Q.18	1	0	1	R_0, R_1
Q.19	1	0	3	H_2
Q.20	1	0	2	D_0, D_2
Q.21	0	1	1	R_0, R
Q.22	1	0	3	H_0, H_2
Q.23	1	0	1	R_0,
Q.24	1	0	3	H_0, H_1
Q.25	0	1	2	D_0
Q.26	1	0	3	H_0, H_2
Q.27	1	0	2	D_0, D_2
Q.28	1	0	1	R_0, R_1
Q.29	1	0	3	H_0
Q.30	0	1	1	R_0
Q.31	0	1	2	D_0
Q.32	1	0	1	R_0, R_2
Q.33	1	0	1	R_0
Q.34	1	0	3	H_0, H_1
Q.35	1	0	1	R_1
Q.36	1	0	2	D_0, D_1

Q Question, R_0 Restraint, R_1 Flexible Restraint, R_2 Rigid Restraint, D_0 Disinhibition, D_1 Habitual Disinhibition, D_2 Emotional Disinhibition, D_3 Situational Disinhibition, H_0 Hunger, H_1 Internal Hunger, H_2 External Hunger. Factor number 1 = Restraint, 2= Disinhibition, 3 = Hunger.

Appendix C.3 Part 2 coding sheet for the Three Factor Eating Questionnaire

Question	Score		Factor number	Category and/or sub-category
	1 or 2	3 or 4		
Q.37	0	1	1	R_0, R_2
Q.38	0	1	1	R_0, R_2
Q.39	0	1	3	H_0, H_1
Q.40	0	1	1	R_0, R_2
Q.41	0	1	3	H_0, H_2
Q.42	0	1	1	R_0, R_1
Q.43	0	1	1	R_0, R_2
Q.44	0	1	1	R_0, R_2
Q.45	0	1	2	D_0, D_1
Q.46	0	1	1	R_0
Q.47	1	0	3	H_0, H_2
Q.48	0	1	1	R_0, R_1
Q.49	0	1	2	D_0, D_1
Q.50	0	1	1	R_0
Q.51	0	1	2	D_0, D_1

Q Question, Score 1 or 2 = First or second answer choice. Score 3 or 4 = Third or fourth answer choice. R_0 Restraint, R_1 Flexible Restraint, R_2 Rigid Restraint, D_0 Disinhibition, D_1 Habitual Disinhibition, D_2 Emotional Disinhibition, D_3 Situational Disinhibition, H_0 Hunger, H_1 Internal Hunger, H_2 External Hunger. Factor number 1 = Restraint, 2= Disinhibition, 3 = Hunger.

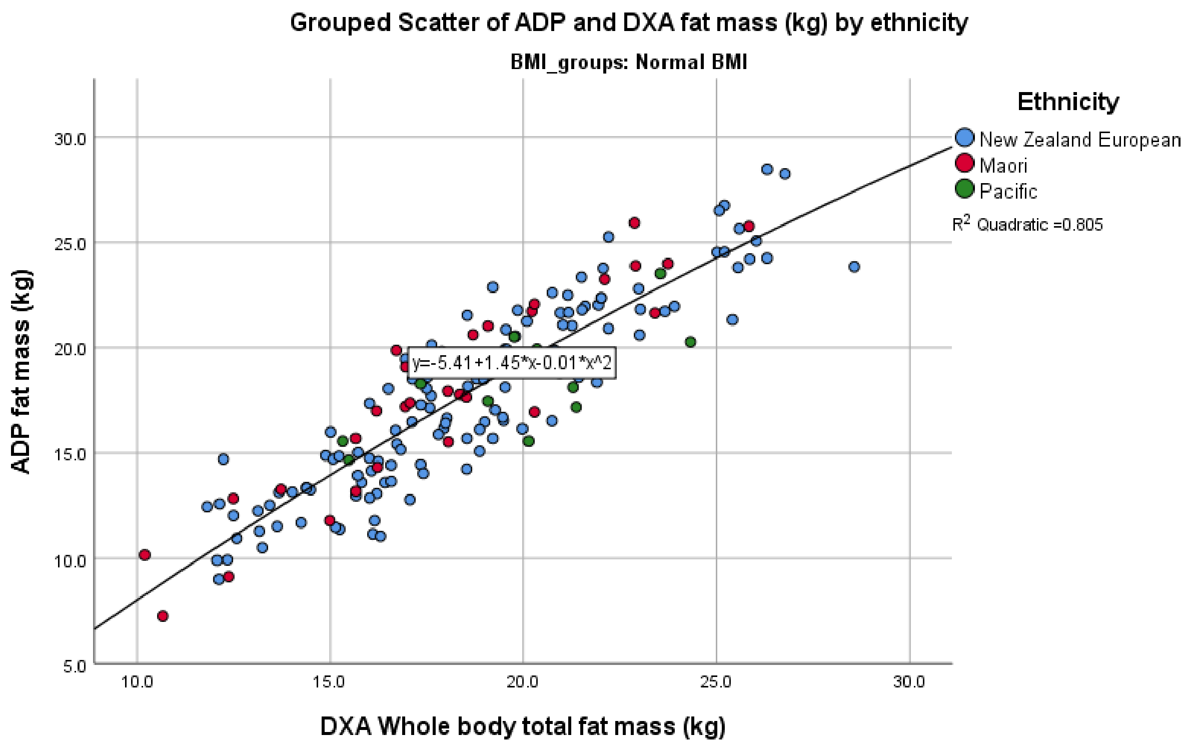
Appendix D Correlations between air displacement plethysmography and dual x-ray absorptiometry for fat mass and body mass percentage

