Adherence to dietary guidelines and nutrient recommendations among New Zealand women

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Abstract

Countries often implement nutrition recommendations to enable people to attain optimal health. This study aims to assess if two groups of New Zealand women adhere to the 2020 Eating and Activity Guidelines (EAG) and some of the Nutrient Reference Values (NRV). This study is a secondary data analysis from two separate, observational longitudinal studies conducted in Manawatu and surrounding areas in 2017. Women aged 18-26 (n= 93) and 52-74 (n= 63) attended the Massey University Manawatu campus for height and weight measurements. One hundred and fifty-six participants completed 3-day diet diaries that provided information on daily nutrient intakes and daily servings of food groups. The majority (57%) of younger women met 1-2 food group guidelines, and over 30% met none. Almost 70% of older women met 1-2 food group guidelines, with 25.4% meeting none. No women met all 5 food group guidelines. Protein-rich food guidelines were adhered to by more younger women (61.9%) than older women (39.8%; p=0.007). Grain food guidelines were adhered to by more older women (15.9%) than younger women (1.1%; p=0.001). Younger women had 5.4% and 8.6% adherence to vegetable and calcium-rich food guidelines, respectively. Older women had 9.5% adherence to both vegetable and calcium-rich food guidelines. The nutrient analysis found that all daily protein intakes were above the Estimated Average Requirement (EAR) and Recommended Dietary Intake (RDI) for both age groups. Almost 50% of younger women and 51.9% of older women did not meet the fibre Adequate Intake (AI). More older women (66.7%) than younger women (55.9%) met the calcium EAR (p=0.001). Over 20% of younger women were below the folate EAR, with 15.4% of older women below the folate EAR. A strong correlation was found between calcium-rich food intake and calcium intake (r_s = 0.507, p=<0.001). Moderate correlations were found between fruit intake and daily fibre intake (r_s = 0.486, p=0<.001), vegetable intake and daily fibre intake (r_s = 0.241, p=0.002), vegetable intake and folate intake (r_s = 0.377, p<0.001). Among this study population, there was low adherence to food group recommendations, and many women had suboptimal intakes of calcium, fibre, folate and thiamin. However, all women are meeting protein recommendations. Suboptimal nutrition can adversely impact health and increase the risk of developing nutrition-related diseases. Further research is required to investigate food group guideline adherence and nutrient intakes at a population level.

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List of Abbreviations

AI	Adequate Intake
AMDR	Acceptable Macronutrient Distribution Range
DFE	Dietary Folate Equivalent
EAG	Eating and Activity Guidelines for New Zealand Adults
EAR	Estimated Average Requirement
FBDG	Food Based Dietary Guidelines
FP	Footprint Study
LTB	Love Them Bones
MoH	Ministry of Health
MUHEC	Massey University Human Ethics Committee
NCD	Non-Communicable Disease
NHMRC	National Health and Medical Research Council
NRV	Nutrient Reference Values
NZANS	2008/09 New Zealand Adult Nutrition Survey
RDI	Recommended Dietary Intake

SD	Standard Deviation
SuNDiAL	Survey of Nutrition, Dietary Assessment and Lifestyles
SDT	Suggested Daily Target
UL	Upper Limit
3DDD	3-Day-Diet-Diary

1 Introduction

1.1 Background:

The World Health Organisation (WHO) identifies a healthy diet as one with limited fat and reduced sugar with increased fruit, vegetable, whole grains and reduced fat meat and dairy (World Health Organisation, 2020). Diets rich in these foods reduce the risk of developing nutrition-related non-communicable diseases (NCD) such as cardiovascular disease, particular cancers, and diabetes (World Health Organisation, 2020). NCDs are often associated with diets high in sodium and low in fruit, vegetables, whole grains, and nuts/seeds (Melaku et al., 2019). Fruit, vegetables, whole grains, nuts/seeds, low-fat dairy, and lean protein are nutrient-dense foods which contain essential nutrients, such as fibre, protein, calcium, and iron, and are vital in promoting health (Cena & Calder, 2020). There are five food groups that most food items are allocated to: 1) fruit, 2) vegetables, 3) grains, 4) dairy and 5) meat and alternatives. High-quality evidence states the benefits of consuming adequate nutrients, mainly fibre, including reduced cancer risk, improved blood cholesterol concentrations, and maintenance of stable weight (Gunness & Gidley, 2010; Masrul & Nindrea, 2019; Miketinas et al., 2019).

Nutrition recommendations are generally nationwide initiatives aimed to improve health by promoting food group intake or recommending specific intake of nutrients. Many bodies produce nutrition recommendations, such as non-government organizations (e.g., WHO, World Cancer Research Fund), and countries often design their recommendations in collaboration with nearby countries. In New Zealand, there are two types of recommendations designed to support optimal nutrition: the 2020 Eating and Activity Guidelines (EAG) and the 2006 Nutrient Reference Values (NRV). The EAGs are the food-based dietary guidelines (FBDG) which provide eating and activity statements for New Zealand adults based on the most recent research to support healthy eating for optimal health and to reduce the risk of developing non-communicable diseases (NCDs) (Ministry of Health, 2020a). NRVs are specific amounts of nutrients aimed for use by health and industry professionals, designed in collaboration with Australia (Ministry of Health & National Health and Medical Research Council, 2006).

The EAGs promote healthy eating through recommendations regarding the five food groups. These groups include *vegetables, fruit*, *grain foods*, *milk + milk products*, and *legumes/nuts/seeds/fish/eggs/poultry or red meat with the fat removed* (Ministry of Health, 2020a). The EAGs aim to improve overall health by providing adequate nutrients while reducing disease risk and mortality. If an individual meets the EAGs, they should theoretically meet NRV recommendations and therefore have a reduced risk of developing chronic disease (Ministry of Health, 2021). The 2020 EAGs contain significant changes to the previous 2015 EAGs. The changes from 2015 to the 2020 guidelines include increased vegetable recommendations (from 3 per day to 5 per day) and separate grain, calcium-food and protein-food recommendations for different genders/age groups (Ministry of Health, 2021). As the EAGs have changed, it is, therefore, crucial to investigate how current intakes compare to these new dietary guidelines.

Research to date has yet to investigate if the current dietary intakes of New Zealand women are meeting the new food-based recommendations and how these align with actual nutrient intakes and recommendations. There are yearly National Health Surveys, although, these only consider the average daily intakes of vegetables and fruit; they do not provide details on the other food groups or nutrient intakes. The only national study, the NZ Adult Nutrition Survey (NZANS), which assesses specific nutrient intake and certain food group intake has not been completed since 2008/09 (Ministry of Health & University of Otago, 2011).

Nutrition recommendations are different for different life stages. The EAGs have varying recommendations depending on age; for example, the suggested daily intake of grain foods is six servings for younger women and three servings for women above 70 years (Ministry of Health, 2021). The NRVs have different requirements for older people, such as a 25% increase in protein requirements for older women above 70 years, due to evidence that older adults may require higher intakes (Ministry of Health & National Health and Medical Research Council, 2006). Research also suggests the need for individualized recommendations for older people, highlighting the importance of analyzing data in specific age groups to compare with specific guidelines (Institute of Medicine Food Forum, 2010).

1.2 Purpose of the study:

The evidence of the effects of diet on health is continuously evolving, and hence dietary recommendations for all life stages require regular updating. As no studies have compared food group intake to the updated 2020 EAGs, it is essential to collect data on current dietary intakes to understand if New Zealanders are achieving food group recommendations. This study compares food group intakes to the recently updated food-based dietary guidelines. It also assesses fibre, folate, calcium, protein and thiamin intake and the relationship between nutrient intake and food group intake. This study investigates fibre, calcium and thiamin, as the 2008/09 NZANS suggested poor intake. This study investigates folate and protein intakes as few studies have assessed the intakes of these nutrients among these age groups. However, the importance of these nutrients is well known.

1.3 Aim:

To compare younger and older women's dietary intake with the updated 2020 Eating and Activity Guidelines for New Zealand Adults (EAG) and the alignment with selected nutrient recommendations from the 2006 Nutrient Reference Values (NRV).

1.3.1 Objectives:

- To investigate consumption of the five food groups and compare the results to the Eating and Activity Guidelines for New Zealand Adults (EAGs).
- To investigate the intakes of fibre, protein, calcium, folate, and thiamin of New Zealand women and assess dietary adequacy against the New Zealand/Australia Nutrient Reference Values (NRVs).
- To investigate how the daily intake of food groups contributes to intakes of fibre, protein, calcium, folate, and thiamin.

1.3.2 Hypothesis:

The majority of 18-26-year-old and 52-74-year-old women are not meeting the dietary and nutrient recommendations set out in the EAGs or the NRVs.

1.3.2 Thesis structure:

This study is divided into four chapters. Chapter one is an introduction of the background, purpose, aims, objectives, and hypotheses of the study. Chapter two is a narrative review of the current literature on the importance of nutrients and international research on adherence to food-based dietary guidelines. Chapter three, written as a manuscript, includes the introduction, methods, results, and discussion. Chapter four establishes conclusions and recommendations based on the study findings.

1.4 Researcher contributions

Research topic and study design	A/Prof Louise Brough Dr Janet Weber
Data collection and handling	Katie Schraders Giancarla Zatta Elizabeth Reynolds
Data entry, statistical analysis, and interpretation	Gabrielle Cortes
Thesis writing	Gabrielle Cortes
Reviewing and Editing	A/Prof Louise Brough Dr Janet Weber

2 Literature review

This chapter highlights the importance of nutrition, the dietary guidelines in New Zealand and the current literature on nutrient intake and adherence to food-based dietary guidelines.

2.1 Nutrition and Nutrition Surveys

A healthy diet involves adequate amounts of macronutrients to support energetic and physiological needs while meeting micronutrient needs to enable the body to function optimally (Cena et al., 2020). Macronutrients include protein, fat, and carbohydrate and micronutrients include vitamins and minerals (Cena et al., 2020). Finding the balance between consuming adequate macronutrients (to fuel the body) and micronutrients (to support bodily functions) and avoiding over-consumption is a significant problem today. Imbalances between macronutrient and micronutrient intake can lead to micronutrient inadequacy on the one hand or obesity/overweight on the other (Cena et al., 2020). According to Budreviciute et al. (2020), NCDs such as cardiovascular disease, cancer and diabetes, are associated with malnutrition and unhealthy diets and are among the leading causes of death in the world (Cena et al., 2020; Budreviciute et al., 2020).

Countries may develop national nutrition surveys to assess population dietary intakes. New Zealand completed national Adult Nutrition Surveys (NZANS) in 1997 and 2008/09. The 2008/09 NZANS involved 4721 New Zealanders over 15 years of age (Ministry of Health & University of Otago, 2011). This survey included questions about dietary habits/eating patterns, dietary supplements, food security and health conditions related to nutrition, and a 24-hour diet recall (Ministry of Health & University of Otago, 2011). The NZ Health Survey is a yearly survey with dietary habit questions to gain a further understanding of the dietary patterns of New Zealanders, and this survey investigates fruit and vegetable guideline adherence (Ministry of Health, 2022). The table below represents key findings from the 2008/09 NZANS for women by age group (Table 1).

Table 1*: Overview of some key nutrient findings from the 2008/09 NZ Adult Nutrition Survey (NZANS) by age group for women, compared to the Recommended Dietary Intake and Estimated Average Requirement.* (Ministry of Health & University of Otago, 2011)

Nutrient	Age Group (years)	NZANS Mean Intake	RDI[A] (or other NRV[B])	EAR[C]	% Of study population with inadequate intake
Energy (kJ)	19-30 31-50 51-70	8426 7921 7205	N/A	N/A	N/A
Protein (g)	19-30 31-50 51-70	73 79 71	46 46 46	37 37 37	0.0 0.0 1.7
Fibre (g)	19-30 31-50 51-70	17.3 18.1 18.7	AI[D] (25)	N/A	N/A
Thiamin (mg)	19-30 31-50 51-70	1.1 1.2 1.2	1.1 1.1 1.1	0.9 0.9 0.9	30.1 29.3 20.5
Calcium (mg)	19-30 31-50 51-70	742 847 775	1000 1000 1300	840 840 1100	68.4 55.5 88.2

[A]= RDI = recommended dietary intake

[B]= NRV = nutrient reference value

[C]= EAR = estimated average requirement

[D]= AI = adequate intake (Ministry of Health & National Health and Medical Research Council, 2006)

The "Survey of Nutrition, Dietary Assessment and Lifestyles" (SuNDiAL) project is a recent sizable study of 15–18-year-olds conducted in Otago (n=290) between 2017 and 2020. This study investigated many aspects of nutrition, including fruit and vegetable consumption and nutrient intakes of folate and fibre, which are relevant to this thesis (Lee, 2019;

Taungapeau, 2019; Trollope, 2020). The SuNDiAL data has been included in this study as, although it is of a younger age group than this study, it is one of the few recent New Zealand studies that assesses dietary intakes of fibre and folate.

2.2 Nutrition Recommendations in New Zealand

2.2.1 Outline

The two nutrition recommendations used by the NZ Ministry of Health (MoH) are the *Eating and Activity Guidelines for New Zealand Adults* (EAG) and the *Nutrient Reference Values* (NRV) for Australia and New Zealand. Both recommendations are based on sex, age and life stages based on up-to-date evidence (Cámara et al., 2021). The EAGs are specific to the lifestyle and culture in New Zealand. The NRVs are a set of recommended intakes of specific nutrients based on scientific evidence (National Health and Medical Research Council et al., 1991).

2.2.2 Eating and Activity Guidelines for New Zealand Adults

The 2020 EAGs are the current evidence-based FBDGs used in New Zealand (Ministry of Health, 2021). The EAGs, produced in 2020, were designed by multiple healthcare professionals, nutrition experts and Ministry of Health (MoH) employees to produce up-to-date, evidence-based nutrition and health guidelines (Ministry of Health, 2021). The evidence for the EAGs comes from the 2013 Australian Eating Guidelines, produced by the National Health and Medical Research Council (NHMRC), and various methodologies showing associations between specific nutrients and positive or negative health outcomes (Ministry of Health, 2020b).

The EAGs refer to five "*food groups,*" which include 1) fruit, 2) vegetables, 3) grains, 4) dairy and 5) meat and alternatives. This study refers to the 'legumes, nuts, seeds, fish, seafood' group as 'protein-rich foods' and 'milk and milk products' as 'calcium-rich foods' for readability purposes. The guidelines on the number of daily recommended servings of food groups for women from different age groups can be found in Table 2.

Table 2: *Recommended daily number of servings of food (and serving size guides) from the food groups in the Eating and Activity Guidelines, for women, by age range* (Ministry of Health, 2020a).

AGE	VEGETABLES[A]	FRUIT[B]	GRAIN FOODS[C]	PROTEIN FOODS[D]	MILK AND MILK PRODUCTS[E]
19-50	5	2	6	2.5	2.5
51-70	5	2	4	2	4
70+	5	2	3	2	4

[A]= Vegetable serving size: 75g

[B]=Fruit serving size: 150g

[C]=Grain serving size: 1 slice bread, ½ bread roll, ½ cup cooked rice/pasta

[D]=Protein food serving size: 100g cooked fish, 2 eggs, 65g meat, 30g poultry, 1 cup legumes/beans

[E]= Milk serving size: 1 cup milk, 200g yogurt

2.2.3 Nutrient Reference Values

The 2006 Nutrient Reference Values (NRVs) are a set of recommendations for nutrient intake based on current scientific knowledge. The recommendations are a collaborative initiative of the Australian National Health and Medical Research Council, the Australian Government Department of Health and Ageing and the New Zealand Ministry of Health (Ministry of Health & National Health and Medical Research Council, 2006). Due to nutrient requirements changing over the lifespan, the NRVs are broken down into three age groups for adults: 19-30 years, 31-50 years, and 51-70 years. Appendix A displays the NRVs for women.

The recommended dietary intake (RDI) is the level of nutrient intake to be adequate to meet the known nutritional needs of almost all healthy people (National Health and Medical Research Council et al., 1991). RDIs were previously based on population needs, exceeded the nutritional requirements of practically all healthy people, and did not determine individual requirements, so they were often misused (National Health and Medical Research Council et al., 1991). A new system that combined the RDI with identifying average

individual requirements was developed to prevent misuse, known as the Nutrient Reference Values (National Health and Medical Research Council et al., 1991). The new NRV terminology involves the estimated average requirement - EAR, recommended dietary intake - RDI, adequate intake - AI and upper limit – UL. When there is high-quality evidence, the EAR (defined as the daily nutrient level estimated to meet the needs of 50% of the population of healthy individuals) and RDI (defined as the intake of nutrients to meet the nutritional needs of all healthy people) are used. The AI is used when there is limited evidence. There are also recommendations to prevent chronic diseases: the AMDRs (acceptable macronutrient distribution range) and SDTs (suggested daily targets). The AMDRs highlight an acceptable range of per cent energy from macronutrients (protein, total fat, carbohydrates and saturated fat). SDTs are the recommended daily intake of certain nutrients that may help prevent the development of chronic diseases (Ministry of Health & National Health and Medical Research Council, 2006). Further details of the NRV terminology can be found in Appendix B.

2.3 Research on food-based dietary guidelines

This section discusses the evidence for the importance of the food groups and the current literature on adherence to food-based dietary guidelines.

2.3.1 Evidence for the importance of the food groups

It is well-known that a high-quality diet comprising high intakes of vegetables, fruit, whole grains, nuts, and seeds may reduce the risk of developing nutrition-related NCDs. Multiple studies have found that diets characterised by high intakes of vegetables, fruit, whole grains, and dairy were associated with lower risks of colorectal cancer, premature death, stroke, and coronary heart disease (Bechthold et al., 2019; Schwingshackl et al., 2018; Schwingshackl et al., 2017). Additionally, these studies found that high consumption of red and processed meat can increase the risk of developing these diseases.

Fruits and vegetables contain high amounts of vitamins, minerals and fibre and are essential for human health. Multiple studies have shown that people with diets low in, or free of, vegetables are at higher risk of developing chronic diseases such as cancer, heart disease

and other NCDs (Oyebode et al., 2014; Wang et al., 2021; World Health Organization, 2003). The impact of fruit and vegetables on whole-body health has been well researched, with evidence highlighting the anti-inflammatory, anti-cancer, and antioxidant properties (Angelino et al., 2019; Wallace et al., 2020; Yahia et al., 2017). The EAG recommends that all age groups consume five servings of vegetables and two servings of fruit per day, an increase from the previous 5-a-day (Ministry of Health, 2020a). This increase was due to evolving evidence on the impact of higher intakes of vegetables on the reduction of disease risk (Ministry of Health, 2020a).

Grain foods are a staple food group for many people, and it is important to consider what type of grain people are consuming, as research highlights the positive impact of unrefined grain versus the negative impacts of refined grains. Unrefined grains (whole grains), such as oats, hulled barley, brown rice and whole-wheat, have been found to reduce cardiovascular disease and cancer risk and are a nutrient-dense food that should be consumed daily (Jonnalagadda et al., 2011). Refined grains include white rice, white flour and white bread, and their production involves removing at least one of the three parts of grain; the endosperm, bran or germ. Refined grains are often lower in fibre, vitamins and minerals due to the extensive processing and are not as beneficial to the body as whole grains (Gaesser, 2019; Jones et al., 2019). Multiple studies involving increasing unrefined wholegrain intake found that people with higher intakes of wholegrains had a lower risk of developing cardiovascular disease, type 2 diabetes and obesity (Chanson-Rolle et al., 2015; Hu et al., 2020; Seal & Brownlee, 2015). In addition to the disease risk-lowering benefits of whole grains, they improve diet quality by providing fibre, magnesium, zinc and vitamin E (Fontanelli et al., 2021; Mann et al., 2018). The MoH recommends that people consume 3-6 servings of grain foods from unrefined sources daily and to avoid refined grains to improve fibre intake and overall health. The recommended daily number of grain servings decreases with age to promote intake of other food groups that provide a range of nutrients.

Protein-rich foods include meat, plant-based meat, eggs, legumes, nuts, seeds and beans. These foods provide a range of nutrients such as protein, B vitamins, and iron (Naghshi et al., 2020). Protein foods from non-animal sources (legumes, nuts, seeds, beans) provide fibre, vitamins and minerals, which improve diet quality and health. Conversely, animal-

based protein foods can be high in saturated fat, and processed meat is often high in carcinogens (Elmadfa & Meyer, 2017). According to the World Cancer Research Fund, red and processed meat consumption may increase the risk of developing colorectal cancer (World Cancer Research Fund, n.d.). The EAG recommend limited amounts of red and processed meat alongside increased intakes of plant-based proteins to improve dietary quality by achieving protein intakes while gaining additional nutrients from plant-based sources (Ministry of Health, 2021).

The MoH recommends daily consumption of dairy or fortified dairy alternatives to improve protein, calcium, and vitamin D intakes (Ministry of Health, 2020a). Evidence suggests that three servings of dairy per day can reduce the risk of developing hypertension, kidney stones and type 2 diabetes (MacDonald, 2008). Dairy alternatives made with soy, oat, coconut or almond milk, are naturally low in nutrients and are often fortified with vitamins/minerals to produce a similar nutrient profile to dairy (Craig & Fresán, 2021). It is important to note that many dairy alternatives are fortified with nutrients that dairy is not naturally high in, such as vitamin B12. Dairy is a beneficial constituent of a healthy diet; however, this generally refers to low-fat or reduced-fat dairy products, as these products contain the beneficial nutrients without the pitfalls of saturated fat (such as increased cardiovascular disease risk) (Timon et al., 2020). The EAG recommends that 19-50-year-old women aim for 2.5 servings of calcium-rich foods per day, and 51+-year-old women should aim for four servings per day (Ministry of Health, 2020a).

As evidence suggests, consuming foods from different food groups provides all the essential nutrients and reduces the risk of developing NCDs. Therefore, it is important to assess food groups' consumption to ensure people are meeting recommendations to achieve optimal health. Understanding what people eat enables specific interventions to be produced to ensure food group consumption is adequate in the New Zealand population to improve health and health outcomes.

2.3.2 Literature Review on FBDG Adherence

This section will review the current literature on adherence to FBDG. Databases used to obtain literature included Massey Discover, Google Scholar, PubMed and other similar

sources. Studies that were selected for this literature review included studies on women, or men and women of similar age groups to this study (18-26 or 55+).

Studies from Belgium, Australia, Germany, and Switzerland that assessed adherence to local FBDG were assessed. It is important to consider that each country has different guidelines for serving sizes, so one country may have a higher recommended weight for one serving than another. Also, differences in methodologies of diet history collection may impact results, as food frequency questionnaires, for example, only collect information on the frequency of consumption; however, diet histories such as 3-day diet diaries collect specific weight/amounts data. Based on the literature review, it is clear that FBDG recommendations are not met by most people in the countries investigated (Table 3). In Australia, two studies assessing adherence to FBDG found that women were not meeting guidelines for all food groups (Irwin et al., 2019; Mishra et al., 2015); however, one study measured median intakes (Irwin et al., 2019) and the other measured per cent adherence (Mishra et al., 2015). The fruit results from the 2015 Australian study are similar to that of the German and Swiss studies, with around 40% of women meeting fruit guidelines (de Mestral et al., 2020; Mishra et al., 2015; Stroebele-Benschop et al., 2018). However, although the fruit findings are similar, there are significant discrepancies between the percentage adhering to protein, vegetable and dairy foods guidelines as the adherence ranges from 8.6% to 97.4%, 1.3% to 27.6% and 1% to 49.4%, respectively (Bel et al., 2019; de Mestral et al., 2020; Mishra et al., 2015; Stroebele-Benschop et al., 2018). These differences are likely due to the difference in guidelines; however, the trend of low adherence to guidelines by women is clear. The 2021/22 NZ Health Survey found that less than 50% of participants met fruit recommendations, only 10% met vegetable recommendations, and less than 7% met fruit and vegetable recommendations (Ministry of Health, 2022). Additionally, in the 2018-2020 NZ Health Survey, 38.1% of women met fruit and vegetable recommendations, 59.3% of women met vegetable recommendations, and 56.4% met fruit recommendations (Ministry of Health, 2019).

Table 3: *International studies comparing food group intakes to food-based dietary guidelines*

Author/Date	**Country**	**Age range + N=**	**Method of data collection**	**Guidelines Used**		**Results**
Irwin et al., 2019	Australia	22 years (± 5) N= 115 (78 females)	Written food record	Fruit: 2 Vegetables: 5 Meat/Alternatives: 2.5 Dairy/Alternatives: 2.5 Bread, cereal, grains: 6		Median intake for women: Fruit: 1.3 Vegetables: 3.2 Meat/Alternatives: 2.2 Dairy/Alternatives: 1.3 Bread, cereal, grains: 3.3
de Mestral et al., 2020	Switzerland	>16 years old N=15,450 (53% women)	Written questionnaire	Fruit: >2 Vegetables: >3 Dairy: >3 Meat: >2/week		Percentage of women adhering to guidelines Fruit: 46.2% Vegetables: 27.6% Dairy: 20.5% Meat: 8.6%
Stroebele-Benschop et al., 2018	Germany	24.3 (± 3.11) N=103 (78 women)	Food frequency questionnaire	Vegetables: >3 Fruit: >2 Dairy: 2-3 Meat: 3-6/week		Percentage of women adhering to guidelines Vegetables: 15.6% Fruit: 42.9% Milk: 49.4 Meat: 97.4
Bel et al., 2019	Belgium	Age: 3-64 years N=3146	Face-to-face interviews.	**Age 19-59** Grains: 210-420g Vegetables: 300g Fruit: 250g Dairy: 450ml Meat: 100g	**60+** Grains: 150-315g Vegetables: 300g Fruit: 250-375g Dairy: 600ml	Percentage of women adhering to guidelines Grains: 7% Vegetables: 6% Fruit: 23% Dairy: 1% Meat: 66%

					Meat: 100g		
Mishra et al., 2015	Australia	31-36 years n=5760 50-55 years n=10467	Food frequency questionnaire	**19-50y** Cereals: 6 Vegetables: 5 Fruit: 2 Dairy: 2.5 Meat: 2.5	**50-71y** Cereals: 4 Vegetables: 5 Fruit: 2 Dairy: 4 Meat: 4	**31-36y** Meat: 28.2% Fruit: 29.2% Dairy: 11.7% Cereals: 7.1% Vegetables: 1.3%	**50-55y** Meat: 40.6% Fruit: 48% Dairy: 1% Cereals: 44.9% Vegetables: 1.8%
Ministry of Health & University of Otago, 2011	New Zealand	>15 years n=4721	24-hour dietary recall	Fruit: 2 Vegetables: >3		Percentage of women adhering to guidelines Vegetables: 72.2% Fruit: 65.8%	
Trollope, 2020	New Zealand	15-18 years N=266 females	Dietary habits questionnaire.	Fruit: 2 Vegetables: >3		Percentage of women adhering to guidelines Vegetables: 34.8% Fruit: 58.8%	

2.4 Research on specific nutrients

This section highlights the literature on the specific nutrients discussed in this study. The specific nutrients are fibre, protein, calcium, folate, and thiamin. This section discusses the benefits, sources, recommended intake and literature on intakes of these nutrients concerning women, where possible. Databases used to obtain literature included Massey Discover, Google Scholar, PubMed and other similar sources. Studies that were selected for this literature review included studies on women, where possible, or men and women of similar age groups to this study (18-26 or 55+). Information on recommended intakes was obtained from the Ministry of Health.

Fibre is found in many foods and is an essential component of a healthy diet. There are two types of fibre: soluble and insoluble. Soluble fibre is in fruit, vegetables and legumes, and insoluble fibre is in cereals and whole grains. The most significant difference between the two is the slower digestive rate of soluble fibre (Barber et al., 2020). However, both fibre types are essential for gut health and preventing constipation (Barber et al., 2020). Research has shown that fibre has multiple roles in lowering disease risk (Gill et al., 2021; Pathirannehelage & Joye, 2020; Veronese et al., 2018). New Zealand recommends an AI of >25g for adult women to reduce the risk of developing chronic diseases and a SDT of 28g per day (National Health and Medical Research Council et al., 1991). The 2008/09 NZANS investigated dietary fibre intakes and found that the average fibre intakes for women aged 19-30, 31-50 and 51-70 years were 17.3g, 18.1g and 18.7g, respectively (Ministry of Health & University of Otago, 2011). The New Zealand SuNDiAL study in 2019 investigated the fibre intakes of 15-18-year-old females and found the mean intake was 24.1g per day (Taungapeau, 2019). Recent data on fibre intake for older women in New Zealand is unavailable and this highlights the need for further studies on fibre intake.

Protein is an essential macronutrient known for its role in muscle development and physiological processes. Protein sources include animal products (meat and dairy) and non-animal products (whole grains, legumes, nuts, and some vegetables) (Wu, 2016). The EAR for protein is 37g per day (for women aged 19-70 years) and 46g per day (71+ years) (Ministry of Health & National Health and Medical Research Council, 2006). Older people may have increased protein needs due to decreased physical activity, which may lead to muscle mass loss (Nowson et al., 2015). The 2008/09 ANS found that the average daily protein intakes for women aged 19-30, 31-50 and 51-70 years were 73g, 79g and 71g, respectively (Ministry of Health & University of Otago, 2011). A New Zealand study from 2009 found that Māori and non-Māori women consumed an average of 58.6g of protein per day (Ram, 2019). A 2007 European study on women aged 57-75 years found that vegetarian and omnivorous women were consuming an average of 58g per day and 65g per day, respectively (Lord et al., 2007). Although previous research has shown that protein intakes are within dietary recommendations for all age groups, this study investigates recent protein intakes and directly compare intakes of protein foods to dietary guidelines, filling the gap in the literature.

Calcium is a heavily researched nutrient with known benefits such as improved bone health, prevention of osteoporosis, and blood pressure reduction (Cormick & Belizán, 2019; Pu et al., 2016). Postmenopausal women risk decreased bone strength and mass due to physiological processes involved with calcium, oestrogen and changes to vitamin D and parathyroid hormone homeostasis (Wawrzyniak & Suliburska, 2021). As a result, postmenopausal women have a higher calcium requirement and should aim to achieve an adequate calcium intake to help maintain optimal bone health (Devarshi et al., 2021). In New Zealand, the RDI for calcium is 1000 mg per day for women aged 19-70 and 1300 mg per day for women aged 71+ years. The 2008/09 NZANS found that women aged 19-30, 31-50, 51-70 and 71+ were consuming 742, 847, 775 and 710mg, respectively (Ministry of Health & University of Otago, 2011). In 2016, the LiLACS study (n=216 Māori, 362 non-Māori) found that the median calcium intake of women was 543mg per day (Wham et al., 2016). In 2019, an Australian study on the nutrient intakes of female football players was published, with the mean calcium intake at 924 mg per day (Condo et al., 2019). These studies highlight the need for measuring calcium intake, as most women are not meeting calcium requirements, with solid evidence supporting the importance of ensuring calcium intake is adequate.

Folate is one of the B-group vitamins and is an essential nutrient for many bodily processes. It is also known for its anti-cancer properties (Yang & Vousden, 2016; Zheng & Cantley, 2018). Research highlights that poor folate status is associated with an increased risk of chronic diseases such as cancer and heart disease (Ebara, 2017). Folate is found in the highest concentrations in liver and dark, leafy vegetables and is destroyed during cooking due to heat instability (Moll & Davis, 2017). Pregnant and older women are at risk of inadequate folate intake due to increased maternal and fetal needs and decreased dietary intakes in older age, respectively (Moll & Davis, 2017). Folic acid, the synthetic version of folate, is commonly prescribed to pregnant women or those trying to conceive, as folate is known to reduce the risk of neural tube defects in infants (Mallard & Houghton, 2012). The EAR for folate, for all age ranges and genders, is 320 µg per day (in dietary folate equivalents - DFEs) (Ministry of Health & National Health and Medical Research Council, 2006); however, the 2008/09 ANS did not measure folate intake. The SuNDiAL study from 2019

investigated dietary folate intakes of female adolescents (15-18 years old) and found that the median folate intake was 347.2 µg (in DFEs) and the prevalence of inadequate folate intake was 47.1% (Lee, 2019). In 2016, the LiLACS study (n=216 Māori, 362 non-Māori) found that the median folate intake of women was 193ug per day (Wham et al., 2016). The high prevalence of inadequacy from the SuNDiAL study and the health impacts of folate indicates the importance of monitoring intakes across the lifespan. The literature has no recent studies on folate intake for young or post-menopausal women in NZ.

Thiamin is a B-group vitamin that is essential for multiple physiological processes. Dietary sources include meat, fortified cereals, beans, lentils and fish (Coates et al., 2004). Thiamin's importance is well-researched, with evidence highlighting the involvement of thiamin in energy metabolism and the potential prevention of developmental abnormalities (Kerns & Gutierrez, 2017; Lonsdale, 2018; Mielgo-Ayuso et al., 2018). Thiamin plays a critical role in energy metabolism, impacting the growth and function of all cells (Polegato et al., 2019). Deficiency of this vitamin is often underdiagnosed and associated with increased mortality and morbidity (Polegato et al., 2019). The EAR for women of all ages is 0.9 mg per day, and the 2008/09 NZANS found that women were consuming an average of 1.1mg per day (Ministry of Health & National Health and Medical Research Council, 2006; Ministry of Health & University of Otago, 2011). However, the 2008/09 ANS found a high percentage of inadequacies, as 30.1%, 29.3%, and 20.5% of 19-30y, 30-50y and 51-70y, were below the EAR, respectively (Ministry of Health & University of Otago, 2011). Literature on thiamin intake and status in New Zealand is difficult to find as studies only investigate thiamin supplementation or are outdated. The gaps in the literature highlight the need for a recent investigation of thiamin intakes and comparison to nutrient recommendations.

As evidence suggests, fibre, protein, calcium, folate, and thiamin are vital in promoting health and reducing the risk of developing nutrition-related diseases. It is, therefore, essential to assess nutrient consumption to ensure people are meeting recommendations to achieve optimal health. The nutrients commonly found in large quantities in the food groups are fruit and vegetables – fibre, folate, pro-vitamin A, vitamin C, magnesium; calcium-foods – protein, calcium, phosphorus, B-vitamins; grains – fibre, protein, B-vitamins, vitamin E, magnesium, zinc; protein-foods – protein, iron, zinc, vitamin B12, thiamin (Ministry of

Health, 2020a). Understanding what people eat enables specific interventions to be produced to ensure food group consumption is adequate in the New Zealand population to improve health and health outcomes.

The nutrient recommendations used in New Zealand contain different guidelines for different age groups due to differences in physiological needs as the body ages. For example, recommendations for the number of calcium-rich food servings per day increase as women age, which is also seen for calcium recommendations in the NRVs (Ministry of Health, 2020a). Therefore, it is important to analyse age groups separately against the appropriate recommendation.

2.5 Rationale of this study

The EAGs and NRVs aim to optimise health at a population level. Meeting these guidelines implies that a person's diet provides adequate nutrition to promote health and reduce the risk of developing illness or disease. There have not been any studies assessing adherence to the updated 2020 EAG in New Zealand, and the most recent national survey investigating nutrient intake was the 2008/09 NZANS (Ministry of Health & University of Otago, 2011). This literature review highlights the importance of certain nutrients and the gaps in the literature on nutrient and food group intake. This study provides insight into the eating habits of some groups of New Zealand women by comparing dietary intakes to dietary guidelines. Measuring dietary intake and FBDG adherence of women, in particular, is essential as women are at increased risk of nutrient deficiencies due to pregnancy and menopause. The results of this study may help understand compliance with the dietary guidelines in New Zealand and assess dietary inadequacy.

3 Research study manuscript – prepared for the journal Nutrients

Adherence to dietary guidelines and nutrient recommendations among New Zealand women.

3.1 Abstract

The Ministry of Health (MoH) has recently updated its dietary guidelines, and studies have yet to assess if people are meeting these updated guidelines. This study aims to assess if two groups of New Zealand (NZ) women adhere to the updated Eating and Activity Guidelines (EAG) and some of the Nutrient Reference Values (NRV). Two studies on women aged 18-25 and 52-74 years were conducted in the Manawatu in 2017. Three-day diet diaries were collected and analysed using FoodWorks 10. Data analysis found that most (57%) of younger women met 1-2 food group guidelines, and over 30% met none. Almost 70% of older women met 1-2 food group guidelines, with 25.4% meeting none. No women met all five food group guidelines. A larger percentage of younger women (61.9%) adhered to protein-rich food guidelines compared to only 39.8% of older women (p=0.007). A larger percentage of older women (15.9%) adhered to grain food guidelines than younger women (1.1%; p=0.001). Younger women consumed 1.0 (0.5, 1.7) daily median servings of calcium-rich foods, and older women consumed more, at 1.8 (1.2, 2.8) median servings per day (p=<0.001). The nutrient analysis found that all protein intakes were above the recommended dietary intake (RDI) for both age groups. The Adequate Intake (AI) for fibre was not met by 49.5% of younger women and 51.9% of older women. The estimated average requirement (EAR) for calcium was not met by 55.9% of younger and compared to 66.7% of older women (p=0.001). Over 20% of younger women were below the folate EAR, with 15.4% of older women below the folate EAR. A strong correlation was found between calcium-rich food intake and calcium intake (rs = 0.507, p=<0.001). Moderate correlations were found between fruit intake and daily fibre intake (rs = 0.486, p=0<.001), vegetable intake and daily fibre intake (rs = 0.241, p=0.002), vegetable intake and folate intake (rs = 0.377, p<0.001). Findings suggest that many women are not adhering to the updated EAG and are not meeting NRVs for fibre, calcium, folate or thiamin. Assessment of adherence to dietary guidelines is needed to determine the population's nutrient status to improve health

outcomes. Further research is required to investigate NZ's barriers to achieving nutrition recommendations.

Key words: nutrients; adherence; guidelines; women; New Zealand; FBDG

3.2 Introduction

The World Health Organisation identifies a healthy diet as one with fruit, vegetables, whole grains, reduced-fat meat, and dairy, with limited fat and added sugar (World health organisation, 2020). This diet aims to prevent malnutrition and reduce the risk of developing nutrition-related non-communicable diseases (NCD) (World Health Organisation, 2020). Nutrition-related NCDs, such as cardiovascular disease, particular cancers, and diabetes, are often associated with diets high in sodium and low in fruit, vegetables, whole grains, and nuts/seeds (Melaku et al., 2019). Nutrient-dense foods (fruit, vegetables, whole grains, nuts/seeds, low-fat dairy, and lean protein) are vital in promoting health due to their nutrient-rich qualities. These foods contain many essential nutrients, including fibre, protein, calcium, and iron, that the body requires to function efficiently (Cena & Calder, 2020). A diet rich in the five food groups (fruit, vegetables, grains, calcium-rich foods and protein-rich foods) provides the body with essential vitamins and minerals to optimise nutrition and health (Cena & Calder, 2020). Studies have found that diets high in fruit, vegetables, and whole grains are high in fibre (Cena & Calder, 2020; Masrul & Nindrea, 2019). High-quality evidence states the benefits of consuming adequate fibre, such as reduced cancer risk, improved blood cholesterol concentrations, and maintenance of stable weight (Gunness & Gidley, 2010; Masrul & Nindrea, 2019; Miketinas et al., 2019).

Countries may develop nutrition recommendations to promote health and enable people to reach optimal nutrition. New Zealand uses the Eating and Activity Guidelines for New Zealand Adults (EAG), which are food-based dietary guidelines (FBDG) and the Nutrient Reference Values (NRV), which provides specific nutrient recommendations (Ministry of Health & National Health and Medical Research Council, 2006; Ministry of Health, 2020a). The NRVs are designed for health professionals to use as a value of appropriate intake. The EAGs are based on the NRVs and are designed for use by individuals to improve health by

promoting intakes of nutrient-rich foods and decreased intake of nutrient-poor foods to reduce the risk of developing NCDs. This study investigates the EAG food-group recommendations, which comprise the servings of each of the five food groups per day (fruit, vegetables, whole grains, protein foods, and calcium foods). The NRVs include recommendations for 34 nutrients; however, this study investigates protein, fibre, folate, calcium, and thiamin intakes.

The most recent New Zealand population-level nutrition survey was the 2008/09 NZ Adult Nutrition Survey (NZANS), where intakes of 18 nutrients and fruit and vegetable intake were measured among 4721 New Zealanders (Ministry of Health & University of Otago, 2011). The NZANS found that fruit, vegetables, fibre and calcium intakes were below recommendations (Ministry of Health & University of Otago, 2011). A recent study of 15–18-year-olds (n=290) conducted in Otago (the SuNDiAL project – Survey of Nutrition, Dietary Assessment and Lifestyles) found that fruit, vegetable, folate and fibre intakes were below recommendations (Lee, 2019; Taungapeau, 2019; Trollope, 2020). Additionally, a local study investigated folate intake in pregnant women where dietary inadequacy was found (Watson & McDonald, 2008; Watson & McDonald, 2014). There have also been overseas studies assessing adherence to FBDG by women where, although methodologies and results differed, the trends were that food group consumption was lower than recommendations for all studies (Bel et al., 2019; de Mestral et al., 2020; Irwin et al., 2019; Mishra et al., 2015; Stroebele-Benschop et al., 2018). In 2016, the Life and Living in Advanced Age Study (LiLACS NZ), which studied nutrient intakes of 216 Māori and 362 non-Māori participants, found that median folate and calcium intakes for non-Māori women were both below nutrient recommendations (Wham et al., 2016). The 2021/22 NZ Health Survey found that less than 50% of participants met fruit recommendations, only 10% met vegetable recommendations, and less than 7% met fruit and vegetable recommendations (Ministry of Health, 2022). Additionally, in 2018-2020, 38.1% of women met both fruit and vegetable recommendations, 59.3% met vegetable recommendations, and 56.4% met fruit recommendations (Ministry of Health, 2019). These studies highlight the need for monitoring food group intake and intakes of thiamin, folate, fibre, and calcium, as intakes were frequently below recommendations.

The lack of in-depth recent investigations into adherence to nutrition recommendations results in uncertainty about New Zealanders' nutrient intake and status. Determining the adherence, or the lack of, to these guidelines may help develop nutrition promotion initiatives to improve the population's health.

This study aims to compare younger and older women's dietary intake with the updated EAGs and the alignment with selected nutrient recommendations from the NRVs. The objectives of this study were: 1) investigate consumption of the five food groups and compare the results to the EAGs 2) investigate the intakes of fibre, protein, calcium, folate, and thiamin of New Zealand women and assess dietary adequacy against the NRVs 3) investigate how the daily intake of food groups contributes to intakes of fibre, protein, calcium, folate, and thiamin.

3.3 Methods

Overview

This study is a secondary analysis of data previously collected from two studies into bone health. *Love Them Bones (LTB)* was a study conducted on post-menopausal women, and *Footprint* (FP) studied women aged 18-26 years. The two longitudinal studies aimed to assess bone health with additional objectives to assess diet and lifestyle habits. Both studies were conducted around the Manawatu and Wellington regions in 2017. This study only focuses on the diet-related data collected using three-day diet histories. This data was collected at baseline.