Correlations	ADP total fat mass (kg)	DXA Whole Body total fat mass (kg)	ADP BF %	DXA BF %
Total[a]	$P < 0.001$		$P < 0.001$	
Ethnicity[b]	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$
BMI Normal group [b]	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$
BMI High group [b]	$P < 0.001$	$P < 0.001$	$P < 0.001$	$P < 0.001$

[a] Bivariate Pearson's correlation

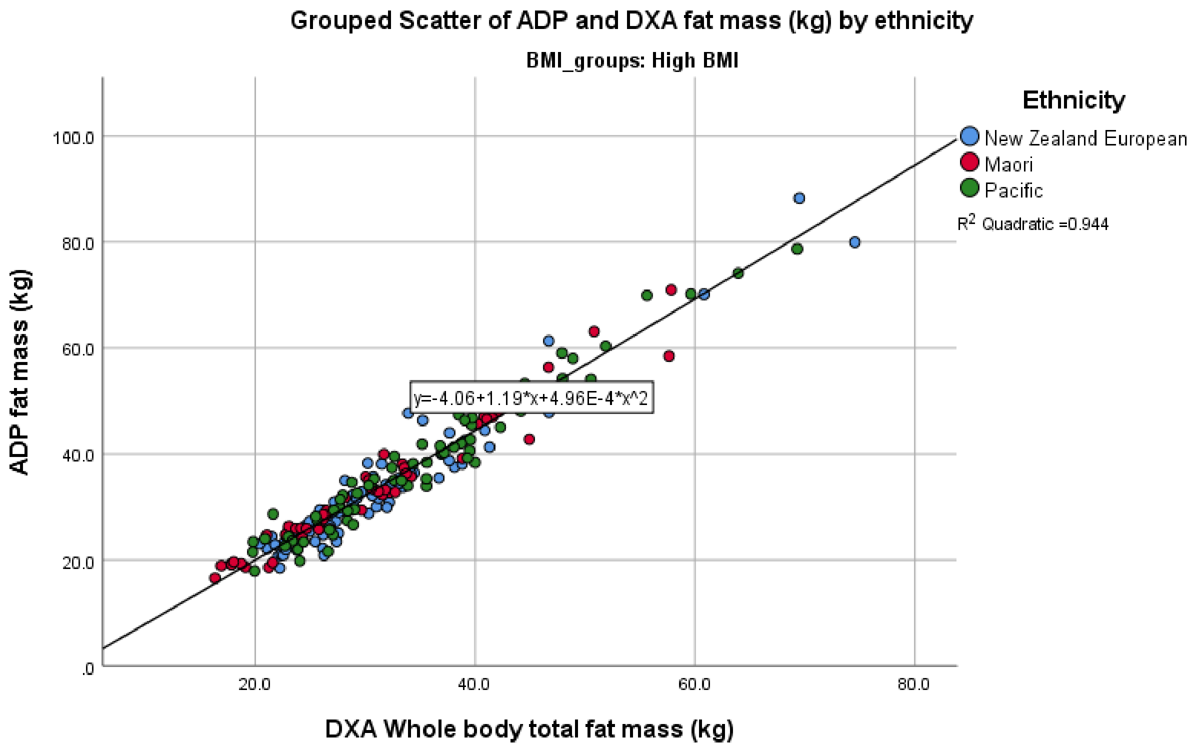
[b] Partial correlation

Appendix E Scatter plot of air displacement plethysmography and dual x-ray absorptiometry fat mass for women with a normal body mass index, in relation to ethnicity.