LTB and FP Studies: Overview

- 3-day diet diaries (N=156)
    - Younger women (N=93)
    - Older women (N=63)
- Anthropometric data (N=147)
    - Weight (kg)
    - Height (cm)

Study Population

Healthy women aged 18-26 were recruited via flyers in tertiary education providers and social media. Healthy active women >5 years post menopause were recruited through local running events, such as the Rotorua full and half marathons. Age-matched, non-active controls were recruited using a random selection from the electoral rolls, and through social media and posters in local areas. Women were excluded from the studies if they were diagnosed with any disease/illness that interfered with bone health. Potential participants responded through email or phone to express their interest and were then provided with an information sheet and a screening questionnaire (Appendix C). Eligible participants provided consent and were scheduled for their first visit to the Massey University Manawatu Campus. Two visits in total were required to collect data on bone health and diet.

Ethical Approval and Considerations

The Massey University Human Ethics Committee (MUHEC) approved both studies: Love Them Bones: SOA17/06 and Footprint: SOA17/07. All participants were given information sheets before enrolling, and written informed consent was gained before data collection. All participants were identified using assigned numbers to ensure confidentiality. Copies of the ethical approval, information sheets and consent forms can be found in Appendix C, D, E.

Anthropometric Data

Women were weighed by trained professionals using electronic floor scales (Life Measurements Inc., Concord, CA, USA) with appropriate control methods such as removing shoes and heavy clothing. Scales were calibrated prior to use. Height was collected by trained professionals using a wall-mounted stadiometer (Seca Medical Measuring Systems, Chino, CA, USA), with shoes and headwear removed to improve accuracy.

3-day diet history

Participants were given a 3-day diet diary (3DDD) as a take-home booklet and verbal and written instructions on completing the diary (Appendix F). The 3DDD booklet also provided instructions on describing details, including serving sizes, brand names and recipes. Participants wrote down everything they consumed (food and drink) over three days, including one weekend day. Participants were reminded to keep to their regular diet during

this time. Researchers assessed the 3DDD upon return to check for mistakes and to ensure completion. Follow-ups were required if extra information on the brand, amount, recipe, and food labels was required.

Analysis of 3DDD

Dietary data were analysed using FoodWorks 10 Professional (Xyris Software, Australia) using the dataset from New Zealand Foodfiles 2016 (The NZ Institute for Plant and Food Research Limited and Ministry of Health, 2017).

A double entry of five food records was completed to address reliability between researchers; nutrient intakes for these five records were compared, and a difference of <5% was obtained and considered acceptable. A list of assumptions was produced to reduce discrepancies before the final analysis. FoodWorks produced daily mean nutrient intakes from the 3DDD as varying daily units (e.g. calcium: 760mg per day). Foods not present in the FoodWorks database were entered as a new recipe (if ingredients and measurements were provided) or were substituted for a similar food item. The steps for food items that were not present in the database were as follows:

1. Search for food in online supermarkets, such as Countdown, Pak'n'save or New World and gather nutritional information, serving size, weight and ingredients.
2. Match food to a similar food in FoodWorks database, ensuring nutritional information (energy, protein, calcium, folate, fibre and thiamin) is within 10%.
3. If no similar food is found, make a new recipe and check nutritional information against online details and ensure they are within 10% of each other.

Data was manually converted from amounts consumed to servings, using the same definitions of servings used in the 2020 EAG (Table 4). Servings were grouped into food groups; (1) vegetables, (2) fruit, (3) grains, (4) calcium-rich foods and (5) protein-rich foods. Foods were grouped into the food groups using definitions from the 2020 EAGs, such as nuts, seeds, legumes, fish, poultry and meat being grouped under the protein-rich foods group. Foods that contained mixed ingredients or were difficult to interpret were calculated to have lesser amounts of servings to avoid overestimation. For example, 100g of meat pie was interpreted as ½ of a protein-rich food serving. Any discretionary foods, such as sweet foods or deep-fried foods were not included in the food group analysis. This study refers to

'protein-rich foods' as the group with 'legumes, nuts, seeds, fish, seafood etc' and 'calcium-rich foods' as the group for dairy and non-dairy alternatives, for readability purposes.

Table 4: *Serving size definitions for the food groups self-reported dietary intake* (Ministry of Health, 2020a)

Food Group	Vegetables	Fruit	Grains	Milk	Protein
Serving (g)	75g	150g	1 slice, ½ bread roll, 1/2c cooked rice, pasta, porridge	1c milk, 40g cheese, 200g yogurt	1c cooked legumes/beans, 170g tofu, 30g nuts, 100g cooked fish, 2 eggs, 30g cooked poultry, 65g cooked lean meat

Participants were defined as meeting NRVs if they were consuming above the EAR or AI of nutrients for their age. The EAR cut-point method was used to determine the adequacy of population intake. This method defines a population as having adequate nutrient intake if the mean/median intake is in excess of the RDI, and the percentage below the EAR approximates the proportion who are deficient (Institute of Medicine, 2000). The percentage of participants below the EAR/AI was used as a proxy measure of inadequate intake. Participants were defined as meeting food group recommendations if they met the MoH EAG guidelines for their age (Table 2).

Data Entry and Statistical Analysis

Statistical analysis of all nutrient, food group and anthropometric information was conducted using IBM SPSS statistics 28.0. All variables were checked for normality using the Kolmogorov-Smirnov test. Normally distributed data was reported as mean (± standard deviation (SD)). Non-normally distributed data was reported as median (25^{th}, 75^{th} percentiles). Categorical variables are displayed as percentages and frequencies.

A chi-square test was used to compare those achieving the EAG, AMDR and EAR/AI with those not achieving for younger and older women. A Mann-Whitney U test was used to compare median intakes of daily servings of food groups and nutrient intakes and also to compare the BMI between younger and older women. Chi-square was also used to determine the relationship between achieving the EAG and achieving the NRVs (achieving/not achieving food group servings vs achieving/not achieving NRVs). Spearman's correlation was used to determine the association between the number of servings of food groups with the mean daily intake of each nutrient. Multiple linear regression was used to determine predictors of mean daily nutrient intake; predictor variables were mean daily servings of each food group consumed (fruit, vegetables, calcium-rich foods, protein-rich foods and grain), which were entered into the model simultaneously. Non-normal data were log-transformed and re-tested for normality in multiple linear regression. Reporting of statistical significance for all data was set at a level of p=<0.05.

3.4 Results

3.4.1 Participant characteristics

Of the 156 women recruited, 40.4% were aged 54-76 years and 59.6% of women were between 18-24 years of age (Table 5). The mean BMI for younger women was 23.7kg/m^2 and older women had a mean BMI of 26.9kg/m^2 (p=<0.05).

Table 5: *Participant characteristics for women*

	YOUNGER WOMEN	OLDER WOMEN
N (%)	93 (59.6)	63 (40.4)
AGE, YEARS (MEAN±SD)	20.6 (2.3)	61.9 (5.1)
HEIGHT [A]	167.3 (6.4)	163.2 (6.0)
WEIGHT [A]	66.6 (11.0)	71.8 (17.0)
BMI (KG/M^2) [A B] *	23.7 (3.4)	26.9 (5.8)

[A] = n=147

*=significant difference between younger and older women (Mann-Whitney U) (p=<0.05)

[B]= Body Mass Index

3.4.2 Adherence to recommended food group servings in the EAG

Of the women recruited, 25.8% of younger women and 28.6% of older women met fruit guidelines (>2 servings per day), with the median fruit intake at 1.0 and 1.3 servings per day, respectively (Table 6). For vegetable servings, only 5.4% of younger women and 9.5% of older women met the guidelines (>5 servings per day) with a median intake of 2.0 and 2.1 servings per day, respectively. Less than 9% of younger women adhered to calcium-rich foods guidelines, and the median daily intake was 1.0 servings with a guideline of 2.5 servings per day. Older women had 9.5% adherence with 1.8 daily median servings of calcium-rich foods per day, with the guideline at four servings per day. The median intake of calcium-rich foods was significantly higher for older women than the younger women ($p<0.001$). The daily median intake of grain foods was 2.7 servings per day for both younger and older women. However, more women were adhering to grain guidelines for older women (15.9%) than younger women (1.1%, $p=<0.001$), reflecting the higher recommendation for younger women (6 servings per day) than older women (3-4 servings per day). Almost 40% of younger women met protein-rich food guidelines (2.5 servings per day) compared to 61.9% of older women (2 servings per day) ($p=0.007$). The median daily intake of protein-rich foods was similar for younger and older women at 2.0, and 2.2 servings per day, respectively.

Table 6: *Daily intake of food group servings for younger women, older women and total compared to Eating and Activity Guidelines* (MoH, 2020a)

	Median (25th, 75th) daily number of servings		Mean ± SD		P-Value[1]	EAG[A] Recommended Servings	>/= EAG[A] n (%)		P-Value[2]
	Younger Women	Older Women	Younger Women	Older Women			Younger Women	Older Women	
Fruit	1.0 (0.3, 2.0)	1.3 (0.7, 2.0)			0.106	2	24 (25.8)	18 (28.6)	0.702
Vegetables	2.0 (1.4, 3.0)	2.2 (1.5, 3.8)			0.968	5	5 (5.4)	6 (9.5)	0.321
Calcium-rich Foods	1.0 (0.5, 1.7)	1.8 (1.2, 2.8)			<0.001*	2.5 (19-50y) 4 (51-70y)	8 (8.6)	6 (9.5)	0.843
Grains	2.7 (1.8, 3.6)	2.7 (1.7, 3.5)	2.7 ± 0.1	2.6 ± 0.2	0.774	6 (19-50y) 4 (51-70y) 3 (71+y)	1 (1.1)	10 (15.9)	0.001*
Protein-rich Foods	2.0 (1.7, 3.0)	2.2 (1.3, 2.7)		2.1 ± 0.1	0.354	2.5 (19-50y) 2 (51-70+y)	37 (39.8)	39 (61.9)	0.007*

[A]= EAG = eating and activity guidelines

[1]= Mann-Whitney U test of significance between median intake of younger vs older women

[2]= Chi-square test for the significance of the difference between younger vs older females meeting guidelines

*= statistically significant (p= <0.05)

3.4.3 Adherence to food group recommendations

The majority of younger women (57%) were meeting 1-2 food group guidelines, with just over 10% of younger women meeting 3-4 guidelines and none meeting all 5 guidelines (Table 7). Older women were mostly adhering to 1-2 food group guidelines (62.2%) with only 8.3% meeting 3-4 guidelines and none meeting all 5 guidelines.

Table 7*: Number of younger, older, and total women meeting <1, 1-2 or >3 food group guidelines*

	Younger women (n=93) n (%)	**Older women (n=63) n (%)**
Meeting 0 food group guidelines	30 (32.3)	16 (25.4)
Meeting 1-2 food group guidelines	53 (57.0)	44 (69.8)
Meeting 3-4 food group guidelines	10 (10.7)	3 (4.8)

3.4.4 Adherence to macronutrient recommendations

The AMDR for protein is 15-25% of total energy, and more older women (77.8%) met this recommendation than younger women (60.2%; *p*=0.022) (Table 8). The daily median percentage of energy from protein was similar for both groups, at 16.7% for younger women and 17.8% for older women. The AMDR for carbohydrates is 45-65% of total energy, and 34.4% of younger women and 28.6% of older women met this guideline. The median per cent of energy from carbohydrates was higher for younger women (42.5%) than older women (39.8%; *p*=0.009). Among the younger women, the median per cent of energy from total fat was 35.5%, slightly higher than the 20-35% recommendation. Over 36% of younger women were meeting this AMDR guideline. Among the older women, the median per cent energy from total fat was 36.5%, with 36.5% meeting the guideline (20-35%). The median per cent energy from saturated fat was 12.5% for younger women and 13.4% for older women, higher than the recommendation for both groups (<10%). Only 14.3% of older women and 21.5% of younger women met this recommendation.

Table 8*: Percentage energy contribution from protein, fat, carbohydrates, and saturated fat compared to Acceptable Macronutrient Distribution Range (AMDR) by age group* (Ministry of Health & National Health and Medical Research Council, 2006).

	Younger women (Love Them Bones Study) (n=93)						
	Median (25th, 75th) percentage of daily energy intake	**Mean ± SD**		**AMDR[A]**	**Meeting AMDR[A] n (%)**	**Below AMDR[A] n (%)**	**Above AMDR[A] n (%)**
Protein	16.7 (14.4, 21.2)			15-25%	56 (60.2)	27 (29.0)	10 (10.8)
Carbohydrate	42.5 (39.2, 47.6)			45-65%	32 (34.4)	61 (65.6)	0
Saturated Fat	12.5 (10.7, 15.2)	13.0 ± 0.4		<10%	20 (21.5)	-	73 (78.5)
Total Fat	35.5 (10.8, 39.2)			20-35%	44 (47.3)	1 (1.1)	48 (51.6)
	Older Women (Footprint Study) (n=63)						
	Median (25th, 75th) percentage of daily energy intake	**Mean ± SD**	**P-value[1]**	**AMDR**	**Meeting AMDR[A] n (%)**	**Below AMDR[A] n (%)**	**Above AMDR[A] n (%)**	**P-value[2]**
Protein	17.8 (15.8, 20.5)		0.273	15-25%	49 (77.8)	11 (17.4)	3 (4.8)	0.022*
Carbohydrate	39.8 (35.6, 46.3)		0.009*	45-65%	18 (28.6)	45 (71.4)	0	0.443
Saturated Fat	13.4 (11.5, 15.5)	13.7 ± 0.4	0.192	<10%	9 (14.3)	-	54 (85.7)	0.255
Total Fat	36.5 (31.9, 41.3)	36.6 ± 0.9	0.265	20-35%	23 (36.5)	0	40 (63.5)	0.181

[A]= AMDR = Acceptable macronutrient distribution range

[1]= Mann-Whitney U test of significance between median percentage of daily energy intake of younger vs older women

[2]= Chi=square test of significance of the difference between the percentage of younger vs older women meeting AMDR guidelines

*= significant value (p=<0.05)

3.4.5 Adherence to EAR or AI recommendations

Younger women had higher median intakes of protein (85.3g per day) compared to older women (74.1g per day; p=0.015) (Table 9). Daily median protein intakes for both groups were above the RDI (46g per day) and EAR (37g per day), with no women below the EAR. No significant differences in daily intake by age group for other nutrients were found. Younger women consumed a median of 25.1g of fibre per day, with 49.5% below the AI (25g per day). Older women consumed a median of 23.2g of fibre per day, with 55.6% below the AI (25g per day). Median thiamin intakes for younger and older women were both 1.27mg per day, above the RDI of 1.1 mg/day, with just over 20% achieving the thiamin EAR ((0.9mg; *p*=0.773). Younger women had higher adherence to folate recommendations (20.4%) than older women (15.4%; *p*=0.034). However, the median daily intake of folate was not significantly different for younger (453.4µg/day) and older women (484.3µg/day). Older women had a higher percentage below the calcium EAR (66.7%) than younger women (55.9%; p=0.001), meaning younger women had better adherence to the calcium EAR. Median calcium intake was not significantly different at 771.3 mg per day for younger women and 810.1mg calcium per day for older women.

Table 9*: Daily micronutrient intake for younger women and older women compared with Nutrient Reference Values* (Ministry of Health & National Health and Medical Research Council, 2006).

	Median (25th, 75th) intake		Mean ± SD	P-value[1]	RDI[a]	EAR[b]	N (%) below EAR[b] or specified nutrient		P-Value[2]
	Younger Women	Older Women	Older Women				Younger Women	Older Women	
Protein (g)	85.3 (68.3, 107.5)	74.1 (66.4, 86.9)	78.3 ± 2.2	0.015*	46 (18-70 yrs) 57 (71+ yrs)	37 (18-70 yrs) 46 (71+ yrs)	0	0	-
Fibre (g)	25.1(19.8, 33.0)	23.2 (17.6, 31.8)		0.200	28 (SDT[C])	25 (AI[D])	46 (49.5)	81 (51.9)	0.455
Thiamin (mg)	1.3 (1.0, 1.8)	1.3 (1.0, 1.7)		0.915	1.1	0.9	21 (22.6)	34 (21.8)	0.773
Folate (µg)	453.4 (340.1, 590.5)	484.3 (383.8, 582.8)		0.158	400	320	19 (20.4)	24 (15.4)	0.034*
Calcium (mg)	771.3 (657.8, 1012.5)	810.1 (646.0, 999.6)		0.978	1000	840	52 (55.9)	104 (66.7)	0.001*

[A]= RDI = Recommended dietary intake

[B]= EAR = Estimated average requirement

[C]=SDT = suggested daily target

[D]= AI = Adequate intake

[1]= Mann-Whitney U test of significance between median daily nutrient intake of younger vs older women

[2]= Chi-square test for the significance of the difference in the percentage meeting NRV guidelines between younger vs older women

*= statistically significant (p-value <0.05

3.4.6 Relationship between the daily number of servings and nutrient intake

Chi-Square Relationship between meeting NRVs and meeting EAGs:

There was a statistically significant association between meeting the fibre AI and meeting both the fruit and vegetable EAG (*p*=<0.001, *p*=0.02). There was also a significant association between meeting the folate EAR and meeting the calcium-rich food EAG (*p*=0.035). Meeting the calcium EAR was significantly associated with meeting both the fruit and calcium-rich food EAG (*p*=0.022, *p*=0.003). There were no other associations between meeting the NRV and meeting the EAG (Appendix G).

Spearman's Correlation between nutrient intake and food group intake:

There was a moderate, positive correlation between fruit intake and fibre intake (r_s = 0.486, *p*=0<.001). Fruit intake was also weakly, positively correlated with folate intake (r_s = 0.252, *p*<0.001) and calcium intake (r_s = 0.241, *p*=0.002).

There was a moderate, positive correlation between vegetable intake and both fibre intake (r_s = 0.441, *p*<0.001) and folate intake (r_s = 0.377, *p*<0.001). Vegetable intake was weakly, positively associated with protein intake (r_s = 0.173, *p*=0.031).

Grain intake was moderately, positively correlated with thiamin intake (r_s = 0.413, *p*<0.001). There was a weak, positive correlation between grain intake and fibre intake (r_s = 0.248, *p*=0.002), folate intake (r_s = 0.342, *p*<0.001) and calcium intake (r_s = 0.241, *p*=0.002).

There was a strong, positive correlation between calcium-rich foods and calcium intake, which was statistically significant (r_s = 0.507, *p*=<0.001). Calcium-rich food intake was also weakly, positively associated with folate intake (r_s = 0.221, *p*=0.006) and protein intake (r_s = 0.170, *p*=0.033).

There was a moderate, positive correlation between protein-rich food intake and protein intake, which was statistically significant (r_s = 0.439, *p*=<0.001). Protein-rich food intake was not correlated with any other nutrient intakes.

Predictors of Nutrient Intake:

Multiple linear regression showed predictors of protein intake (g per day) were number of servings of grain, protein and calcium foods ($F(5, 150) = 634.8$, $p < 0.001$, $R^2 = 0.314$.) Predictors of fibre intake were number of servings of grain, vegetables, and fruit ($F(5, 118) = 91.03$, $p = 0.001$, $R^2 = 0.347$). Thiamin intake was predicted by number of servings of grain and protein foods ($F(5, 118) = 0.342$, $p = 0.009$, $R^2 = 0.120$). Folate was predicted by all five food groups ($F(5, 118) = 0.105$, $p = 0.001$, $R^2 = 0.390$). Calcium intake was predicted by number of servings of grain, vegetable and calcium foods servings ($F(5, 118) = 0.101$, $p = 0.001$, $R^2 = 0.294$).

3.5 Discussion

3.5.2 Summary of Findings:

This study found that many of the women studied are not adhering to New Zealand's food-based dietary guidelines, with no women achieving all five food group guidelines and approximately 60% achieving just one or two recommendations. The findings also show that many participating women have intakes below the EAR/AI recommendations for fibre, calcium, folate and thiamin.

3.5.3 Recommended food group servings

The current study found that younger and older women consumed a median of 1.0 and 1.3 servings of fruit per day, respectively. Only 25.8% of younger and 28.6% of older women adhered to the guideline of two daily servings, suggesting both groups of women are at risk of suboptimal fruit intake. The 2008/09 NZANS found that 60.6% of females aged 19-30 years and 73.4% of women aged 51-70 years were consuming ≥ 2+ fruit servings per day, respectively; however, no median daily intake of servings was reported (Ministry of Health & University of Otago, 2011). The SuNDiAL study found that 58.8% of 15-18-year-old participants adhere to fruit recommendations (Trollope, 2020). The percentage adherence in this study is significantly lower than in previous New Zealand studies, which may be due to factors such as food cost changes, fruit availability during the data collection period or differences in methods used. International studies have also shown low fruit intakes, with an Australian study (n= 2397) finding mean daily fruit intake for men and women aged 18-

34 years was 0.9 servings per day (Nour et al., 2017). Similarly, a Singaporean study (*n* = 884) found that pre-graduate men and women were consuming a mean fruit intake of 1.3 servings per day (Lim et al., 2017).

The current guideline for vegetables is at least five servings per day for younger and older women, and the current study found that the median daily intake of vegetables for younger women was 2.0 servings, with only 5.4% adherence compared to 2.2 vegetable servings per day for older women, with 9.5% adherence. These results are much lower than those from the 2008/09 NZANS, with percentage adherence to vegetable guidelines being 56.2% for women aged 19-30 years and 83.3% for women aged 51-70 years (Ministry of Health & University of Otago 2011). The SuNDiAL study found that 34.9% of 15–18-year-old participants adhered to vegetable guidelines (Trollope, 2020). However, the NZANS and SuNDiAL were conducted when the daily guideline for vegetable servings was only three per day. This difference in vegetable guidelines means that not only was it easier to achieve guidelines, but also that people had no incentive to increase their vegetable intake above three per day, as that was the recommendation for improved health. The findings of this study are higher than the results from an Australian study (*n*=18226) where the percentage adherence to vegetable guidelines was approximately 2% for women aged 31-36 and 50-55 (Mishra et al., 2015). However, another study in Australia (*n*= 2397) found that the mean intake of vegetables for men and women aged 18-34 years was 2.7 servings per day (Nour et al., 2017). Further, a study in Singapore (*n*= 884) found that the mean daily intake of vegetables for pre-graduate men and women was only 1.7 servings per day (Lim et al., 2017), which is less than both the results of this study and the Australian study. Comparing studies from different countries is difficult due to differences in methodologies and the calculation of serving sizes. Overall, adherence to vegetable guidelines is poor among the study population, and the daily intake of vegetables is much lower than the guidelines.

The present study found that the median daily intake of calcium-rich foods was higher in older than younger women (at 1.8 and 1.0 servings, respectively; p=<0.001). Older women above 50 years of age have a guideline of four servings per day, and younger women (below 50 years of age) are recommended to have 2.5 servings per day (Ministry of Health, 2020a). This increased requirement is due to the increased metabolic need for calcium and the

increased risk of osteoporosis due to increased bone turnover as women age (North American Menopause Society, 2006). The results of this study indicate that this group of women are consuming suboptimal calcium-rich food servings. An Australian (*n*=115) study found that pre-graduate women consumed 1.3 servings per day, similar to this study (Irwin et al., 2019). Additionally, this study found that 8.6% of younger women and 9.5% of older women met calcium-rich food guidelines, although surprisingly, there was no difference despite higher recommendations for older women. An Australian study found that very few women met calcium guidelines, with 1% of 50–55-year-old women and 11.7% of 31-36-year-old women adhering (Mishra et al., 2015). Although older women in the current study have higher intakes of calcium-rich foods, the increase in recommendations means that the percentage adherence is the same for both groups.

The current study found that the daily intake of grain foods was 2.7 servings per day for both younger and older women. The recommended daily intake of grain foods is six servings per day for younger women and three to four servings per day for older women (Ministry of Health, 2020a). This study found that 15.9% of older women, compared to only 1.1% of younger women, adhered to grain guidelines (p=0.001), indicating that the higher requirement for younger women may be difficult to achieve. A study conducted in Australia (using data from the Australian Longitudinal Study on Women's Health; *n*=18226) investigated adherence to the 2013 Australian Dietary Guidelines and found that only 7.1% of women aged 31-36 met grain guidelines compared to 44.9% of women aged 50-55 (Mishra et al., 2015). The current study found that women were consuming fewer grains than in the Australian study; however, the trend of older women having a higher adherence percentage was present in both this study and the Australian study. Both groups in the present study consumed a similar number of grains. The higher percentage of older women adhering to guidelines is likely due to the daily recommendation of grain servings being much lower than that of younger women. The differences between adherence to grain guidelines between younger and older women highlight that the daily recommendation for grain foods may be unachievable for younger women as it is much higher than the intake of this group.

In this study, the median daily intake of protein-rich foods for younger women was 2.0 servings, with 39.8% meeting the recommended two protein-rich food servings per day. The median daily intake of protein-rich foods was 2.2 servings for older women, with 61.9% adhering to the recommended 2.5 protein-rich food servings per day. A larger percentage of older women (61.9%) met guidelines than younger women (39.8%; p=0.007), likely due to the lower requirements for older women and suggesting that the increased protein-rich food guideline may be difficult for younger women to achieve. An Australian study (n=18226) also found that most women were not meeting protein-food recommendations, as only 28.2% of women aged 31-36 and 40.6% of women aged 50-55 met recommendations (Mishra et al., 2015). Interestingly, another Australian (n=115) study found that pre-graduate women were consuming a median intake of 2.2 protein-rich foods per day, compared to the guideline of 2.5 servings per day (Irwin et al., 2019). The results indicate that these women are not meeting protein-rich food guidelines. However, protein-rich foods are only one of the sources of protein, which will be discussed further.

3.5.4 Nutrient Reference Values

Daily protein intakes for both groups in the present study were all above the RDI, with median intakes sitting at 85.3g per day for younger women and 74.1g per day for older women (p=0.015), compared to the RDI of 46g and 57g, (Ministry of Health & National Health and Medical Research Council, 2006). The 2008/09 NZANS also found that the women's median daily intake was above the protein RDI (Ministry of Health & University of Otago, 2011). The current study found that the median percentage of daily energy intake from protein was similar for both groups, at 16.7% for younger women and 17.8% for older women. In 2009, a New Zealand study found that women aged 80-80 years consumed an average of 58.6g of protein per day, with an average of 15.5% of total energy coming from protein (Ram, 2019). The current study findings seem at odds with the high proportion of women with intakes of protein-rich foods below the recommendations. However, these women are likely receiving their protein from multiple food groups, not from protein-rich foods alone. Protein intake was positively associated with intakes of vegetables, calcium-rich foods, and protein-rich foods, and these food groups were also predictors of protein intake. Research highlights that dietary habits involving reducing meat intake are on the rise (Wild et al., 2014), and New Zealand had the third-highest vegan population in 2018 (Ismail

et al., 2020). Thus, if people exclude meat, they must obtain protein from other dietary sources.

This study found that younger women consumed a median of 771 mg of calcium per day with 55.9% below the EAR (840mg per day), and older women consumed a median of 810mg of calcium per day with 82.5% below the EAR (1100mg). The intakes of calcium among the two groups are similar. However, many more of the younger women achieved the EAR than older women (p=0.001); this is most likely due to the calcium EAR for older women being much higher than that for younger women. These findings are similar to the 2008/09 NZANS, which found that the median calcium intake for 19-30-year-old women was 742mg per day and 775mg per day for women aged 51-70 years (Ministry of Health & University of Otago, 2011). A comparable study in Auckland on women over 65 years found that the mean calcium intake was 866 mg per day (Bristow et al., 2019). In 2016, the LiLACS study (n=216 Māori, 362 non-Māori) found that the median calcium intake for women aged 80-90 was 543mg per day (Wham et al., 2016). This study and previous research indicate that many women, especially older ones, are at risk of inadequate calcium. Calcium intake was found to be positively associated with intakes of calcium-rich foods, fruit, and grains and predictors of median calcium intake were found to be intakes of grain, vegetable and calcium-rich foods. This association suggests that calcium-rich foods, grains, and vegetables are important for calcium intake.

Median folate intake in this study was higher for older women (484 µg per day), with 7.9% below the EAR, than younger women (453 µg per day), with 20.4% below the EAR, which is 320 µg per day for both age groups (Ministry of Health & National Health and Medical Research Council, 2006). Female adolescents aged 15-18 years assessed in the 2019 SuNDiAL study had median folate intakes of 347.2 µg per day, with 47.1% below the EAR (Lee, 2019). In 2016, the LiLACS study (n=216 Māori, 362 non-Māori) of those over 65 years found that the median folate intake of women was 193 µg per day (Wham et al., 2016). The conflicting results between this study, LiLACS and the SuNDiAL study indicate that more research is needed to understand folate intakes. It is concluded that the younger women in this study group are likely at risk of inadequacy as more than 20% of younger participants have intakes below the EAR, which is essential to investigate further. It is also important to

assess folate intake after the mandatory fortification of bread with folic acid which will be fully introduced by mid-2023 ("*Fortification of flour with the B vitamin folic acid,"* n.d.). Folate intakes were positively associated with intakes of fruit, vegetables, calcium-rich foods and grains, and predictors of folate were found to be by all five food groups, meaning that increasing the number of servings of all food groups may improve folate intake.

In this study, younger and older women had median thiamin intakes of 1.3 mg per day, with 22.6% of younger women and 20.6% of older women below the EAR (0.9 mg per day). The 2008/09 NZANS found median thiamin intakes were 1.1 mg for women aged 19-30 years and 1.2 for women aged 51-70 years (Ministry of Health & University of Otago, 2011), in line with the current research. As the proportion of participants below the EAR is above 20%, this group may be at risk of inadequacy. Therefore, it is crucial for thiamin intakes to be further investigated to determine intake at a population level and measure biomarkers to understand if thiamin deficiency exists. Thiamin intake was positively associated with intakes of grain foods, and predictors of thiamin intake were found to be grain and protein-rich foods, meaning that increasing daily servings of these food groups may improve thiamin intake.

This study found that the median fibre intake for younger women was 25.1g per day, with 49.5% of women below the AI (25g per day). Older women in this study had similar intakes consuming a median of 23.15g per day, with 55.6% below the AI (25g per day). Median intakes for both groups are therefore also below the Suggested Dietary Target (SDT, 28g per day), which is set to reduce the risk of developing chronic disease (National Health and Medical Research Council et al., 1991). In the 2008/09 NZANS, the median intake for fibre was 17.0g, 18.1g and 17.5g for women aged 19-30, 51-70 and 71+ years, respectively (Ministry of Health & University of Otago, 2011). The SuNDiAL study in NZ found that students (aged 15-18 years) consumed an average of 24.1g of fibre per day (Taungapeau, 2019). The conflicting results from this study and the NZANS show the necessity of an in-depth investigation into fibre intake at a national level. Fibre median intake was positively associated with intakes of fruit, vegetables and grain foods, and these food groups also predicted fibre intake. This association means that increasing the daily number of servings of these food groups may improve fibre intake.

3.5.5 Changes to food trends

Since 2017, when this data was collected, many dietary habits have changed. In 2018, an Australian study assessed popular online nutrition information to examine the advice and determine alignment with Australian healthy eating guidelines (Ramachandran et al., 2018). This study found that many online nutrition information sources were publishing non-regulated nutrition advice, some of which were not in line with national recommendations (Ramachandran et al., 2018). Having incorrect nutrition advice readily available for consumers to read and practice may negatively impact their nutrition. In 2020, a New Zealand study assessed the impact of the COVID-19 lockdown on eating habits (Gerritsen et al., 2021). This study found that New Zealanders had shifted towards an 'unhealthy' eating pattern with increased consumption of sweet and salty snacks, alcohol, and sugary drinks during the lockdown period (Gerritsen et al., 2021). Food costs and availability have also drastically changed over the past few years. A recent New Zealand study assessing food insecurity found that over 80% of respondents reported 'cost exceeding income' as their main reason for food insecurity (Neuwelt-Kearns et al., 2022). Many factors impact consumer choice, so differences in nutrient and food group intake from previous studies are expected, emphasising the importance of investigating current intakes relative to the FBDGs. It is, therefore, important to consider food security and lifestyle habits when assessing dietary intake.

3.6 Conclusion

3.6.1 Study Strengths and Limitations

The dietary analysis method is in-depth and comprehensive, adding valuable information to our understanding of the nutritional adequacy of women's diets in New Zealand. This study examines dietary intake of protein, fibre, folate, thiamin, and calcium along with the five food groups rather than one nutrient or the food groups alone. Additionally, the 3-day-diet-diary allows for an investigation of the number of servings of food groups and nutrient intakes at an individual level. Also, this study is the most recent nutrition study in New Zealand that compares dietary food group consumption with nutrient intake.

This study has multiple limitations, including convenience sampling and older data. Participants volunteered to attend Massey University for studies about bone health, so there are likely biases in the population recruited. No data is available for ethnic groups, activity level or socioeconomic status, so we cannot compare with the New Zealand population. The sample only included women from two age groups, with no data from women aged 26-53 years, further highlighting the inability to represent the whole population. Therefore, the findings of this study cannot be generalised to all women in New Zealand. Secondly, the data was collected as part of previous studies in 2017, so the data were five years old at the time of analysis, and the food environment may have changed, such as changes to food cost, availability and the impact of COVID-19. Additionally, dietary analysis was completed at least four years after collection, resulting in potential changes to the dietary composition of food items.

3.6.2 Conclusions

The findings suggest that most participants were not adhering to the updated 2020 Eating and Activity Guidelines, with protein-rich food guidelines having the best adherence among older women. Additionally, many participants were not meeting the Nutrient Reference Values for calcium, fibre, folate or thiamin.

Further research is required to assess the diet quality and adherence to dietary guidelines of other age groups and genders, and assessing adherence to other nutrients. Larger studies should also investigate the enablers and barriers to healthy food choices. Determining the intake of nutrients and food groups and the level of dietary inadequacy will help develop interventions designed to improve nutrition and diet quality. Further research on multiple nutrients would provide deeper insight into adherence to the NRVs to understand the population's health and the potential risk of developing nutrition-related diseases.

This study found multiple associations between food group intakes and nutrient intakes, such as grain food intake associating with protein intake, which were expected. However, for associations that were unexpected, such as grain foods and calcium intake, these associations could be associated with a higher diet quality rather than the direct impact of

grain foods on calcium intake. This is an important factor to consider and should be investigated further.

4 Conclusion and Recommendations

4.1 Conclusion

This study investigated if New Zealand women were meeting current nutrition recommendations. The results from this sample of women aged 18-26 and 53-76 years found that many women were not adhering to any food-based dietary guidelines in the EAG, with the food group with the best adherence being protein-rich foods. This study also found that these groups of women had inadequate intakes of fibre, folate, thiamin and calcium, while most women consumed protein in adequate amounts. These results are consistent with literature from around the world, which has shown poor adherence to food-based dietary guidelines and below-recommended intakes of calcium, fibre, folate and thiamin. Grain food intake was found to predict intakes of all nutrients, and vegetable intake was found to predict fibre, folate and calcium intakes. Protein-rich food intake was found to predict protein, folate and thiamin intakes. Fruit intake predicted fibre and folate intakes, and calcium-rich foods predicted protein, folate and calcium intakes. These findings suggest that promoting consumption of foods from a range of food groups may improve overall nutrient intake.

This study addressed a gap in the literature by directly comparing food and nutrient intakes to guidelines set by the Ministry of Health. This study hypothesised that the majority of 18-26-year-old and post-menopausal women would not meet the nutrition recommendations in the 2006 NRVs or the EAGs. This hypothesis was partially supported by the results of this study, as no women met all of the dietary guidelines in the EAGs and only met the nutrient recommendations for one of the investigated five nutrients.

For a population to have sufficient nutrient intakes, intake should be at, or above, the RDI with a small percentage below the EAR (National Research Council, 1989). This study investigated women's intakes of five nutrients (protein, fibre, calcium, folate, and thiamin) and found a high proportion had intakes below the EAR for calcium, folate and thiamin and below the AI for fibre, suggesting dietary inadequacy of these nutrients. However, protein intakes were mainly above the RDI, with some women below the EAR, suggesting dietary adequacy.

This study assessed the average daily number of servings consumed for the five food groups (protein-rich foods, calcium-rich foods, grains, vegetables, and fruit) and compared the results to the EAG recommendations. Most of the study population did not meet the recommended daily number of servings for all food groups. The food group with the highest adherence to guidelines was protein-rich foods, with 39.8% of younger and 61.9% of older women meeting guidelines. Grain foods had poor adherence, with 1.1% of younger women and 15.9% of older women adhering to guidelines. Vegetable guidelines were also poorly adhered to, with 5.4% of younger women and 9.5% of older women adhering to guidelines. Additionally, no women met all five food group guidelines, with 57% of younger women meeting 1-2 guidelines and 69.8% of older women meeting 1-2 guidelines. This study's findings highlight that the population consumed sub-optimal intakes of fruit, vegetables, calcium-rich foods, protein-rich foods and grains.

The results found a positive relationship between meeting fruit and vegetable recommendations and meeting the fibre AI, suggesting that increasing the intake of fruit and vegetables may improve dietary fibre intake. Results also found a positive relationship between calcium-food servings and daily calcium intake, suggesting that increasing calcium-rich foods may improve daily calcium intake.

One of the most significant findings is that younger and older women consumed less than the recommended number of protein-rich foods per day. However, these women all had intakes above the EAR for protein. This finding is important as it highlights that protein comes from other food sources and that women do not need the recommended servings of protein-rich foods to achieve the protein EAR. However, protein-rich foods are also important for providing other nutrients, such as iron or zinc. Higher intakes of protein-rich foods may be necessary for these nutrients. Therefore, it is important to conduct larger studies investigating the associations between food groups and a wider range of nutrient intakes.

This study calculated the acceptable macronutrient distribution range (AMDR) of carbohydrates, total fat, saturated fat and protein. This study found that 60.2% of younger

and 77.8% of older women adhered to the AMDR for protein. However, 51.6% of younger and 63.5% of older women exceeded the AMDR for total fat. The AMDR for carbohydrates was met by 28.5% of younger women and 34.4% of older women, with no women exceeding this AMDR. This study also found that almost 80% of younger women and 85.7% of older women exceeded the saturated fat AMDR. These higher-fat, lower-carbohydrate diets were also seen in the 2008/09 NZANS (Ministry of Health & University of Otago, 2011). The Ministry of Health recommends avoidance of high-fat foods, especially those containing saturated fat (such as red meat and full-fat dairy), which many of the women in this study did not achieve.

Further research into assessing barriers and enablers to achieving nutrition recommendations would provide critical information to help researchers develop nutrition interventions targeted to the population's needs. Barriers such as cost, accessibility, cooking abilities and living situations are vital determinants of nutrient intake and are essential to understand. Enablers such as gardening and cooking skills, nutrition knowledge and government initiatives are also important to acknowledge. Understanding the current food and lifestyle situation will significantly improve the outcomes of further research into nutrition and adherence to nutrition recommendations in New Zealand.

This study found multiple associations between food group intake and nutrient intake that were slightly surprising. For example, calcium intake was correlated with fruit and grain intakes, and meeting the fruit EAG was associated with meeting the calcium EAR. These results could be further investigated to understand if these relationships are directly due to the contribution of grain foods/fruit intake to calcium intake, or if people who consume more grain foods/fruit tend to consume higher quality diets with more calcium-rich foods.

Overall, this study demonstrates that many women are not meeting all the dietary guidelines, resulting in inadequate intake of some nutrients. Further studies are needed to investigate the factors which impact dietary choices, which may provide beneficial information to help guide nutrition public health interventions. The food-group recommendations have recently changed, and people may need to be aware of them.

4.2 Strengths and Limitations of the study

This study was the first to investigate New Zealand women's nutrient and food group intakes and compare them to nutrition recommendations since the updated EAGs were published. This study uses in-depth dietary analysis to assess average daily intakes and provides a wide range of information on dietary intakes. Another strength of this study is that the sample size of over 150 women includes women from two different life stages and compares their intakes to their age-specific guidelines. Another strength of this study is the method of dietary data collection. Three-day diet diaries require participants to provide accurate recordings of the food they have consumed for three consecutive days. As a result, this method provides high-quality details of diet patterns and food intakes with the ability to analyse average daily nutrient intakes. However, there are some limitations to this, such as under- and over-reporting of certain foods due to the nature of being able to self-record dietary intake. However, 3DDD is the current gold standard of dietary assessment.

One of the limitations of this study is the age of the data. In 2017, when this data was collected, the dietary guidelines were different. In 2020 the EAGs were released, with an updated daily vegetable intake of five per day, an increase from the previous three vegetable servings per day. Additionally, dietary analysis was completed at least four years after collection, resulting in potential changes to the dietary composition of food items. Also, since 2017, the food environment and the accessibility of food products has changed, impacting on the ability to afford certain food items, such as fresh fruit and vegetables.

4.3 Research Recommendations

More research is required to understand nutrient intakes and nutritional guideline adherence at a larger scale. One recommendation is to conduct further studies involving women from a more extensive age range, a larger sample size, and from various ethnic and social backgrounds. This study found minimal adherence to nutrition guidelines among the study population, which suggests that poor adherence may be prevalent in the broader population.

Many barriers and enablers impact dietary choices, such as cost, accessibility and nutrition knowledge. Therefore, a new study assessing barriers and enables to dietary choices will

provide researchers with crucial information. For example, a study that is based on assessing barriers and enablers to current dietary habits will provide insight into the reasons as to why people are eating what they are eating.