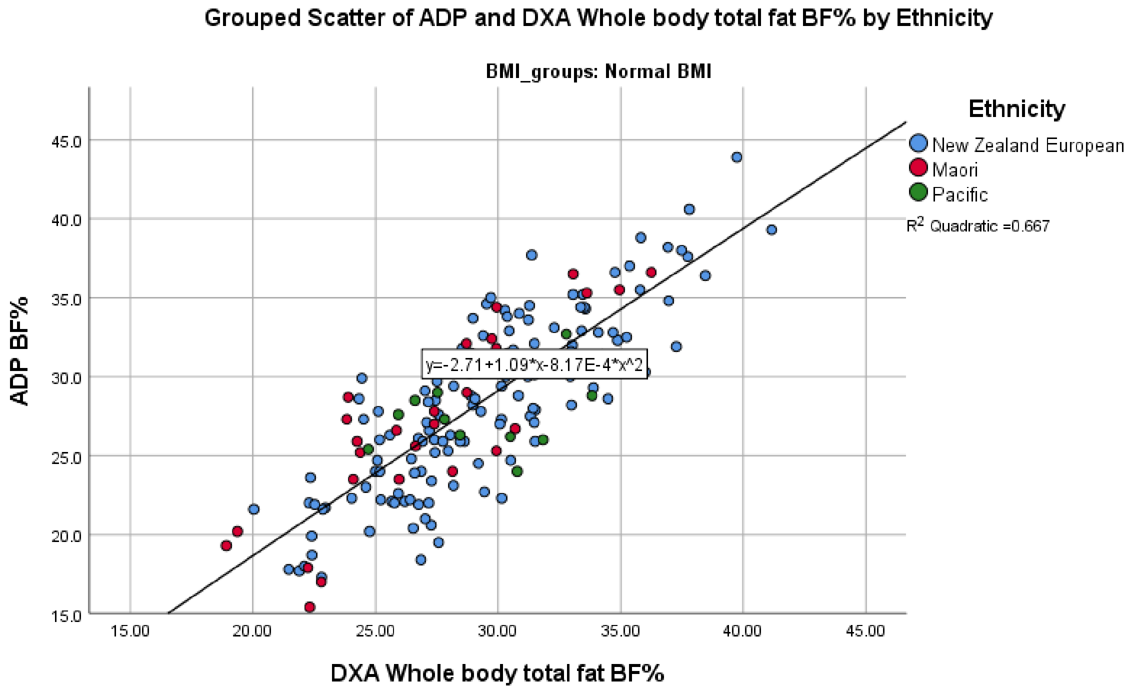
Pearson's correlation ($p < 0.001$). ADP = Air displacement plethysmography, DXA = Dual x-ray absorptiometry, KG = kilogram, BMI = Body mass index.

Appendix F Scatter plot of air displacement plethysmography and dual x-ray absorptiometry fat mass for women with a high body mass index, in relation to ethnicity.