References

Angelino, D., Godos, J., Ghelfi, F., Tieri, M., Titta, L., Lafranconi, A., Marventano, S., Alonzo, E., Gambera, A., Sciacca, S., Buscemi, S., Ray, S., Galvano, F., Del Rio, D., & Grosso, G. (2019). Fruit and vegetable consumption and health outcomes: An umbrella review of observational studies. *International Journal of Food Sciences and Nutrition, 70*(6), 652-667. https://doi.org/10.1080/09637486.2019.1571021

Barber, T. M., Kabisch, S., Pfeiffer, A. F. H., & Weickert, M. O. (2020). The health benefits of dietary fibre. *Nutrients, 12*(10). https://doi.org/10.3390/nu12103209

Bechthold, A., Boeing, H., Schwedhelm, C., Hoffmann, G., Knüppel, S., Iqbal, K., De Henauw, S., Michels, N., Devleesschauwer, B., Schlesinger, S., & Schwingshackl, L. (2019). Food groups and risk of coronary heart disease, stroke and heart failure: A systematic review and dose-response meta-analysis of prospective studies. *Critical Reviews in Food Science and Nutrition, 59*(7), 1071-1090. https://doi.org/10.1080/10408398.2017.1392288

Bel, S., De Ridder, K. A. A., Lebacq, T., Ost, C., Teppers, E., Cuypers, K., & Tafforeau, J. (2019). Habitual food consumption of the Belgian population in 2014-2015 and adherence to food-based dietary guidelines. *Archives of Public Health, 77*(1), 14. https://doi.org/10.1186/s13690-019-0343-3

Bristow, S. M., Horne, A. M., Gamble, G. D., Mihov, B., Stewart, A., & Reid, I. R. (2019). Dietary calcium intake and bone loss over 6 years in osteopenic postmenopausal women. *The Journal of Clinical Endocrinology & Metabolism, 104*(8), 3576-3584. https://doi.org/10.1210/jc.2019-00111

Budreviciute, A., Damiati, S., Sabir, D. K., Onder, K., Schuller-Goetzburg, P., Plakys, G., Katileviciute, A., Khoja, S., & Kodzius, R. (2020). Management nd prevention strategies for non-communicable diseases (NCDs) and their risk factors. *Frontiers in Public Health, 8*. https://doi.org/10.3389/fpubh.2020.574111

Cámara, M., Giner, R. M., González-Fandos, E., López-García, E., Mañes, J., Portillo, M. P., Rafecas, M., Domínguez, L., & Martínez, J. A. (2021). Food-based dietary guidelines around the world: A comparative analysis to update AESAN scientific committee dietary recommendations. *Nutrients, 13*(9). https://doi.org/10.3390/nu13093131

Cena, H., & Calder, P. C. (2020). Defining a healthy diet: Evidence for the role of contemporary dietary patterns in health and disease. *Nutrients, 12*(2). https://doi.org/10.3390/nu12020334

Chanson-Rolle, A., Meynier, A., Aubin, F., Lappi, J., Poutanen, K., Vinoy, S., & Braesco, V. (2015). Systematic review and meta-analysis of human studies to support a quantitative recommendation for whole grain intake in relation to type 2 diabetes. *PLOS ONE, 10*(6). https://doi.org/10.1371/journal.pone.0131377

Coates, P. M., Blackman, M. R., Cragg, G. M., Levine, M., Moss, J., & White, J. D. (2004). Encyclopedia of dietary supplements. *National Institute of Health.* https://doi.org/10.1201/b13959

Condo, D., Lohman, R., Kelly, M., & Carr, A. (2019). Nutritional intake, sports nutrition knowledge and energy availability in female Australian rules football players. *Nutrients, 11*(5), 971. https://www.mdpi.com/2072-6643/11/5/971

Cormick, G., & Belizán, J. M. (2019). Calcium intake and health. *Nutrients, 11*(7), 1606. https://www.mdpi.com/2072-6643/11/7/1606

Craig, W. J., & Fresán, U. (2021). International analysis of the nutritional content and a review of health benefits of non-dairy plant-based beverages. *Nutrients, 13*(3), 842. https://www.mdpi.com/2072-6643/13/3/842

de Mestral, C., Khalatbari-Soltani, S., Stringhini, S., & Marques-Vidal, P. (2020). Perceived barriers to healthy eating and adherence to dietary guidelines: Nationwide study. *Clinical Nutrition, 39*(8), 2580-2585. https://doi.org/https://doi.org/10.1016/j.clnu.2019.11.025

Devarshi, P. P., Legette, L. L., Grant, R. W., & Mitmesser, S. H. (2021). Total estimated usual nutrient intake and nutrient status biomarkers in women of childbearing age and women of menopausal age. *American Journal of Clinical Nutrition, 113*(4), 1042-1052. https://doi.org/10.1093/ajcn/nqaa392

Ebara, S. (2017). Nutritional role of folate. *Congenital Anomalies, 57*(5), 138-141. https://doi.org/https://doi.org/10.1111/cga.12233

Elmadfa, I., & Meyer, A. L. (2017). Animal Proteins as Important Contributors to a Healthy Human Diet. *Annual Review of Animal Biosciences, 5*(1), 111-131. https://doi.org/10.1146/annurev-animal-022516-022943

Fontanelli, M. d. M., Martinez Arroyo, A., Sales, C. H., Seal, C. J., & Fisberg, R. M. (2021). Opportunities for diet quality improvement: the potential role of staple grain foods. *Public Health Nutrition, 24*(18), 6145-6156. https://doi.org/10.1017/S1368980021001531

Gaesser, G. A. (2019). Perspective: Refined Grains and Health: Genuine Risk, or Guilt by Association? *Advances in Nutrition, 10*(3), 361-371. https://doi.org/10.1093/advances/nmy104

Gerritsen, S., Egli, V., Roy, R., Haszard, J., Backer, C. D., Teunissen, L., Cuykx, I., Decorte, P., Pabian, S. P., Van Royen, K., & Te Morenga, L. (2021, 2021/05/31). Seven weeks of home-cooked meals: changes to New Zealanders' grocery shopping, cooking and eating during the COVID-19 lockdown. *Journal of the Royal Society of New Zealand, 51*(sup1), S4-S22. https://doi.org/10.1080/03036758.2020.1841010

Gill, S. K., Rossi, M., Bajka, B., & Whelan, K. (2021). Dietary fibre in gastrointestinal health and disease. *Nature Reviews Gastroenterology & Hepatology, 18*(2), 101-116. https://doi.org/10.1038/s41575-020-00375-4

Gunness, P., & Gidley, M. J. (2010). Mechanisms underlying the cholesterol-lowering properties of soluble dietary fibre polysaccharides. *Food & Function, 1*(2), 149-155. https://doi.org/10.1039/c0fo00080a

Hu, Y., Ding, M., Sampson, L., Willett, W. C., Manson, J. E., Wang, M., Rosner, B., Hu, F. B., & Sun, Q. (2020). Intake of whole grain foods and risk of type 2 diabetes: results from three prospective cohort studies. *Bmj, 370*, m2206. https://doi.org/10.1136/bmj.m2206

Institute of Medicine. (2000). Dietary reference intakes: Applications in dietary assessment. In *DRI Dietary Reference Intakes: Applications in Dietary Assessment*. National Academies Press (US) https://doi.org/10.17226/9956

Institute of Medicine Food Forum. (2010). Providing healthy and safe foods as we age: Workshop summary. *National Academy of Sciences.* https://doi.org/10.17226/12967

Irwin, C., Desbrow, B., Khalesi, S., & McCartney, D. (2019). Challenges following a personalised diet adhering to dietary guidelines in a sample of Australian university students. *Nutrition and Health, 25*(3), 185-194. https://doi.org/10.1177/0260106019841247

Ismail, I., Hwang, Y. H., & Joo, S. T. (2020). Meat analog as future food: a review. *Journal of Animal Science Technology, 62*(2), 111-120. https://doi.org/10.5187/jast.2020.62.2.111

Jones, J. M., García, C. G., & Braun, H. J. (2019). Perspective: Whole and refined grains and health—evidence supporting "Make Half Your Grains Whole". *Advances in Nutrition, 11*(3), 492-506. https://doi.org/10.1093/advances/nmz114

Jonnalagadda, S. S., Harnack, L., Hai Liu, R., McKeown, N., Seal, C., Liu, S., & Fahey, G. C. (2011). Putting the whole grain puzzle together: Health benefits associated with whole grains—Summary of American society for nutrition 2010 satellite symposium. *The Journal of Nutrition, 141*(5), 1011S-1022S. https://doi.org/10.3945/jn.110.132944

Kerns, J. C., & Gutierrez, J. L. (2017). Thiamin. *Advances in Nutrition, 8*(2), 395-397. https://doi.org/10.3945/an.116.013979

Fortification of flour with the B vitamin folic acid. (n.d.). Ministry for Primary Industries. https://www.mpi.govt.nz/food-business/bakery-and-grain-based-products/folic-acid-fortification-of-bread/

Lee, L.Y. (2019). *Dietary folate intake of female adolescents in New Zealand* [Thesis].

University of Otago

Lim, R. B. T., Tham, D. K. T., Müller-Riemenschneider, F., & Wong, M. L. (2017). Are university students in Singapore meeting the international and national recommended daily servings of fruits and vegetables? *Asia Pacific Journal of Public Health, 29*(3), 199-210. https://doi.org/10.1177/1010539517696553

Lonsdale, D. (2018). In N. A. M. Eskin (Ed.), *Advances in Food and Nutrition Research* (Vol. 83, pp. 1-56). Academic Press. https://doi.org/https://doi.org/10.1016/bs.afnr.2017.11.001

Lord, C., Chaput, J., Aubertin-Leheudre, M., Labonté, M., & Dionne, I. (2007). Dietary animal protein intake: Association with muscle mass index in older women. *The Journal of Nutrition, Health & Aging, 11*, 383-387. PMID: 17657359.

MacDonald, H. B. (2008, 2008/07/01/). Dairy nutrition: What we knew then to what we know now. *International Dairy Journal, 18*(7), 774-777. https://doi.org/https://doi.org/10.1016/j.idairyj.2008.04.001

Mallard, S. R., & Houghton, L. A. (2012). *Folate knowledge and consumer behaviour among pregnant New Zealand women prior to the potential introduction of mandatory fortification* (Vol. 21). HEC Press. https://doi.org/10.3316/ielapa.557674438991678

Mann, K. D., Yu, D., Hopkins, S., Foster, J., & Seal, C. J. (2018). Investigating the impact of replacing refined grain foods with whole-grain foods on fibre intake in the UK. *Proceedings of the Nutrition Society, 77*(OCE4), E134, Article E134. https://doi.org/10.1017/S0029665118001404

Masrul, M., & Nindrea, R. D. (2019). Dietary fibre protective against colorectal cancer patients in Asia: A meta-analysis. *Open Access Macedonian Journal of Medical Sciences, 7*(10), 1723-1727. https://doi.org/10.3889/oamjms.2019.265

Melaku, Y. A., Renzaho, A., Gill, T. K., Taylor, A. W., Dal Grande, E., de Courten, B., Baye, E., Gonzalez-Chica, D., Hyppönen, E., Shi, Z., Riley, M., Adams, R., & Kinfu, Y. (2019). Burden and trend of diet-related non-communicable diseases in Australia and comparison with 34 OECD countries, 1990–2015: findings from the Global Burden of Disease Study 2015. *European Journal of Nutrition, 58*(3), 1299-1313. https://doi.org/10.1007/s00394-018-1656-7

Mielgo-Ayuso, J., Aparicio-Ugarriza, R., Olza, J., Aranceta-Bartrina, J., Gil, Á., Ortega, R. M., Serra-Majem, L., Varela-Moreiras, G., & González-Gross, M. (2018). Dietary intake and food sources of niacin, riboflavin, thiamin and vitamin B6 in a representative sample of the spanish population. The ANIBES study. *Nutrients, 10*(7), 846. https://www.mdpi.com/2072-6643/10/7/846

Miketinas, D. C., Bray, G. A., Beyl, R. A., Ryan, D. H., Sacks, F. M., & Champagne, C. M. (2019). Fiber intake predicts weight loss and dietary adherence in adults consuming

calorie-restricted Diets: The POUNDS lost (preventing overweight using novel dietary strategies) study. *Journal of Nutrition, 149*(10), 1742-1748. https://doi.org/10.1093/jn/nxz117

Ministry of Health, & National Health and Medical Research Council. (2006). *Recommended dietary intakes for use in Australia. Canberra*. https://www.nrv.gov.au/

Ministry of Health, & University of Otago. (2011). *A focus on nutrition: Key findings of the 2008/09 New Zealand adult nutrition survey.* https://www.health.govt.nz/system/files/documents/publications/a-focus-on-nutrition-v2.pdf

Ministry of Health. (2019). Annual Data Explorer 2018/19: New Zealand Health Survey [Data File]. https://minhealthnz.shinyapps.io/nz-health-survey-2018-19-annual-data-explorer/

Ministry of Health. (2020a). *Eating and activity guidelines for New Zealand adults*. https://www.health.govt.nz/system/files/documents/publications/eating-activity-guidelines-new-zealand-adults-updated-2020-jul21.pdf

Ministry of Health. (2020b). *New serving size advice*. https://www.health.govt.nz/system/files/documents/publications/new-serving-size-advice-dec20-v3.pdf

Ministry of Health. (2021). *Eating and activity guidelines*. https://www.health.govt.nz/our-work/eating-and-activity-guidelines

Ministry of Health. (2022). Annual Data Explorer 2021/22: New Zealand Health Survey [Data File]. https://minhealthnz.shinyapps.io/nz-health-survey-2021-22-annual-data-explorer/

Mishra, G. D., Schoenaker, D. A., Mihrshahi, S., & Dobson, A. J. (2015). How do women's diets compare with the new Australian dietary guidelines? *Public Health Nutrition, 18*(2), 218-225. https://doi.org/10.1017/s1368980014000135

Moll, R., & Davis, B. (2017). Iron, vitamin B12 and folate. *Medicine, 45*(4), 198-203. https://doi.org/https://doi.org/10.1016/j.mpmed.2017.01.007

Naghshi, S., Sadeghi, O., Willett, W. C., & Esmaillzadeh, A. (2020). Dietary intake of total, animal, and plant proteins and risk of all cause, cardiovascular, and cancer mortality: Systematic review and dose-response meta-analysis of prospective cohort studies. *Bmj, 370*, m2412. https://doi.org/10.1136/bmj.m2412

National Research Council. (1989) *Recommended Dietary Allowances: 10th Edition.* https://pubmed.ncbi.nlm.nih.gov/25144070/

National Health and Medical Research Council, MoH, & FNB. (1991). *Recommended Dietary Intakes for use in Australia, Canberra*. https://www.nrv.gov.au/node/50

Neuwelt-Kearns, C., Nicholls, A., Deane, K. L., Robinson, H., Lowe, D., Pope, R., Goddard, T., van der Schaaf, M., & Bartley, A. (2022). The realities and aspirations of people experiencing food insecurity in Tāmaki Makaurau. *Kōtuitui: New Zealand Journal of Social Sciences Online, 17*(2), 135-152. https://doi.org/10.1080/1177083X.2021.1951779

North American menopause society. (2006). The role of calcium in peri- and postmenopausal women: 2006 position statement of the North American Menopause Society. *Menopause, 13*(6), 862-877.https://doi.org/10.1097/01.gme.0000243566.25205.0b

Nour, M., Sui, Z., Grech, A., Rangan, A., McGeechan, K., & Allman-Farinelli, M. (2017). The fruit and vegetable intake of young Australian adults: A population perspective. *Public Health Nutrition, 20*(14), 2499-2512. https://doi.org/10.1017/S1368980017001124

Nowson, C., & Connell, S. (2015). Protein requirements and recommendations for older people: A review. *Nutrients, 7*(8), 6874-6899. https://www.mdpi.com/2072-6643/7/8/5311

Oyebode, O., Gordon-Dseagu, V., Walker, A., & Mindell, J. S. (2014). Fruit and vegetable consumption and all-cause, cancer and CVD mortality: Analysis of health survey for England data. *Journal of Epidemiology and Community Health, 68*(9), 856-862. https://doi.org/10.1136/jech-2013-203500

Pathirannehelage, N. V. P., & Joye, I. J. (2020). Dietary fibre from whole grains and their benefits on metabolic health. *Nutrients, 12*(10), 3045. https://www.mdpi.com/2072-6643/12/10/3045

Polegato, B. F., Pereira, A. G., Azevedo, P. S., Costa, N. A., Zornoff, L. A. M., Paiva, S. A. R., & Minicucci, M. F. (2019). Role of thiamin in health and disease. *Nutrition in Clinical Practice, 34*(4), 558-564. https://doi.org/https://doi.org/10.1002/ncp.10234

Pu, F., Chen, N., & Xue, S. (2016). Calcium intake, calcium homeostasis and health. *Food Science and Human Wellness, 5*(1), 8-16. https://doi.org/https://doi.org/10.1016/j.fshw.2016.01.001

Ramachandran, D., Kite, J., Vassallo, A. J., Chau, J. Y., Partridge, S., Freeman, B., & Gill, T. (2018). Food trends and popular nutrition advice online - implications for public health. *Online Journal of Public Health Informatics, 10*(2), e213. https://doi.org/10.5210/ojphi.v10i2.9306

Schwingshackl, L., Schwedhelm, C., Hoffmann, G., Knüppel, S., Laure Preterre, A., Iqbal, K., Bechthold, A., De Henauw, S., Michels, N., Devleesschauwer, B., Boeing, H., &

Schlesinger, S. (2018). Food groups and risk of colorectal cancer. *International Journal of Cancer, 142*(9), 1748-1758. https://doi.org/https://doi.org/10.1002/ijc.31198

Schwingshackl, L., Schwedhelm, C., Hoffmann, G., Lampousi, A.-M., Knüppel, S., Iqbal, K., Bechthold, A., Schlesinger, S., & Boeing, H. (2017). Food groups and risk of all-cause mortality: A systematic review and meta-analysis of prospective studies. *The American Journal of Clinical Nutrition, 105*(6), 1462-1473. https://doi.org/10.3945/ajcn.117.153148

Seal, C. J., & Brownlee, I. A. (2015). Whole-grain foods and chronic disease: Evidence from epidemiological and intervention studies. *Proceedings of the Nutrition Society, 74*(3), 313-319. https://doi.org/10.1017/S0029665115002104

Stroebele-Benschop, N., Dieze, A., & Hilzendegen, C. (2018). Students' adherence to dietary recommendations and their food consumption habits. *Nutrition and Health, 24*(2), 75-81. https://doi.org/10.1177/0260106018772946

Taungapeau, F. K. (2019) *Fibre intake and the main food sources of fibre in New Zealand female adolescents aged 15 – 18 years* [Thesis]. University of Otago.

The New Zealand Institute for Plant & Food Research Limited, & Ministry of Health. (2017). FOODfilesTM 2016 version 1 - New Zealand Food Composition Database. https://www.foodcomposition.co.nz/foodfiles/.

Timon, C. M., O'Connor, A., Bhargava, N., Gibney, E. R., & Feeney, E. L. (2020). Dairy Consumption and Metabolic Health. *Nutrients, 12*(10). https://doi.org/10.3390/nu12103040

Trollope, L. (2020). *Dietary habits between New Zealand adolescent males and females.* [Thesis]. University of Otago.

Veronese, N., Solmi, M., Caruso, M. G., Giannelli, G., Osella, A. R., Evangelou, E., Maggi, S., Fontana, L., Stubbs, B., & Tzoulaki, I. (2018). Dietary fiber and health outcomes: An umbrella review of systematic reviews and meta-analyses. *American Journal of Clinical Nutrition, 107*(3), 436-444. https://doi.org/10.1093/ajcn/nqx082

Wallace, T. C., Bailey, R. L., Blumberg, J. B., Burton-Freeman, B., Chen, C. y. O., Crowe-White, K. M., Drewnowski, A., Hooshmand, S., Johnson, E., Lewis, R., Murray, R., Shapses, S. A., & Wang, D. D. (2020). Fruits, vegetables, and health: A comprehensive narrative, umbrella review of the science and recommendations for enhanced public policy to improve intake. *Critical Reviews in Food Science and Nutrition, 60*(13), 2174-2211. https://doi.org/10.1080/10408398.2019.1632258

Wang, D. D., Li, Y., Bhupathiraju, S. N., Rosner, B. A., Sun, Q., Giovannucci, E. L., Rimm, E. B., Manson, J. E., Willett, W. C., Stampfer, M. J., & Hu, F. B. (2021). Fruit and vegetable

intake and mortality. *Circulation, 143*(17), 1642-1654. https://doi.org/doi:10.1161/CIRCULATIONAHA.120.048996

Watson, P. E., & McDonald, B. W. (2008). Major influences on nutrient intake in pregnant New Zealand women. *Maternal and Child Health Journal, 13*(5), 695. https://doi.org/10.1007/s10995-008-0405-6

Watson, P. E., & McDonald, B. W. (2014). Water and nutrient intake in pregnant New Zealand women: Association with wheeze in their infants at 18 months. *Asia Pacific Journal of Clinical Nutrition, 23*(4), 660-670. https://search.informit.org/doi/10.3316/ielapa.874716018885145

Wawrzyniak, N., & Suliburska, J. (2021). Nutritional and health factors affecting the bioavailability of calcium: A narrative review. *Nutrition Reviews, 79*(12), 1307-1320. https://doi.org/10.1093/nutrit/nuaa138

Wham, C., Teh, R., Moyes, S. A., Rolleston, A., Muru-Lanning, M., Hayman, K., Kerse, N., & Adamson, A. (2016). Micronutrient intake in advanced age: Te Puāwaitanga o Ngā Tapuwae Kia ora Tonu, life and living in advanced age: A cohort study in New Zealand (LiLACS NZ). *British Journal of Nutrition, 116*(10), 1754-1769. https://doi.org/10.1017/S0007114516003597

Wild, F., Czerny, M., Janssen, A., M, Kole, A., Zunabovic, M., & Domig, K., J. (2014). The evolution of a plant-based alternative to meat. *Agro FOOD Industry Hi Tech, 25*(1), 45-49.