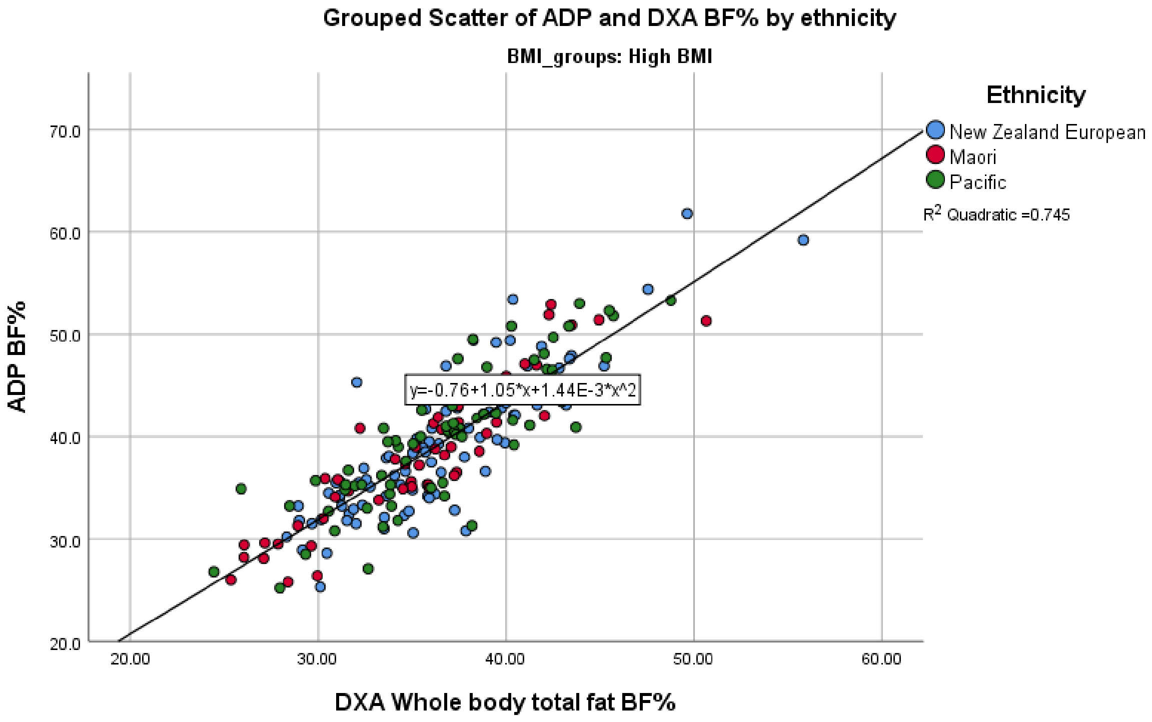
Pearson's correlation ($p < 0.001$). ADP = Air displacement plethysmography, DXA = Dual x-ray absorptiometry, KG = kilogram, BMI = Body mass index

Appendix G Scatter plot of air displacement plethysmography and dual x-ray absorptiometry body fat percentage for women with a normal body mass index, in relation to ethnicity.



Pearson's correlation ($p < 0.001$). ADP = Air displacement plethysmography, DXA = Dual x-ray absorptiometry, BF % = Body fat percentage, BMI = Body mass index.

Appendix H Scatter plot of air displacement plethysmography and dual x-ray absorptiometry body fat percentage for women with a high body mass index, in relation to ethnicity.



Pearson's correlation ($p < 0.001$). ADP = Air displacement plethysmography, DXA = Dual x-ray absorptiometry, KG = kilogram, BMI = Body mass index

Appendix I Linear Regression for Three Factor Eating Questionnaire main categories correlation to body mass index and body fat percentage

Model for BMI[a]		B	Std error β	95% CI β	Std'ised β	*P*-value
1	Intercept	24.8	1.58	21.7 27.9		< 0.001
	Disinhibition	0.60	0.11	0.38 0.83	0.33	< 0.001
	Restraint	-0.28	0.08	-0.45 -0.19	-0.17	0.003
	Hunger	0.07	0.13	-0.18 0.31	0.03	0.602
	Age	0.02	0.04	-0.06 0.09	0.02	0.655
	[a]F ratio 13.7 (4, 359), adjusted R^2 0.12, $p < 0.001$					
2	Intercept	17.3	1.56	14.2 20.3		< 0.001
	Disinhibition	0.66	0.10	0.46 0.85	0.36	< 0.001
	Restraint	-0.20	0.07	-0.34 -0.05	-0.12	0.007
	Hunger	-0.14	0.12	-0.36 0.08	-0.07	0.223
	Ethnicity	3.72	0.36	3.02 4.42	0.47	< 0.001
	Age	0.06	0.03	-0.00 0.13	0.08	0.066
	F ratio 36.0 (5, 358), adjusted R^2 0.33, $p < 0.001$					
3	Intercept	16.9	1.52	14.2 20.3		< 0.001
	Disinhibition	0.62	0.41	0.45 0.81	0.36	< 0.001
	Restraint	-0.18	0.05	-0.31 -0.07	-0.12	0.008
	Hunger	-0.10	0.11	-0.34 0.10	-0.07	0.322