World Cancer Research Fund. (n.d.). *Limit red and processed meat.* https://www.wcrf.org/diet-activity-and-cancer/cancer-prevention-recommendations/limit-red-and-processed-meat/#:~:text=Eat%20no%20more%20than%20moderate,%2C%20if%20any%2C%20processed%20meat

World Health Organisation. (2020). *Healthy diet*. https://www.who.int/news-room/fact-sheets/detail/healthy-diet

World Health Organization. (2003). *Diet, nutrition, and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation (Vol. 916).* World Health Organization. http://apps.who.int/iris/bitstream/handle/10665/42665/WHO_TRS_916.pdf;jsessionid=50D826B350DEA57E322227235A23A5C3?sequence=1

Wu, G. (2016, Mar). Dietary protein intake and human health. *Food Funct, 7*(3), 1251-1265. https://doi.org/10.1039/c5fo01530h

Yahia, E. M., Maldonado Celis, M. E., & Svendsen, M. (2017). The contribution of fruit and vegetable consumption to human health. In *Fruit and Vegetable Phytochemicals* (pp. 1-52). https://doi.org/https://doi.org/10.1002/9781119158042.ch1

Yang, M., & Vousden, K. H. (2016). Serine and one-carbon metabolism in cancer. *Nature Reviews Cancer, 16*(10), 650-662. https://doi.org/10.1038/nrc.2016.81

Zheng, Y., & Cantley, L. C. (2018). Toward a better understanding of folate metabolism in health and disease. *Journal of Experimental Medicine, 216*(2), 253-266. https://doi.org/10.1084/jem.20181965

Appendices

Appendix A: Nutrient Reference Values

Appendix B: Terminology for Nutrient Reference Values

Appendix C: Information Sheets

Appendix D: Ethical Approval

Appendix E: Consent form

Appendix F: 3-day-diet-diary

Appendix G: Chi-Square Associations Between Meeting NRVs and Meeting EAGs

Appendix A: Nutrient Reference Values

The Nutrient Reference Values for women aged 19-30, 31-50, 51-70 years (Ministry of Health & National Health and Medical Research Council, 2006).

Age Range	Nutrient	AI	EAR	RDI	UL	SDT
19-30	Biotin (ug/day)	25			NP	
	Calcium (mg/day)		840	1000	2500	
	Choline (mg/day)	425			3500	
	Chromium (ug/day)	25			NP	
	Copper (mg/day)	1.2			10	
	Fluoride (mg/day)	3			10	
	Folate (ug/day)		320	400	1000	
	Iodine (ug/day)		100	150	1100	
	Iron (mg/day)		8	18	45	
	Magnesium (mg/day)		255	310	350	
	Manganese (mg/day)	5			NP	
	Molybdenum (ug/day)		34	45	2000	
	Niacin (mg/day)		11	14	35	
	Pantothenic acid (mg/day)	4			NP	

	Phosphorus (mg/day)		580	1000	4000	
	Potassium (mg/day)	2800			NP	4700
	Riboflavin (mg/day)		0.9	1.1	NP	
	Selenium (mg/day)		50	60	400	
	Sodium (mg/day)	460-920			ND	2000
	Thiamin (mg/day)		0.9	1.1	NP	
	Vitamin A (ug/day)		500	700	3000	1220
	Vitamin B12 (ug/day)		2	2.4	NP	
	Vitamin B6 (mg/day)		1.1	1.3	50	
	Vitamin C (mg/day)		30	45	NP	190
	Vitamin D (ug/day)	5			80	
	Vitamin E (mg/day)	7			300	14
	Vitamin K (ug/day)	60			NP	
	Zinc (mg/day)		6.5	8	40	
31-50	Biotin (ug/day)	25			NP	
	Calcium (mg/day)		840	1000	2500	
	Choline (mg/day)	425			3500	
	Chromium (ug/day)	25			NP	
	Copper (mg/day)	1.2			10	
	Fluoride (mg/day)	3			10	
	Folate (ug/day)		320	400	1000	
	Iodine (ug/day)		100	150	1100	
	Iron (mg/day)		8	18	45	
	Magnesium (mg/day)		265	320	350	
	Manganese (mg/day)	5			NP	

	Molybdenum (ug/day)		34	45	2000	
	Niacin (mg/day)		11	14	35	
	Pantothenic acid (mg/day)	4			NP	
	Phosphorus (mg/day)		580	1000	4000	
	Potassium (mg/day)	2800			NP	4700
	Riboflavin (mg/day)		0.9	1.1	NP	
	Selenium (mg/day)		50	60	400	
	Sodium (mg/day)	460-920			ND	
	Thiamin (mg/day)		0.9	1.1	NP	
	Vitamin A (ug/day)		500	700	3000	1220
	Vitamin B12 (ug/day)		2	2.4	NP	
	Vitamin B6 (mg/day)		1.1	1.3	50	
	Vitamin C (mg/day)		30	45	NP	190
	Vitamin D (ug/day)	5			80	
	Vitamin E (mg/day)	7			300	14
	Vitamin K (ug/day)	60			NP	
	Zinc (mg/day)		6.5	8	40	
51-70	Biotin (ug/day)	25			NP	
	Calcium (mg/day)		1100	1300	2500	
	Choline (mg/day)	425			3500	
	Chromium (ug/day)	25			NP	
	Copper (mg/day)	1.2			10	
	Fluoride (mg/day)	3			10	
	Folate (ug/day)		320	400	1000	
	Iodine (ug/day)		100	150	1100	

	Iron (mg/day)		5	8	45	
	Magnesium (mg/day)		265	320	350	
	Manganese (mg/day)	5			NP	
	Molybdenum (ug/day)		34	45	2000	
	Niacin (mg/day)		11	14	35	
	Pantothenic acid (mg/day)	4			NP	
	Phosphorus (mg/day)		580	1000	4000	
	Potassium (mg/day)	2800			NP	4700
	Riboflavin (mg/day)		0.9	1.1	NP	
	Selenium (mg/day)		50	60	400	
	Sodium (mg/day)	460-920			ND	
	Thiamin (mg/day)		0.9	1.1	NP	
	Vitamin A (ug/day)		500	700	3000	1220
	Vitamin B12 (ug/day)		2	2.4	NP	
	Vitamin B6 (mg/day)		1.1	1.3	50	
	Vitamin C (mg/day)		30	45	NP	190
	Vitamin D (ug/day)	5			80	
	Vitamin E (mg/day)	7			300	14
	Vitamin K (ug/day)	60			NP	
	Zinc (mg/day)		6.5	8	40	

NP = not possible to set as there may be insufficient evidence for the level for adverse effects.

ND = Not determined as there is an inability to identify the point below which there is low risk.

Appendix B: Terminology for Nutrient Reference Values for Australia and New Zealand

Term	Definition

Estimated Average Requirement (EAR)	A daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group.
Recommended Dietary Intake (RDI)	The average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97–98 per cent) healthy individuals in a particular life stage and gender group.
Adequate Intake (AI)	The average daily nutrient intake level based on observed or experimentally-determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate.
Estimated Energy Requirement (EER)	The average dietary energy intake that is predicted to maintain energy balance in a healthy adult of defined age, gender, weight, height and level of physical activity, consistent with good health. In children and pregnant and lactating women, the EER is taken to include the needs associated with the deposition of tissues or the secretion of milk at rates consistent with good health.
Upper Level of Intake (UL)	The highest average daily nutrient intake level likely to pose no adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects increases.
Suggested Daily Target (SDT)	A daily average from food and beverages for certain nutrients that may help in prevention of chronic disease. Average intake may be based on the mean or median depending on the nutrient and available data.
Acceptable Macronutrient Distribution Range (AMDR)	An estimate of the range of intake for each macronutrient for individuals (expressed as per cent contribution to energy), which would allow for an adequate intake of all the other nutrients whilst maximising general health outcome.

*Table copied directly from *Nutrient Reference Values for Australia and New Zealand* (Ministry of Health & National Health and Medical Research Council, 2006)

Appendix C: Information Sheets

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

School of Food and Nutrition
Massey Institute of Food Science and Technology,
College of Health

Footprint Study: Fracture Risk of Post-Menopausal Low-Active Women

INFORMATION SHEET

Researcher(s) Introduction
The research group is a team of nutritionists interested in bone health. The lead researcher for this stage of the project is Dr Jasmine Thomson from the School of Food and Nutrition. Other researchers include Dr Louise Brough, Dr Janet Weber, Professor Jane Coad and Professor Marlena Kruger, also from the School of Food and Nutrition, in the College of Health.

Project Description and Invitation
Osteoporosis is one of the leading healthcare issues worldwide. We will investigate bone mineral density and fracture risk of women who are 5 years post menopause (since last period) in relation to their lifestyle factors.

We will be using a relatively new approach to assess bone health; the Quantitative Ultrasound. Quantitative Ultrasound transmits and receives sound waves; which will be altered by the properties of bone. Quantitative Ultrasound compares well with the established methods for diagnosing osteoporosis, DEXA bone mineral density scan.

The common sites of osteoporosis fractures are the hip and spine, which can be measured for bone density by DEXA; however, the Quantitative Ultrasound measurement is done at the heel bone. Therefore we want to compare how well this new technology compares to DEXA when we measure post-menopausal with both instruments.

We will be comparing lifestyle factors and bone health in post-menopausal runners to age-matched women not very active running and walking

We are recruiting **low-active women** for this study. If you would like to participate please contact Jasmine on 06 951 7559 or email j.a.thomson@massey.ac.nz

Participant Identification and Recruitment
We are recruiting women from the general community in the Rangitikei, Palmerston North, Tukituki, Wairarapa, Otaki, Rimutaka, and Wellington Central Regions by written invitation to women randomly selected using electoral rolls. We are also advertising the study in local papers, social media groups, and workplaces. We are recruiting 76 post-menopausal women from the general community to participate in this study.

Inclusion criteria
To become a participant you will need to be:
• A post-menopausal woman (at least 5 years since your last period).
• Healthy, but you may be on some medication e.g. hypertensive tablets, thyroxine treatment or some diuretics
• Not very active running and walking (<7499 steps/day)

Exclusion criteria
Unfortunately you cannot participate if you have been diagnosed with a condition that might affect your bones or absorption of nutrients such as:
- Osteoporosis

- Osteogenesis Imperfecta
- Rheumatoid Arthritis
- Type I (insulin dependent) diabetes
- Uncontrolled Thyroid Disease
- Inflammatory Bowel Disease (e.g. Crohn's, Ulcerative Colitis, Coeliac Disease)
- Chronic Renal (Kidney) Disease
- Clinically Significant Liver Disease
- Eating Disorder (DSM-V)

If you are being medically treated with the following:
- Biphosphonates (Fosamax, Arrow-Etidronate, Risedronate-Sandoz, Aclasta)
- HRT (Evista, Forteo)
- Corticosteroid tablets (e.g. prednisone, cortisone) daily for >3 months previously

What is involved?
If you think you fit the non-active in running and walking criteria, you will be provided with a step counter to record your steps for a 7 day period to determine your average number of steps per day. A non-active in running and walking lifestyle is considered to consist of less than 7499 steps per day. We will provide self-addressed envelopes so you can send the step counters back to the researchers for analysis following your 7day trial period.

You will be asked to fill out some questionnaires on lifestyle factors affecting bone health and a diary of all the food and beverages you consume for three days (3 Day Food Record) at home.

You will be required to make one visit to our Human Nutrition Research Unit at Massey University in Palmerston North. This is the location of our DEXA bone mineral scan instrument.

At the Human Nutrition Laboratory you will have the following measurements taken:
Height, weight, DEXA bone scan, and Quantitative Ultrasound bone scan.

You will be provided with a form you can take to your local Medlab Collection Centre for blood tests. Otherwise if you live locally we can make an appointment for you to return to the Human Nutrition Research Unit at Massey University and the researchers can take the blood samples

We would like to contact you in 2 years, 5 years and 10 years' time to see if anything has changed in terms of your bone health. We will give you a ring or mail out a short questionnaire.

Fasted Blood Sample:
This is a fasted blood sample (no food; but water is allowed), and you will need to have your appointment between 8am and 10am. Trained and certified phlebotomists at either your local Medlab Collection Centre or at the Massey University Human Nutrition Research Unit will take blood samples. You will lie down on a bed or be seated in a chair while blood is taken to avoid risk of injury if you faint. Bruising is rare. The amount of blood taken will be about 20 mL, which should not have any harmful effects.

DEXA Dual-emission X-ray absorptiometry scan:
Measurement involves you lying down on a bed fully clothed in surgical scrubs and having an X ray of your body on the Hologic DEXA machine. This machine is used to estimate bone mineral density and bone mineral content of your hip and lumbar spine (L1-L4) and total body composition. The DEXA has X-ray beams of different energies and while no dose of radiation is harmless this dose is very low and unlikely to cause harm. The total effective dose of radiation to which you will be exposed to is 10.8 microsieverts (μSv), which is much lower than the range normally used in medical diagnostics. To place this in perspective, the amount of radiation you are exposed to during a return flight to the United Kingdom is 100 μSv and from a dental X-ray 50 μSv. This procedure is quick, non-invasive and does not require anaesthetic. The room is private and the staff certified. It should take approximately 15 minutes. Your scan results will be assessed and approved by our consultant Radiologist. If your scan shows a T score of > 2.5 S.D below normal, you will be advised and a copy of the scan, the report from the radiologist and a letter provided to take to your GP to discuss if further investigation is necessary.

If you elect to receive the results of your bone scan and they show abnormalities, later if you seek life or health insurance you may be asked to disclose them by the insurer. Failure to disclose them could invalidate your insurance policy.

Quantitative Ultrasound scan:
Our Achilles Quantitative Ultrasound machine will provide a quick safe and comfortable scan of your non-dominant heel bone using sound-waves. You will feel a warm water filled membrane that hugs your heel during your scan. The procedure is quick; just a few minutes from shoe off to shoe on. We will provide you with a printout of your results, for you to keep.

Time Commitment
We have arranged for you to have blood samples at a Medlab Collection Centre in your town or city, or if you live close to Massey University you can come to our lab. Unfortunately the DEXA is situated at Massey University in Palmerston North so there will be some travel time involved for visit one. It is expected that measurements in the Human Nutrition Research Unit will take 1-1.5 h. Questionnaires and diaries done at home will take a further 70 minutes.

What benefits you will get from participation
You will have contributed to scientific understanding of the influence of lifestyle factors on bone health in post-menopausal women in New Zealand
You will not be charged for any of the measurements conducted for the study
You will be provided a nutrient analysis of your diet from your 3 day diet diaries
You will be reimbursed ($20) for petrol costs
You will get a summary of the study results

This study is supported by a grant from the College of Health Massey University Research Fund.

Data Management
We will keep your name and contact details private and they will be stored in a locked filing cabinet in my office and disposed of in 3 years' time. You will only ever be identified by a code number for any data analysis and research reports.

There are currently other studies on post-menopausal women being undertaken by the researchers at the School of Food and Nutrition, Massey University. If you enjoyed being a part of this study and are happy to have your name and contact details passed on to the lead researcher of a similar study, please let us know. When you have heard about that study you can decide if you want to participate in it or not. Otherwise your details will be kept strictly confidential.

Please also bear in mind that it is not advisable for you to have DEXA scans performed more frequently than once per year. So, if you have already participated in a bone health study recently and had a DEXA scan we would like your permission obtain a copy of your DEXA results in order to avoid you having a second scan.

Participant's Rights
You are under no obligation to accept this invitation. If you decide to participate, you have the right to:
- decline to answer any particular question;
- withdraw from the study at any time;
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- be given access to a summary of the project findings when it is concluded.

Project Contacts
There are several researchers involved in this project; however, if you have any questions about the project or any of the tests and activities planned, please contact the lead researchers in this instance.

Dr Jasmine Thomson
Phone; 06 356 9099 ext 84559
Email; J.A.Thomson@massey.ac.nz

Institute of Food, Nutrition and Human Health
Massey University
Palmerston North

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 17/07. If you have any concerns about the conduct of this research, please contact Dr Lesley Batten, Chair, Massey University Human Ethics Committee: Southern A, telephone 06 356 9099 x 85094, email humanethicsoutha@massey.ac.nz .

Compensation for Injury

If physical injury results from your participation in this study, you should visit a treatment provider to make a claim to ACC as soon as possible. ACC cover and entitlements are not automatic and your claim will be assessed by ACC in accordance with the Accident Compensation Act 2001. If your claim is accepted, ACC must inform you of your entitlements, and must help you access those entitlements. Entitlements may include, but not be limited to, treatment costs, travel costs for rehabilitation, loss of earnings, and/or lump sum for permanent impairment. Compensation for mental trauma may also be included, but only if this is incurred as a result of physical injury.

If your ACC claim is not accepted you should immediately contact the researcher. The researcher will initiate processes to ensure you receive compensation equivalent to that to which you would have been entitled had ACC accepted your claim.

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

School of Food and Nutrition
Massey Institute of Food Science and Technology,
College of Health

Love them Bones Study: Osteoporosis Knowledge, Beliefs & Behaviour Change in Young Women

INFORMATION SHEET

Researcher(s) Introduction
The research group is a team of nutritionists interested in bone health. The lead researcher for this stage of the project is Dr Jasmine Thomson from the School of Food and Nutrition, in conjunction with Elizabeth Reynolds, PhD student and NZ Registered Dietitian. Other researchers include Dr Louise Brough, Dr Janet Weber, Professor Jane Coad, and Professor Marlena Kruger, also from the School of Food and Nutrition, in the College of Health and Dr Mary Jane De Souza from the College of Health and Human Development at Penn State University.

Project Description and Invitation
Osteoporosis is one of the leading healthcare issues worldwide. Osteoporosis is characterised by reduced bone tissue and changes in bone structure resulting in increased fragility and risk of fractures in older adults. It is estimated that about 22% of women over 50 years of age will develop osteoporosis.

Peak bone mass, i.e. maximum bone mineral density and strength, occurs during young adulthood. Therefore, developing some lifestyle habits that help increase peak bone mass when you are 18-25 is an important strategy to reduce your risk of osteoporosis later in life.

However, we know you have a lot of things going on in your life right now, and it is hard to worry about a disease you *could* get when you are old. So we want to investigate a strategy to teach you some facts about osteoporosis and get you engaged in making some changes to your lifestyle that will reduce your risk of getting osteoporosis when you are older. We also want to investigate some of the other things going on in your life that may affect you making some good lifestyle changes.

If you would like to participate please contact Jasmine on 06 951 7559 or email j.a.thomson@massey.ac.nz

Participant Identification and Recruitment
We are recruiting women from the general community in Palmerston North and Wellington Regions. We are advertising the study in local media and social media, Universities, and workplaces. We are recruiting 142 women to participate in the full study.

Inclusion criteria
To become a participant you will need to:

- Be a healthy young woman
- Aged 18-25 years
- Not pregnant
- Live in the Palmerston North and Wellington Regions

Exclusion criteria
Unfortunately you cannot participate if you have been diagnosed with a condition that might affect your bones or absorption of nutrients such as:

- Osteogenesis Imperfecta
- Juvenile Rheumatoid Arthritis
- Type I (insulin dependent) diabetes
- Uncontrolled Thyroid Disease

- Inflammatory Bowel Disease (e.g. Chron's, Ulcerative Colitis, Coeliac Disease)
- Chronic Renal (Kidney) Disease
- Clinically Significant Liver Disease

If you are or have been medically treated with the following:
- Corticosteroid tablets (e.g. prednisone, cortisone) daily for >3 months previously

What is involved?
This assessment will be at the Human Nutrition Research Unit at Massey University in Palmerston North or at the Sport Science and Research Lab at Massey University in Wellington

First we are going to ask you some questions on your lifestyle, diet, and physical activity, next we will ask some questions on how much you already know about osteoporosis. This is not a test so do not study for it, we are simply interested in things you have picked up from friends, family, TV, and internet. You will not be marked on the number of correct answers!

After you have completed the paperwork, we have a new machine that measures your bone quality by ultrasound. The Quantitative Ultrasound transmits and receives sound waves; the intensity and speed of these sound waves are altered by the properties of your bones. Quantitative ultrasound measurements are pretty close to results from medically established methods for diagnosing low bone mineral density. The best part about the Quantitative Ultrasound is that it produces your results pretty much immediately, so you can keep your results after the measurement. We will also like to do a finger prick collection of a few drops of blood to test for presence of anaemia. We have a couple of diaries for you to take home and write about what you eat and drink, and the physical activity that you do each day.