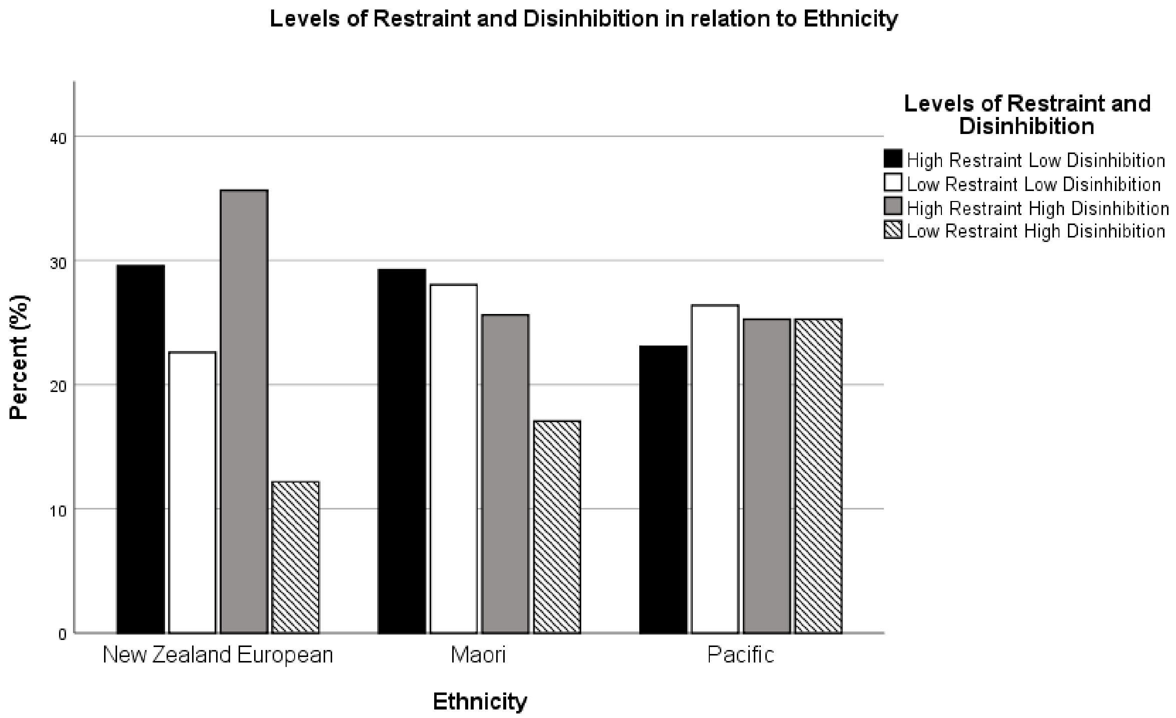
Model for BMI[a]		B	Std error β	95% CI β	Std'ised β	*P*-value
	Ethnicity	3.63	0.36	3.10 4.20	0.47	< 0.001
	Age	0.06	0.01	-0.01 0.18	0.08	0.123
	Energy	0.12	0.05	0.00 0.24	0.25	0.238
	F ratio 36.2 (4, 360), adjusted R^2 0.32, $p < 0.001$					
Model for BF %[a]		**B**	**Std error β**	**95% CI β**	**Std'ised β**	***P*-value**
1	Intercept	29.4	1.82	25.9 33.0		< 0.001
	Disinhibition	0.78	0.13	0.52 1.34	0.36	< 0.001
	Restraint	-0.32	0.10	-0.51 -0.13	-0.17	0.001
	Hunger	-0.07	0.15	-0.36 0.21	-0.03	0.621
	Age	0.11	0.05	0.02 0.20	0.12	0.013
	[a]F ratio 15.8 (4, 363) adjusted R^2 0.14, $p < 0.001$					
2	Intercept	23.6	1.94	19.8 27.5		< 0.001
	Disinhibition	0.82	0.12	0.57 1.06	0.40	< 0.001
	Restraint	-0.26	0.09	-0.44 -0.08	-0.14	0.005
	Hunger	-0.23	0.14	-0.50 0.05	-0.09	0.103
	Age	0.14	0.04	0.06 0.23	0.16	0.001
	Ethnicity	2.88	0.44	2.01 3.75	0.31	< 0.001
	F ratio 22.8 (5, 363) adjusted R^2 0.23 $p < 0.001$					
3	Intercept	23.6	1.94	19.8 27.5		< 0.001
	Disinhibition	0.82	0.12	0.57 1.06	0.40	< 0.001
	Restraint	-0.26	0.09	-0.44 -0.08	-0.14	0.005
	Hunger	-0.23	0.14	-0.50 0.05	-0.09	0.103
	Age	0.14	0.04	0.06 0.23	0.16	0.001
	Ethnicity	2.74	0.44	2.01 3.75	0.31	< 0.001
	Energy	0.63	0.85	0.32 0.96	0.74	0.198
	F ratio 20.9 (4, 359) adjusted R^2 0.21 $p < 0.001$					

Appendix J Linear Regression for Three Factor Eating Questionnaire sub-categories correlation to body mass index and body fat percentage

Model for BMI [a]		B	Std error β	95% CI β	Std'ised β	*P*-value
1	Intercept	27.9	1.56	24.8 31.0		< 0.001
	Habitual Disinhibition	1.43	0.27	0.90 1.96	0.32	< 0.001
	Emotional Disinhibition	0.60	0.32	-0.04 1.23	0.11	0.009
	Rigid Restraint	-0.50	0.23	-0.95 0.05	-0.13	0.030
	External Hunger	0.47	0.28	-0.08 1.02	-0.11	0.096
	Flexible Restraint	-0.35	0.23	-0.80 0.10	-0.09	0.128
	Situational Disinhibition	-0.45	0.30	-1.04 0.14	-0.09	0.132
	Internal Hunger	-0.14	0.22	-0.56 0.29	-0.04	0.523
	Age	-0.00	0.04	-0.08 0.07	-0.00	0.959
		[a] F ratio 10.2 (8, 363) adjusted R^2 0.19, $p < 0.001$				
2	Intercept	19.9	1.62	16.7 23.1		< 0.001
	Habitual Disinhibition	1.00	0.24	0.53 1.49	0.23	< 0.001
	Emotional Disinhibition	1.08	0.29	0.50 1.65	0.20	< 0.001
	Flexible Restraint	-0.34	0.20	-0.75 0.06	-0.09	0.093
	Situational Disinhibition	-0.26	0.27	-0.78 0.27	-0.05	0.336
	Internal Hunger	-0.15	0.19	-0.53 0.23	-0.04	0.450
	External Hunger	0.11	0.25	-0.39 0.60	0.25	0.673
	Rigid Restraint	-0.17	0.21	-0.58 0.24	-0.21	0.417
	Age	0.05	0.03	-0.02 0.11	0.03	0.180
	Ethnicity	3.55	0.37	2.83 4.27	0.37	< 0.001
		[a] F ratio 23.2 (9, 378) adjusted R^2 0.34, $p < 0.001$				
3	Intercept	20.0	1.68	15.4 23.1		< 0.001
	Habitual Disinhibition	1.00	0.24	0.53 1.49	0.22	< 0.001
	Emotional Disinhibition	1.08	0.29	0.50 1.69	0.20	< 0.001
	Flexible Restraint	-0.34	0.20	-0.75 0.06	-0.09	0.092
	Situational Disinhibition	-0.26	0.26	-0.4 0.27	-0.03	0.342
	Internal Hunger	-0.15	0.19	-0.53 0.23	-0.04	0.467
	External Hunger	0.11	0.25	-0.28 0.69	0.26	0.693
	Rigid Restraint	-0.17	0.21	-0.58 0.24	-0.21	0.472
	Age	0.05	0.03	-0.01 0.12	0.03	0.188
	Ethnicity	3.55	0.40	2.83 4.28	0.31	< 0.001
	Energy	0.520	0.09	-0.001 0.018	0.04	0.124
		[a] F ratio 24 (8, 369) adjusted R^2 0.34, $p < 0.001$				
Model for BF % [b]		**B**	**Std error β**	**95% CI β**	**Std'ised β**	***P*-value**
1	Intercept	32.5	1.82	28.9 36.0		< 0.001
	Habitual Disinhibition	1.33	0.31	0.71 1.95	0.26	< 0.001
	Emotional Disinhibition	1.14	0.38	0.40 1.88	-0.13	0.003
	Rigid Restraint	-0.60	0.27	-1.12 -0.07	-0.13	0.027