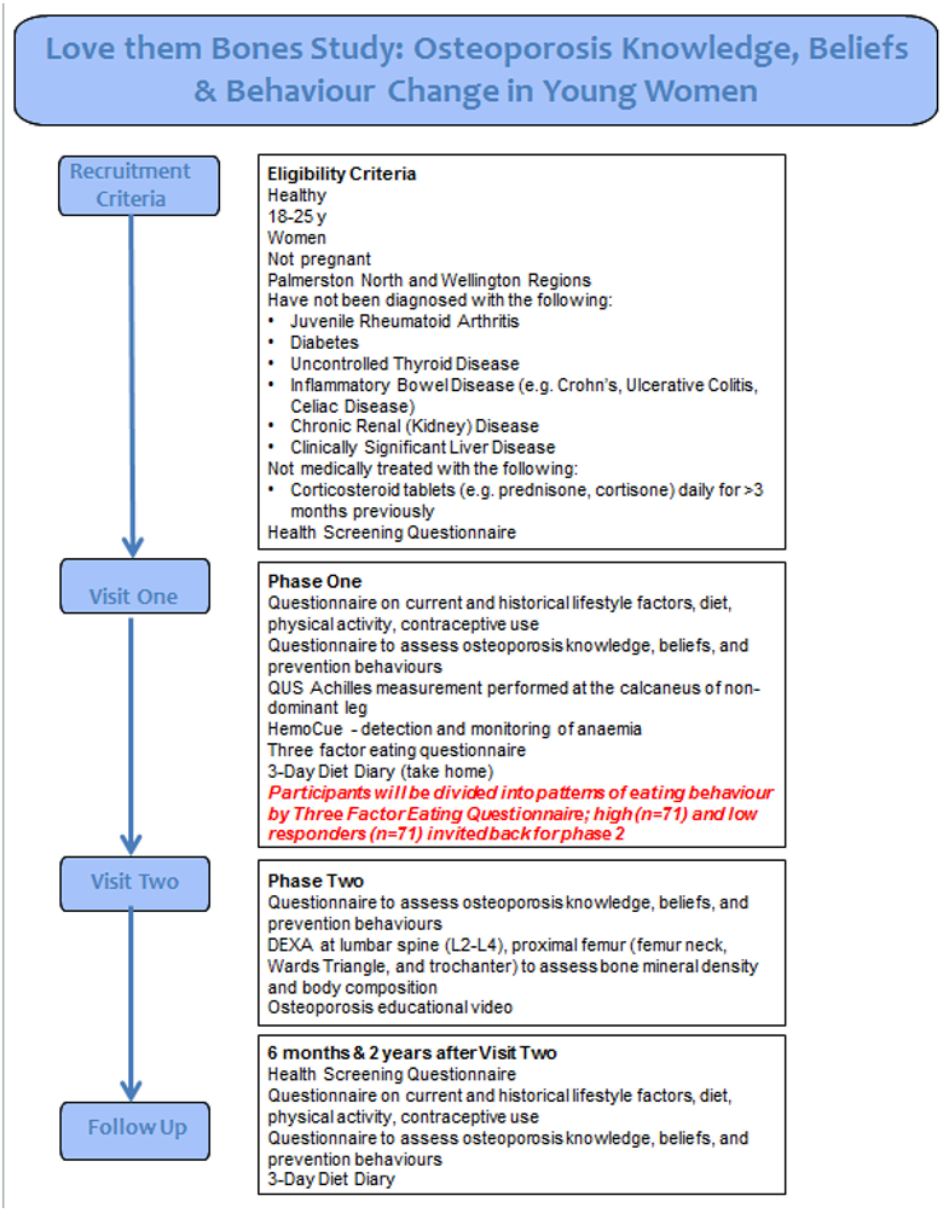
Based on the results from the questionnaires you did we will be asking some of you back for further assessment.

This assessment will be at the Human Nutrition Research Unit at Massey University in Palmerston North.

During the second visit, for those of you asked back we are going to ask you some of the questions from visit one again to see if anything has changed in the meantime. Next we will show you a short video to give you some information on osteoporosis and how to reduce your risk of getting it. Finally we will use a DEXA (Dual-emission X-ray absorptiometry) to measure your bone density, this machine uses very low dose radiation X-rays to measure the bone density of your hip and spine, and also measures your body composition (fat mass, lean mass, and bone mass of your body).

After this education session we would like to invite you to repeat the questionnaires at 6 months and 2 years to see what, if anything has changed about your daily lives in response to learning about osteoporosis and having your bones assessed. The follow-up questionnaires will be done via email or mail. For those of you requesting mail, a postage paid self-addressed envelope will be provided.

We would like to keep in touch and contact you about your bone health in 35 years time.
Members of the bone health team would like to contact you in about 3 decades to see how your lifestyle and bone health has changed with time.



Tests involved for all participants - in more detail

Quantitative Ultrasound bone scan:

Our Achilles Quantitative Ultrasound machine will provide a quick safe and comfortable scan of your non-dominant heel bone using sound-waves. You will feel a warm water filled membrane that hugs your heel during your scan. The procedure is quick; just a few minutes from shoe off to shoe on. We will provide you with a printout of your results, for you to keep.

Finger Prick Blood Sample:

Trained staff will take capillary blood sample from your finger using lancet and HEMOCUE Hb 201+ to measure whole blood Haemoglobin value. We will ask you to sit in a comfortable lounge chair to avoid risk of fainting. The amount of blood taken is only about 2-3 drops, which should not have any harmful effects.

Tests involved for only some participants - in more detail

DEXA Dual-emission X-ray absorptiometry bone scan:
Measurement involves you lying down on a bed fully clothed in surgical scrubs and having an X ray of your body on the Hologic DEXA machine. This machine is used to estimate bone mineral density and bone mineral content of your hip and lumbar spine (L1-L4) and total body composition. The DEXA has X-ray beams of different energies and while no dose of radiation is harmless this dose is very low and unlikely to cause harm. The total effective dose of radiation to which you will be exposed to is 10.8 microsieverts (μSv), which is much lower than the range normally used in medical diagnostics. To place this in perspective, the amount of radiation you are exposed to during a return flight to the United Kingdom is 100 μSv and from a dental X-ray 50 μSv. This procedure is quick, non-invasive and does not require anaesthetic. The room is private and the staff certified. It should take approximately 15 minutes. Your scan results will be assessed and approved by our consultant Radiologist. If your scan shows a T score of > 2.5 S.D below normal, you will be advised and a copy of the scan, the report from the radiologist and a letter provided to take to your GP to discuss if further investigation is necessary.

Although ionising radiation doses from the DEXA are relatively low, it is still ionising radiation exposure, so there is a risk to an unborn child. Therefore we will need to ask you on two separate occasions if you are or think you might be pregnant. We will ask you at the beginning of the study and again immediately before the DEXA scan to sign a form to confirm that you are not pregnant, nor suspect that you might be pregnant. If you are pregnant you will not be able to further participate in the study to avoid the risk from ionising radiation to your unborn child.

If you elect to receive the results of your bone scan and they show abnormalities, later if you seek life or health insurance you may be asked to disclose them by the insurer. Failure to disclose them could invalidate your insurance policy.

Time Commitment
It is expected that visit one will take about an hour. Measurements done for visit two in the Human Nutrition Research Unit will also take about an hour. Questionnaires and diaries done at home will take a further 1-1.5 hours in total. Travel time from Wellington to Palmerston North for visit two for participants who are Wellington residents is approximately 2 h.

What benefits you will get from participation

- You will have contributed to scientific understanding of the influence of lifestyle factors on bone health of young women in New Zealand
- You will not be charged for any of the measurements conducted for the study.
- You will get a copy of your body composition results
- You will be provided a nutrient analysis of your diet from your 3 day diet diaries
- You go into a prize draw to win one voucher to the value of $200 from a chain store of your choice
- You will get a summary of the study results

This study is supported by a grant from the Massey Institute of Food Science and Technology Massey University Research Fund.

Data Management
We will keep your name and contact details private and they will be stored in a locked filing cabinet in my office and disposed of in 35 years' time. You will only ever be identified by a code number for any data analysis and research reports.

Please also bear in mind that it is not advisable for you to have DEXA scans performed more frequently than once per year. So, if you have already participated in a bone health study recently and had a DEXA scan we would like your permission to obtain a copy of your DEXA results from the previous measurement in order to avoid you having a second scan.

Participant's Rights
You are under no obligation to accept this invitation. If you decide to participate, you have the right to:

- decline to answer any particular question;
- withdraw from the study at any time;
- ask any questions about the study at any time during participation;
- provide information on the understanding that your name will not be used unless you give permission to the researcher;
- be given access to a summary of the project findings when it is concluded.

Project Contacts
There are several researchers involved in this project; however, if you have any questions about the project or any of the tests and activities planned, please contact the lead researchers in this instance.

Dr Jasmine Thomson
Phone; 06 356 9099 ext 84559
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Institute of Food, Nutrition and Human Health
Massey University
Palmerston North

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 17/06. If you have any concerns about the conduct of this research, please contact Dr Lesley Batten, Chair, Massey University Human Ethics Committee: Southern A, telephone 06 356 9099 x 85094, email humanethicsoutha@massey.ac.nz .

Compensation for Injury
If physical injury results from your participation in this study, you should visit a treatment provider to make a claim to ACC as soon as possible. ACC cover and entitlements are not automatic and your claim will be assessed by ACC in accordance with the Accident Compensation Act 2001. If your claim is accepted, ACC must inform you of your entitlements, and must help you access those entitlements. Entitlements may include, but not be limited to, treatment costs, travel costs for rehabilitation, loss of earnings, and/or lump sum for permanent impairment. Compensation for mental trauma may also be included, but only if this is incurred as a result of physical injury.

If your ACC claim is not accepted you should immediately contact the researcher. The researcher will initiate processes to ensure you receive compensation equivalent to that to which you would have been entitled had ACC accepted your claim.

Appendix D: Footprint Screening Questionnaire

FOOTPRINT STUDY SCREENING QUESTIONNAIRE

Name

Address

1. How long ago did you experience menopause (had your last period) years ago

2. Have you ever been diagnosed with the following?

	No	Yes
Osteoporosis	○	○
Osteogenesis Imperfecta	○	○
Rheumatoid Arthritis	○	○
Type I (insulin dependent) diabetes	○	○
Thyroid Disease ***which is not under control***	○	○
Inflammatory Bowel Disease (e.g. Crohn's, Ulcerative Colitis, Celiac Disease)	○	○
Chronic Renal (Kidney) Disease	○	○
Clinically Significant Liver Disease	○	○
Eating Disorder (DSM-V)	○	○

3. Are you currently being treated with the following?

	No	Yes
Biphosphonates (e.g. Fosamax, Arrow-Etidronate, Risedronate-Sandoz, Aclasta)	○	○
Hormone Replacement Therapy HRT (Evista, Forteo)	○	○

4. Have you previously been treated with the following?

	No	Yes
Corticosteroid tablets (e.g. prednisone, cortisone) daily for >3 months	○	○

Thank you for taking the time to fill in this screening questionnaire.

The researchers will be in touch with you shortly to let you know if you are eligible for inclusion in this study

Appendix E: Footprint Health Screening Questionnaire

Footprint - Bone Health Questionnaire

Osteoporosis is a disease in which the body loses too much bone density and bones become very brittle and weak so that they break easily.

The first group of questions are about your medical history

1. Personal Information

Name

Participant ID

Date

2. Do you have someone in your immediate family who had a hip fracture or was diagnosed with osteoporosis (parent, grandparent)?

Yes	No	Don't Know
○	○	○

3. Have you ever been diagnosed with the following?

	Yes	No	Don't Know
Stress Fractures	○	○	○
Osteopenia (lower than normal bone density)	○	○	○
Osteoporosis	○	○	○

4. Have you had the following medical procedures?

	Yes	No	Don't Know
Hysterectomy	○	○	○
Gastric Surgery (Gastrectomy, Gastric Bypass)	○	○	○
Chemotherapy for breast cancer	○	○	○
Radiation therapy in the previous year	○	○	○

1

Footprint - Bone Health Questionnaire

Reproductive history

The next group of questions are about your Reproductive History.

5. What was your age at menarche (first started your menstrual periods)?

11 years or younger	12-14 years	15 years or older	Don't Remember
○	○	○	○

6. Have you previously used the oral contraceptive pill?

Yes	No	Don't Know
○	○	○

7. If you have previously used the oral contraceptive pill, please estimate the total number of years you used it? (in years)

8. Have you previously used contraceptive injection (Depo Provera) or implant (Jadelle)?

Yes	No	Don't know
○	○	○

9. Have you ever missed 3 or more menstrual periods in a row (other than start of menopause, during pregnancy, breast feeding, or consecutive use of active contraceptive pill)?

Yes	No	Don't Know
○	○	○

10. What was your age at menopause (please estimate when your menstrual periods stopped entirely)?

11. Are you currently taking Hormone Replacement Therapy (HRT)?

Yes	No	Don't know
◯	◯	◯

12. Have you ever taken Hormone Replacement Therapy (HRT) in the past?

Yes	No	Don't know
◯	◯	◯

If you have had hot flashes please answer the following questions. *Otherwise skip to question 17.*

13. How old were you when you first experienced hot flashes?

14. How old were you when your hot flashes were most severe for you?

15. How would you describe the majority of your hot flashes

Mild (sensation of heat without sweating)	Moderate (sensation of heat with sweating)	Severe (sensation of heat with sweating that disrupts your usual activity)
◯	◯	◯

16. Overall, how long did you have hot flashes?

17. Have you had children?

Yes	No
◯	◯

If you have had children please answer the following questions. *Otherwise skip to question 22.*

18. How many children have you given birth to?

19. What was the average time between pregnancies?

If you breastfed please answer the following questions. *Otherwise skip to question 22.*

20. What was your total duration of breastfeeding?

21. How old were you when you finished breastfeeding last?

Footprint - Bone Health Questionnaire

Eating behaviours

The next group of questions are about your past and present eating behaviours.

22. Have you ever restricted what you eat to purposely lose weight?

Yes	No
○	○

23. If you have dieted in the past, please indicate the number of times you have lost 5kg of more

24. How often did you have cow's milk growing up? Please indicate how often you ate or drank cows milk, such as drinking milk, milky drinks, adding milk to cereal.
Where 1 glass is about 250mL

	didn't have milk	1 glass/day	2 glasses/day	3 glasses/day	4 glasses/day	>4 glasses
Aged >12 years	○	○	○	○	○	○
Aged 14-18 years	○	○	○	○	○	○
Aged 18-25 years	○	○	○	○	○	○

25. Please write down the number of times that you usually eat or drink the items listed below.
e.g. if you drink 1 glass of milk 3 times a week, write 3 in the weekly column

	Daily	**OR** Weekly	**OR** Monthly	**OR** Never/Infrequently
1 cup of tea with milk				
1 cup instant coffee with milk				
1 cup of milk				
1 cup milk drink (latte/flat white, flavoured milk, milk milo, soy drink)				

	Daily	**OR** Weekly	**OR** Monthly	**OR** Never/Infrequently
1 cup milk with cereal/porridge	☐	☐	☐	☐
1 slice of bread	☐	☐	☐	☐
1 matchbox portion of hard cheese (e.g. cheddar)	☐	☐	☐	☐
1 matchbox portion of soft cheese (e.g. camembert, brie)	☐	☐	☐	☐
1 tablespoon of fresh cheese (e.g. cottage cheese, ricotta, sour cream)	☐	☐	☐	☐
1 pottle of yoghurt	☐	☐	☐	☐
1/2 cup dairy-based pudding (e.g. ice cream, custard, rice pudding)	☐	☐	☐	☐
Canned fish with bones (e.g. sardines, salmon)	☐	☐	☐	☐
1/2 cup green vegetables	☐	☐	☐	☐
1 tablespoon of hummus	☐	☐	☐	☐
3/4 cup bean curd/tofu	☐	☐	☐	☐
1 handful peanuts or almonds	☐	☐	☐	☐
1 handful of other nuts (hazelnuts, brazil, walnuts)	☐	☐	☐	☐
1 cup of cheese sauce based dish (e.g. macaroni cheese)	☐	☐	☐	☐
1 bar chocolate (50g) or two squares from a family sized block of chocolate (50g) (not bitter/dark)	☐	☐	☐	☐
1 fillet of oily fish (kahawai, pilchard, salmon, warehou, alfonsino, freshwater eel, fresh tuna)	☐	☐	☐	☐

26. What type of milk do you mostly use at the moment?

Milk type, brand.

<footer>6</footer>

27. What type of yoghurt do you mostly use at the moment?
Yoghurt type, brand.

28. Do you try to choose foods with added of fortified

	Yes	No
Calcium?	○	○
Vitamin D?	○	○

29. If you choose foods with added calcium or vitamin D, please list them

30. Do you regularly take dietary supplements?

Yes	No
○	○

31. If you take Calcium supplements, please provide some details below
Brand, amount (tablets/day), length of time (years)

32. If you take Vitamin D supplements, please provide some details below
Brand, amount (tablets/day), length of time (years)

33. If you take other vitamin and mineral or sports supplements please list them

34. This question is about caffeine. How often do you consume brewed or barista coffee in a day? *(e.g. plunger coffee at home or cafe' espresso, macchiato, latte, flat white, cappuccino)*

<1 per day	1-2 per day	3-4 per day	4-5 per day	6-7 per day	>7 per day
◯	◯	◯	◯	◯	◯

35. Please write down the number servings per week of alcohol that you currently consume on average from the following options.

	Number of servings
Stubbie of beer (375mL)	
Glass of alcoholic cider (250mL)	
Small glass of wine (100mL)	
Single shot of spirits (30mL)	
RTD (Ready to Drink) (335mL) (x2 as there are 2 servings in an RTD bottle)	

36. How often did you previously drink more than 6 servings in one drinking session?

The amount you usually poured in your drink might have been larger than the serving sizes given above, please try to estimate the number of times you drank more than 6 of the serving sizes given above.

	Never	<Monthly	Monthly	Weekly	Almost daily
In your 20's	◯	◯	◯	◯	◯
In your 30's	◯	◯	◯	◯	◯
In your 40's	◯	◯	◯	◯	◯

Footprint - Bone Health Questionnaire

Physical activity

For the next group of questions we want to know about your past and present physical activity.

For the following questions please indicate your history of physical activities

We are interested in all types of physical activities such as part of your everyday activities e.g. walking to school, riding your bicycle to the shops, gardening, physical jobs, as well as sports.

Please answer the following questions providing the year age you began and the age you finished the activity. For any activities you are still taking part in please select "Ongoing" for the age you finished this activity.

For any activities that you have not participated in please leave these questions with no response.

37. For any of the below athletic activities you have participated in pleas the age you began and finished these activities.

For any athletic activities not listed below please list these (with the start in the other section below.

	Age you started this activity	Age you finished th
Jumps		
Middle distance		
Throws		
Sprints/hurdles		
Junior/little athletics		

Other (please specify including the age that you began this activity and the age that you finished)

38. Bat, stick and ball sports:

	Age you started this activity	Age you finished th
Baseball		
Cricket		
Field Hockey		
Golf (walking)		
Golf (electric cart)		
Ice hockey		
Softball		
T-ball		

Other (please specify including the age that you began this activity and the age that you finished)

39. Bowling activities:

	Age you started this activity	Age you finished th
Lawn		
Ten-pin		

Other (please specify including the age you began this activity and the age that you finished)

40. Climbing activities:

	Age you started this activity	Age you finished th
Rockwall		
Gym based		
Bouldering		

Other (please specify including the age that you began this activity and the age that you finished)

41. Cycling:

	Age you started this activity	Age you finished th
Recreational		
Transport/purpose		
Sprint		
Endurance		

Other (please specify including the age that you began this activity and the age that you finished)

42. Dance:

	Age you started this activity	Age you finished th
Ballet		
Ballroom		
Cheerleading		
Contemporary		
Highland		
Hiphop		
Jazz		
Line dancing		
Square dancing		
Tap		

Other (please specify including the age that you began this activity and the age that you finished)

43. Football sports:

	Age you started this activity	Age you finished th
Australian rules		
Flag football		
Oz tag		
Rugby league		
Rugby union		
Soccer		
Touch football		

Other (please specify including the age that you began this activity and the age that you finished)

44. Gymnastics:

	Age you started this activity	Age you finished th
Acrobatics		
Gymnastics artistic		
Gymnastics developmental		
Gymnastics rhythmic		
Trampolining		

Other (please specify including the age that you began this activity and the age that you finished)

45. Gym/workout activities:

	Age you started this activity	Age you finished th
Aerobics high impact		
Aerobics low impact		
Boot camp		
Cross fit		
Elliptical trainer		
Personal trainer		
Pilates		
Resistance training heavy upper and lower		
Resistance training heavy upper body		
Resistance training heavy lower body		
Resistance training light		
Resistance training body weight		
Skipping		
Spin class		
StairMaster		
Treadmill running		
Treadmill walking		
Yoga		
Zumba		

Other (please specify including the age that you began this activity and the age that you finished)

46. Household activities:

	Age you started this activity	Age you finished th
Heavy indoor work (lifting furniture, carrying buckets etc)		
Heavy gardening (digging, carrying heavy loads)		

Other (please specify including the age that you began this activity and the age that you finished)

47. Jumping activities:

	Age you started this activity	Age you finished th
Jump rope		
Skipping		
Plyometrics		

Other (please specify including the age that you began this activity and the age that you finished)

48. Lifting activities:

	Age you started this activity	Age you finished th
Power lifting		
Resistance training heavy		
Resistance training light		
Body weight exercises (eg pushup, chinup, dips etc)		

Other (please specify including the age that you began this activity and the age that you finished)

49. Martial arts:

	Age you started this activity	Age you finished th
Akido		
Boxing		
Hapkido		
Judo		
Karate		
Kick boxing		
Kung fun		
Tae kwon do		
Tai chi		
Wrestling		

Other (please specify including the age you began this activity and the age that you finished)

50. Occupational activities:

	Age you started this activity	Age you finished th
Light-moderate (on feet for at least 5h/day)		
Heavy work (landscaping, construction, chopping, landscaping, garden maintenance etc)		

Other (please specify including the age that you began this activity and the age that you finished)

51. Racquet/racket sports:

	Age you started this activity	Age you finished th
Badminton		
Ping pong/table tennis		
Racket ball		
Squash		
Tennis		

Other (please specify including the age that you began this activity and the age that you finished)

52. Riding:

	Age you started this activity	Age you finished th
Horse riding		
Motorcross		

Other (please specify including the age that you began this activity and the age that you finished)

53. Jogging/running activities:

	Age you started this activity	Age you finished th
Beach sprint		
Cross country		
Long distance/marathon		
Middle distance		
Recreational jogging		
Sprint		

Other (please specify including the age that you began this activity and the age that you finished)

54. Skating activities:

	Age you started this activity	Age you finished th
Ice hockey		
Recreational ice skating		
Figure skating		
Roller blading		
Roller derby		
Roller skating		
Foot/kick soccer		
Skateboard		

Other (please specify including the age that you began this activity and the age that you finished)

55. Snowsports:

	Age you started this activity	Age you finished th
Cross country ski/biathlon		
Shoeing		
Skiing		
Sledding/tobogganing		
Snowboarding		

Other (please specify including the age you began this activity and the age that you finished)

56. Surfing sports:

	Age you started this activity	Age you finished th
Kite surfing		
Competitive surfing		
Recreational surfboarding		
Windsurfing		

Other (please specify including the age that you began this activity and the age that you finished)

57. Swimming/pool based activities:

	Age you started this activity	Age you finished th
Diving		
Swimming recreational		
Swimming sprint competitive		
Swimming training laps		
Scuba		
Snorkeling		
Synchronised swimming		
Water aerobics		
Water polo		

Other (please specify including the age that you began this activity and the age that you finished)

58. Throwing and catching sports:

	Age you started this activity	Age you finished th
Basketball		
Beach volleyball		
Handball		
Netball		
Ultimate frisbee		
Volleyball		

Other (please specify including the age that you began this activity and the age that you finished)

59. Triathlons:

	Age you started this activity	Age you finished th
Junior/Recreational		
Competitive (including training)		

Other (please specify including the age that you began this activity and the age that you finished)

60. Walking activities:

	Age you started this activity	Age you finished th
Hiking		
Pedestrian/leisure/walk to work		
Power walking		
Race walking		
Stair climbing		
Exercise/competition		

Other (please specify including the age that you began this activity and the age that you finished)

61. Water sports:

	Age you started this activity	Age you finished th
Body boarding		
Canoeing		
Dragon boat		
Kayaking		
Kite surfing		
Standing paddle board		
Rowing		
Sailing		
Sculling		
Surf boarding recreational		
Surf boarding competitive		
Wake boarding		
Water skiing		
Windsurfing		

Other (please specify including the age that you began this activity and the age that you finished)

62. Please list the sports or other physical activities you participated in regularly during the last 12 months and indicate the average frequency (sessions per week).