	Flexible Restraint	-0.34	0.27	-0.86 0.19	-0.07	0.207
	Internal Hunger	-0.27	0.25	-0.77 0.23	-0.06	0.288
	External Hunger	0.35	0.33	-0.07 1.27	0.07	0.291
	Situational Disinhibition	-0.27	0.35	-0.95 0.41	-0.05	0.437
	Age	0.09	0.04	0.00 0.18	0.10	0.040
		[b] F ratio 10.1 (8, 363) adjusted R^2 0.17, $p < 0.001$				
2						
	Intercept	26.3	2.03	22.3 30.3		< 0.001
	Habitual Disinhibition	1.00	0.30	0.40 1.60	0.19	< 0.001
	Emotional Disinhibition	1.51	0.37	0.79 2.23	-0.08	< 0.001
	Rigid Restraint	-0.34	0.26	-0.85 0.17	-0.08	0.192
	Flexible Restraint	-0.33	0.25	-0.83 0.17	-0.07	0.193
	Internal Hunger	-0.27	0.24	-0.75 0.20	-0.06	0.256
	Situational Disinhibition	-0.12	0.33	-0.78 0.53	-0.02	0.713
	External Hunger	0.07	0.32	-0.55 0.69	0.01	0.828
	Age	0.13	0.04	0.04 0.21	0.14	0.003
	Ethnicity	2.72	0.50	1.82 3.62	0.29	< 0.001
3						
	Intercept	26.3	2.08	22.1 30.7		< 0.001
	Habitual Disinhibition	0.94	0.30	0.63 1.65	0.19	< 0.001
	Emotional Disinhibition	1.42	0.20	0.79 2.23	-0.08	< 0.001
	Rigid Restraint	-0.34	0.26	-0.81 0.11	-0.04	0.230
	Flexible Restraint	-0.39	0.24	-0.83 0.17	-0.03	0.563
	Internal Hunger	-0.27	0.23	-0.74 0.22	-0.07	0.842
	Situational Disinhibition	-0.18	0.49	-0.70 0.57	-0.08	0.966
	External Hunger	0.07	0.65	-0.55 0.69	0.06	0.874
	Age	0.14	0.85	0.04 0.21	0.52	0.010
	Ethnicity	2.42	0.63	1.89 3.63	0.19	< 0.001
	Energy	1.24	0.25	0.08 0.45	0.09	0.322
		[b] F ratio 13.9 (8, 372) adjusted R^2 0.24, $p < 0.001$				

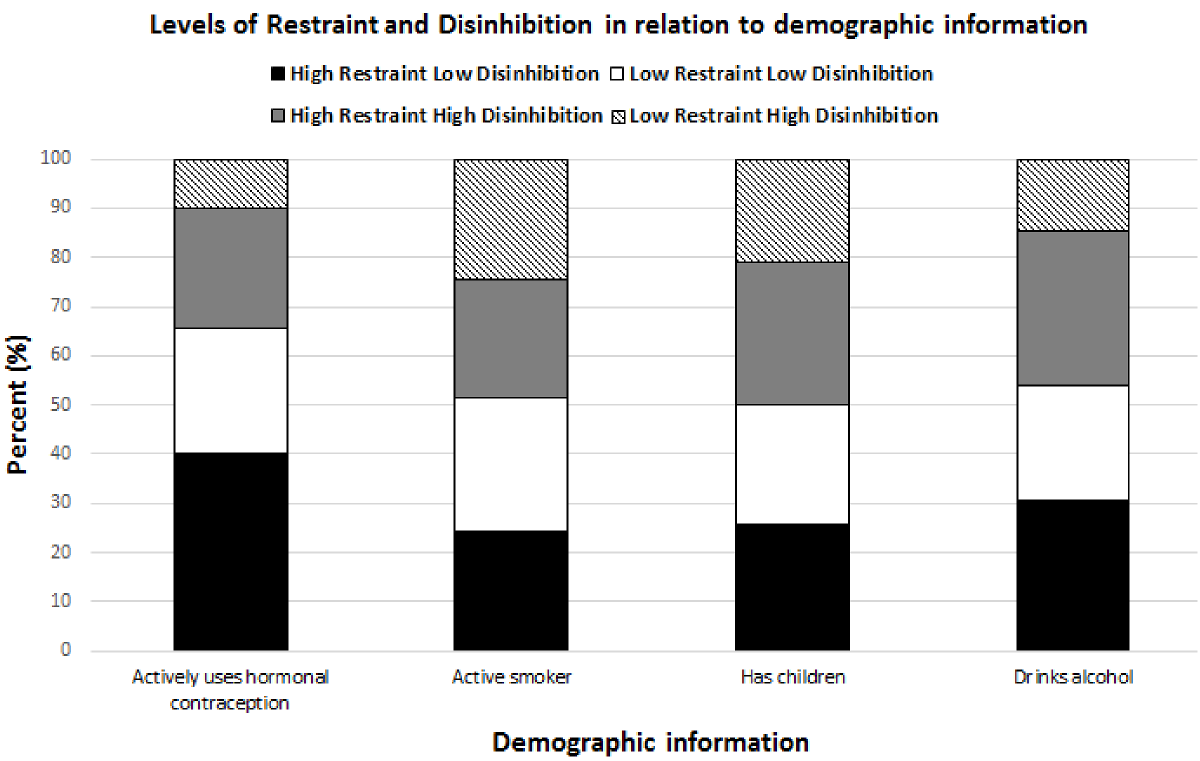
Appendix K.1 Sub-groups of Restraint and Disinhibition in relation to ethnicity



P-value determined by Chi-Square. *P* = 0.059 for comparing sub-groups of Restraint and Disinhibition between ethnicities.

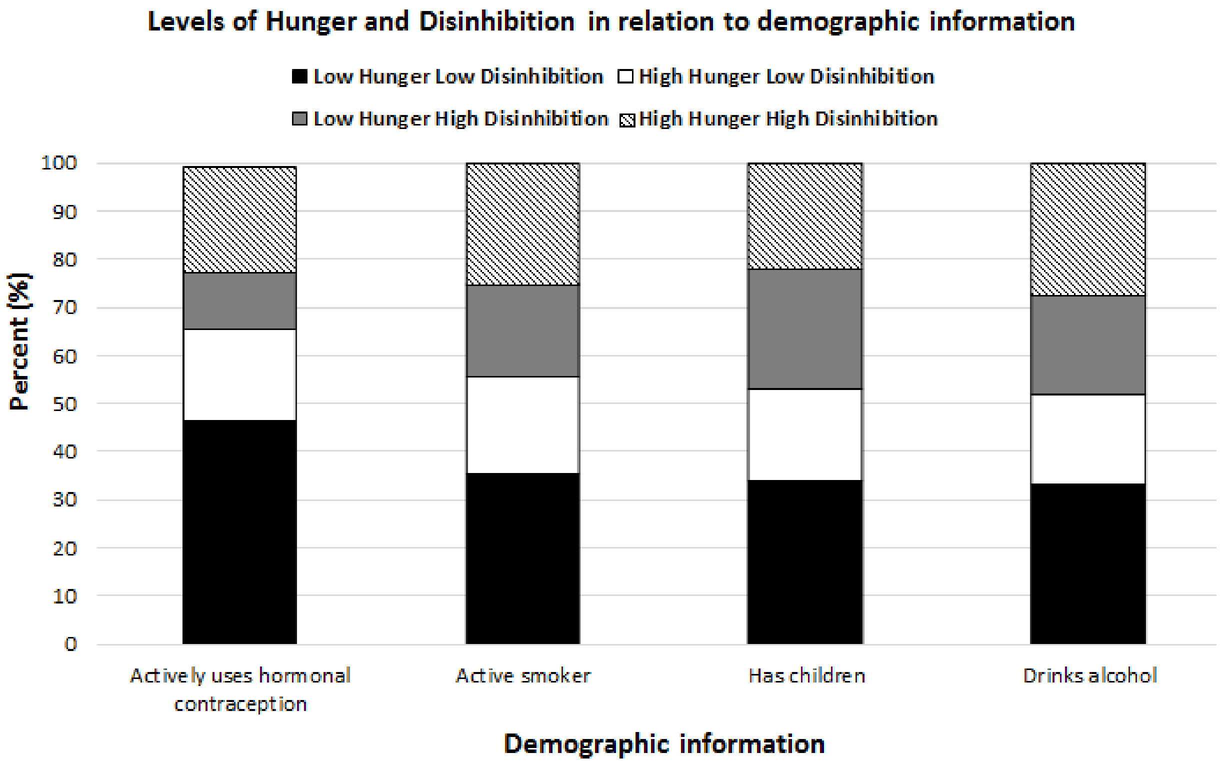
.

Appendix L.2 Sub-groups of Restraint and Disinhibition in relation to demographic information



P-value determined by Chi-Square. Hormonal contraception p = 0.004. Significant difference observed between High Restraint Low Disinhibition and Low Restraint High Disinhibition. Active smoker p = 0.122. Has children p = 0.215. Drinks alcohol p = 0.135. Odds-ratio effect size are determined as small (1.5), medium (3.5) or large (9.0) when $p < 0.05$

Appendix M Sub-groups of Hunger and Disinhibition in relation to demographic information



P-value determined by Chi-Square. Hormonal contraception p = 0.015. Significant difference observed between High Hunger High Disinhibition and Low Hunger Low Disinhibition, High Hunger Low Disinhibition and Low Hunger High Disinhibition. Active smoker p = 0.280. Has children p = 0.164. Drinks alcohol p = 0.133. Odds-ratio effect size are determined as small (1.5), medium (3.5) or large (9.0) when $p < 0.05$.