Please be as specific as possible e.g. walking, tramping, rugby, horseback riding, light or heavy gardening etc

Eg:
Cycling to school/university/work, twice per day (30 minutes) 3 times per week

The next group of questions are about your past and present lifestyle behaviours

63. Vitamin D is synthesised in the skin from exposure to UV light from the sun. Please indicate your past and present sun exposure in answer to the questions below.

	Yes	No
From childhood to your early 20's were you usually covered up (sunscreen and clothing) to limit exposure to sun?	◯	◯
Currently, do you usually cover up (sunscreen and clothing) to limit exposure to sun?	◯	◯

64. During the past summer, how long on average would you spend outdoors without sun protection?

	<15 minutes	15-30 minutes	>30 minutes
On weekdays how many minutes per day do you usually spend outdoors between the hours of 10am-3pm with your arms EXPOSED to the sun	◯	◯	◯
On the weekends how many minutes per day do you usually spend outdoors between the hours of 10am-3pm with your arms EXPOSED to the sun?	◯	◯	◯

65. Which parts of your body do you usually cover up between the hours of 10am-3pm when outdoors.

Tick all parts that are covered up with sunscreen, moisturiser or makeup with SPF, and clothing.

- [ ] Head
- [ ] Face
- [ ] Back and Shoulders
- [ ] Arms
- [ ] Hands
- [ ] Legs
- [ ] All bare skin

66. Do you currently smoke 1 or more pack/day?

No	Yes
○	○

67. Have you ever smoked 1 or more pack/day in the past?

No	Yes
○	○

68. Are you regularly exposed to second hand smoke, for example someone in your house or a house you visit smokes?

No	Yes
○	○

Footprint - Bone Health Questionnaire

Demographic questions

Finally, we would like to ask you some demographic questions.

69. Which ethnic group or groups do you identify with? *(tick all that apply)*

- ◯ New Zealand European
- ◯ Māori
- ◯ Samoan
- ◯ Cook Islands Māori
- ◯ Tongan
- ◯ Niuean
- ◯ Chinese
- ◯ Indian
- ◯ Other (please specify)

70. What is your highest level of education you have achieved?

71. What is your current age?

72. Are you currently

A student	Employed part-time	Employed full-time	Self employed	Unemployed	Retired
◯	◯	◯	◯	◯	◯

Thank you so much for answering the Bone Health Questionnaire.

Appendix F: Footprint Three-Factor Eating Questionnaire

Footprint - Three Factor Eating Questionnaire

Part I

This questionnaire is designed to assess different patterns of eating behaviour.

There are no right or wrong answers. We all have different experiences which will influence how we feel. After reading each statement, select if the statement is **True** or **False** for you

1. Personal Information

Name

Participant ID

Date

2. When I smell a delicious food, I find it very difficult to keep from eating it, even if I have just finished eating 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 meals and two snacks day.

- ◯ True
- ◯ False

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

- ◯ True
- ◯ False

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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

9. Since I am often hungry, I sometimes wish that while I am 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 weight loss diets more than once.

- ◯ True
- ◯ False

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

- ◯ 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 foods.

- ◯ True
- ◯ False

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

- ◯ True
- ◯ False

17. It is not hard for me to leave some food on my plate after I have finished eating.

- ◯ True
- ◯ False

18. At certain times of the day, I get hungry because I have gotten used to eating 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 sad or depressed, 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 really delicious food, I often get so hungry that I have to eat it right away

- ◯ True
- ◯ False

24. I often stop eating when I am not really full as a conscious way 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

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 way 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

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

- ◯ 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

Footprint - Three Factor Eating Questionnaire

Part II

Please answer the following questions by selecting 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 5 kg affect the way you live your life?

Not at all	Slightly	Moderately	Very Much
○	○	○	○

40. How often do you feel hungry?

Only at meal times	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
○	○	○	○

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 your food choices and what you eat?

Not at all	Slightly	Moderately	Extremely
○	○	○	○

44. How frequently do you avoid stocking your pantry with tempting foods?

Almost never	Seldom	Usually	Almost always
○	○	○	○

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

Unlikely	Slightly unlikely	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 would you skip dessert offered 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?

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

52. To what extent does this statement describe your eating behavior ? ‘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.’

1	2	3	4
Not like me	A little like me	Pretty good description of me	Describes me perfectly
◯	◯	◯	◯

Thank you for completing the survey. Please check to be sure you answered all of the questions

Appendix G: Love Them Bones Bone Health Questionnaire

Love Them Bones - About You

Osteoporosis is a disease in which the body loses too much bone density and bones become very brittle and weak so that they break easily.

The first group of questions are about your medical history

1. Personal Information

Name

Participant ID

Date

2. Do you have someone in your immediate family who had a hip fracture or was diagnosed with osteoporosis (parent, grandparent)?

Yes	No	Don't Know
◯	◯	◯

3. Have you ever been diagnosed with the following?

	Yes	No	Don't Know
Stress Fractures	◯	◯	◯
Osteopenia (lower than normal bone density)	◯	◯	◯
Osteoporosis	◯	◯	◯

4. Have you had the following medical procedures?

	Yes	No	Don't Know
Hytserectomy	◯	◯	◯
Gastric Surgery (Gastrectomy, Gastric Bypass)	◯	◯	◯
Chemotherapy for breast cancer	◯	◯	◯
Radiation therapy in the previous year	◯	◯	◯

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5. What is your age?

6. The next group of questions are about anthropometry, your body measurements and proportions.

	kg
What is your current weight?	
What is your highest weight at your present height? (excluding pregnancy)	
What is your lowest weight at your present height?	
What is your desired weight?	

Love Them Bones - About You

Reproductive history

The next group of questions are about your Reproductive History.

7. What was your age at menarche (first started your menstrual periods)?

11 years or younger	12-14 years	15 years or older	Don't Remember
○	○	○	○

8. Did your first menstrual period come naturally (by itself)?

Yes	No	Don't Know
○	○	○

9. At present do you have normal menstruation (regularly monthly period)?

Yes	No	Don't Know	I'm pregnant
○	○	○	○

10. When was your last period?

0-4 weeks	1-2 months	3-4 months	5 months or more
○	○	○	○

11. Are your periods regular (28 - 34 day cycle)?

Yes most of the time	No mostly not
○	○

12. How many days do you normally bleed?

1-2 days	3-4 days	5-6 days	7-8 days	9 or more
○	○	○	○	○

13. Have you ever had problems with heavy menstrual bleeding?

Yes	No	Don't Know
○	○	○

14. Have you ever missed 3 or more menstrual periods in a row (other than start of menopause, during pregnancy, breast feeding, or consecutive use of active contraceptive pill)?

Yes	No	Don't Know
○	○	○

15. Approximately how many periods have you had in the past year?

>11	9-11	6-8	3-5	0-2	Don't Know
○	○	○	○	○	○

16. Have you previously used the oral contraceptive pill?

Yes	No	Don't Know
○	○	○

If you have used the oral contraceptive pill please answer the following questions.
Otherwise skip to question 19.

17. If you have previously used the oral contraceptive pill, please estimate the total number of years you used it? (in years)

18. Why do/did you use the oral contraceptive pill? You can choose more than one answer.

	Yes	No
Birth Control	☐	☐
Reduce menstrual pains	☐	☐
Reduce bleeding	☐	☐
Regulate menstrual cycle	☐	☐
Otherwise menstruation stops	☐	☐
Other	☐	☐

Other (please specify)

19. Have you previously used contraceptive injection (Depo Provera) or implant (Jadelle)?

Yes	No
○	○

20. Have you had children?

Yes	No
○	○

If you have had children please answer the following questions. *Otherwise skip to question 25.*

21. How many children have you given birth to?

22. What was the average time between pregnancies? (Prompt: If you are unsure, enter the age gap between your children).

If you breast fed please answer the following questions. *Otherwise skip to question 25.*

23. What was your total duration of breast feeding?

24. How old were you when you finished breast feeding the last time?

The next group of questions are about your past and present eating behaviours.

25. Have you ever restricted what you eat to purposely lose weight?

Yes	No
○	○

26. If you have dieted in the past, please indicate the number of times you have lost 5kg or more

27. How often did you have cow's milk growing up? Please indicate how often you had cows milk, such as drinking milk, milky drinks, adding milk to cereal.
Where 1 glass is about 250 mL

	didn't have milk	1 glass/day	2 glass/day	3 glass/day	4 glass/day	> 4 glass
Aged >12 years	○	○	○	○	○	○
Aged 14 - 18 years	○	○	○	○	○	○
Aged 18 - 25 years	○	○	○	○	○	○

28. What type of milk do you mostly use at the moment? (Brand, colour of top e.g.: anchor, full-fat, dark blue top)

29. What type of yoghurt do you mostly use at the moment?

Love Them Bones - About You

30. Please write down the number of times that you usually eat or drink the items listed below.
e.g. if you drink 1 glass of milk 3 times a week, write 3 in the weekly column

	Daily	**OR** Weekly	**OR** Monthly	**OR** Never/Infrequently
1 cup of tea with milk				
1 cup instant coffee with milk				
1 cup of milk				
1 cup milk drink (latte/flat white, flavoured milk, milk milo, soy drink)				
1 cup milk with cereal/porridge				
1 slice of bread				
1 matchbox portion of hard cheese (e.g. cheddar)				
1 matchbox portion of soft cheese (e.g. camembert, brie)				
1 tablespoon of fresh cheese (e.g. cottage cheese, ricotta, sour cream)				
1 pottle of yoghurt				
1/2 cup dairy-based pudding (e.g. ice cream, custard, rice pudding)				
Canned fish with bones (e.g. sardines, salmon)				
1/2 cup green vegetables				
1 tablespoon of hummus				
3/4 cup bean curd/tofu				

	Daily	**OR** Weekly	**OR** Monthly	**OR** Never/Infrequently
1 handful peanuts or almonds				
1 handful of other nuts (hazelnuts, brazil, walnuts)				
1 cup of cheese sauce based dish (e.g. macaroni cheese)				
1 bar chocolate (50g) or two squares from a family sized block of chocolate (50g) (not bitter/dark)				
1 fillet of oily fish (kahawai, pilchard, salmon, warehou, alfonsino, freshwater eel, fresh tuna)				

31. Do you try to choose foods with added of fortified

	Yes	No
Calcium?	◯	◯
Vitamin D?	◯	◯

32. If you choose foods with added calcium or vitamin D, please list them

33. Do you regularly take vitamin and mineral or sports supplements?

Yes	No
◯	◯

34. If you take Calcium supplements, please provide some details below
Brand, amount (tablets/day), length of time (years)

35. If you take Vitamin D supplements, please provide some details below
Brand, amount (tablets/day), length of time (years)

36. If you take other vitamin and mineral or sports supplements please list them

37. This question is about caffeine. How often do you consume brewed or barista coffee in a day?*(e.g. plunger coffee at home or cafe' espresso, macchiato, latte, flat white, cappuccino)*

<1 per day	1-2 per day	3-4 per day	4-5 per day	6-7 per day	>7 per day
○	○	○	○	○	○

38. Please write down the number servings per week of alcohol that you currently consume on average from the following options.

	Number of servings
Stubbie of beer (375mL)	
Glass of alcoholic cider (250mL)	
Small glass of wine (100mL)	
Single shot of spirits (30mL)	
RTD (Ready to Drink) (335mL)	

39. Thinking back to your teens and 20's, how often did you drink > 6 drinks in one session?

The amount you usually poured in your drink might have been larger than the serving sizes given above, please try to estimate the number of times you drank more than 6 of the serving sizes given above

	Never	< Monthly	Monthly	Weekly	Almost Daily
In your teens	○	○	○	○	○
In your 20s	○	○	○	○	○

Love Them Bones - About You

Physical activity

For the next group of questions we want to know about your past and present physical activity.

For the following questions please indicate your history of physical activities

We are interested in all types of physical activities such as part of your everyday activities e.g. walking to school, riding your bicycle to the shops, gardening, physical jobs, as well as sports.

Please answer the following questions providing the year age you began and the age you finished the activity. For any activities you are still taking part in please select "Ongoing" for the age you finished this activity.

For any activities that you have not participated in please leave these questions with no response.

40. For any of the below athletic activities you have participated in please indicate the age you began and finished these activities.

For any athletic activities not listed below please list these (with the start and end age) in the other section below.

	Age you started this activity	Age you finished this activity
Jumps		
Middle distance		
Throws		
Sprints/hurdles		
Junior/little athletics		

Other (please specify including the age that you began this activity and the age that you finished)

41. Bat, stick and ball sports:

	Age you started this activity	Age you finished this activity
Baseball		
Cricket		
Field Hockey		
Golf (walking)		
Golf (electric cart)		
Ice hockey		
Softball		
T-ball		

Other (please specify including the age that you began this activity and the age that you finished)

42. Bowling activities:

	Age you started this activity	Age you finished this activity
Lawn		
Ten-pin		

Other (please specify including the age you began this activity and the age that you finished)

43. Climbing activities:

	Age you started this activity	Age you finished this activity
Rockwall		
Gym based		
Bouldering		

Other (please specify including the age that you began this activity and the age that you finished)

44. Cycling:

	Age you started this activity	Age you finished this activity
Recreational		
Transport/purpose		
Sprint		
Endurance		

Other (please specify including the age that you began this activity and the age that you finished)

45. Dance:

	Age you started this activity	Age you finished this activity
Ballet		
Ballroom		
Cheerleading		
Contemporary		
Highland		
Hiphop		
Jazz		
Line dancing		
Square dancing		
Tap		

Other (please specify including the age that you began this activity and the age that you finished)

46. Football sports:

	Age you started this activity	Age you finished this activity
Australian rules		
Flag football		
Oz tag		
Rugby league		
Rugby union		
Soccer		
Touch football		

Other (please specify including the age that you began this activity and the age that you finished)

47. Gymnastics:

	Age you started this activity	Age you finished this activity
Acrobatics		
Gymnastics artistic		
Gymnastics developmental		
Gymnastics rhythmic		
Trampolining		

Other (please specify including the age that you began this activity and the age that you finished)

48. Gym/workout activities:

	Age you started this activity	Age you finished this activity
Aerobics high impact		
Aerobics low impact		
Boot camp		
Cross fit		
Elliptical trainer		
Personal trainer		
Pilates		
Resistance training heavy upper and lower		
Resistance training heavy upper body		
Resistance training heavy lower body		
Resistance training light		
Resistance training body weight		
Skipping		
Spin class		
StairMaster		
Treadmill running		
Treadmill walking		
Yoga		
Zumba		

Other (please specify including the age that you began this activity and the age that you finished)

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49. Household activities:

	Age you started this activity	Age you finished this activity
Heavy indoor work (lifting furniture, carrying buckets etc)		
Heavy gardening (digging, carrying heavy loads)		

Other (please specify including the age that you began this activity and the age that you finished)

50. Jumping activities:

	Age you started this activity	Age you finished this activity
Jump rope		
Skipping		
Plyometrics		

Other (please specify including the age that you began this activity and the age that you finished)

51. Lifting activities:

	Age you started this activity	Age you finished this activity
Power lifting		
Resistance training heavy		
Resistance training light		
Body weight exercises (eg pushup, chinup, dips etc)		

Other (please specify including the age that you began this activity and the age that you finished)

52. Martial arts:

	Age you started this activity	Age you finished this activity
Akido		
Boxing		
Hapkido		
Judo		
Karate		
Kick boxing		
Kung fun		
Tae kwon do		
Tai chi		
Wrestling		

Other (please specify including the age you began this activity and the age that you finished)

53. Occupational activities:

	Age you started this activity	Age you finished this activity
Light-moderate (on feet for at least 5h/day)		
Heavy work (landscaping, construction, chopping, landscaping, garden maintenance etc)		

Other (please specify including the age that you began this activity and the age that you finished)

54. Racquet/racket sports:

	Age you started this activity	Age you finished this activity
Badminton		
Ping pong/table tennis		
Racket ball		
Squash		
Tennis		

Other (please specify including the age that you began this activity and the age that you finished)

55. Riding:

	Age you started this activity	Age you finished this activity
Horse riding		
Motorcross		

Other (please specify including the age that you began this activity and the age that you finished)

56. Jogging/running activities:

	Age you started this activity	Age you finished this activity
Beach sprint		
Cross country		
Long distance/marathon		
Middle distance		
Recreational jogging		
Sprint		

Other (please specify including the age that you began this activity and the age that you finished)

57. Skating activities:

	Age you started this activity	Age you finished this activity
Ice hockey		
Recreational ice skating		
Figure skating		
Roller blading		
Roller derby		
Roller skating		
Foot/kick soccer		
Skateboard		

Other (please specify including the age that you began this activity and the age that you finished)

58. Snowsports:

	Age you started this activity	Age you finished this activity
Cross country ski/biathlon		
Shoeing		
Skiing		
Sledding/tobogganing		
Snowboarding		

Other (please specify including the age you began this activity and the age that you finished)

59. Surfing sports:

	Age you started this activity	Age you finished this activity
Kite surfing		
Competitive surfing		
Recreational surfboarding		
Windsurfing		

Other (please specify including the age that you began this activity and the age that you finished)

60. Swimming/pool based activities:

	Age you started this activity	Age you finished this activity
Diving		
Swimming recreational		
Swimming sprint competitive		
Swimming training laps		
Scuba		
Snorkeling		
Synchronised swimming		
Water aerobics		
Water polo		

Other (please specify including the age that you began this activity and the age that you finished)

61. Throwing and catching sports:

	Age you started this activity	Age you finished this activity
Basketball		
Beach volleyball		
Handball		
Netball		
Ultimate frisbee		
Volleyball		

Other (please specify including the age that you began this activity and the age that you finished)

62. Triathlons:

	Age you started this activity	Age you finished this activity
Junior/Recreational		
Competitive (including training)		

Other (please specify including the age that you began this activity and the age that you finished)

63. Walking activities:

	Age you started this activity	Age you finished this activity
Hiking		
Pedestrian/leisure/walk to work		
Power walking		
Race walking		
Stair climbing		
Exercise/competition		

Other (please specify including the age that you began this activity and the age that you finished)

64. Water sports:

	Age you started this activity	Age you finished this activity
Body boarding		
Canoeing		
Dragon boat		
Kayaking		
Kite surfing		
Standing paddle board		
Rowing		
Sailing		
Sculling		
Surf boarding recreational		
Surf boarding competitive		
Wake boarding		
Water skiing		
Windsurfing		

Other (please specify including the age that you began this activity and the age that you finished)

65. Please list the sports or other physical activities you participated in regularly during the last 12 months and indicate the average frequency (sessions per week).

Please be as specific as possible e.g. walking, tramping, rugby, horseback riding, light or heavy gardening etc

Eg:
Cycling to school/university/work, twice per day (30 minutes) 3 times per week

Love Them Bones - About You

The next group of questions are about your past and present lifestyle behaviours

66. Vitamin D is synthesised in the skin from exposure to UV light from the sun. Please indicate your past and present sun exposure in answer to the questions below.

	Never	Seldom	Sometimes	Often	Always
During your childhood were you usually covered up (sunscreen and clothing) to limit exposure to sun ?	○	○	○	○	○
As an adult, do you you usually cover up (sunscreen and clothing) to limit exposure to sun?	○	○	○	○	○

67. During the past summer, how long on average would you spend outdoors without sun protection?

	<15 minutes	15-30 minutes	>30 minutes
On weekdays how many minutes per day do you usually spend outdoors between the hours of 10am-3pm with your arms EXPOSED to the sun	○	○	○
On the weekends how many minutes per day do you usually spend outdoors between the hours of 10am-3pm with your arms EXPOSED to the sun?	○	○	○

Thank you so much for answering the Bone Health Questionnaire

Appendix H: Love them Bones Three-Factor Eating Questionnaire

Love Them Bones - Three Factor Eating Questionnaire

Part I

This questionnaire is designed to assess different patterns of eating behaviour.

There are no right or wrong answers. We all have different experiences which will influence how we feel. After reading each statement, select if the statement is True or False for you

1. Personal Information

Name

Participant ID

Date

2. When I smell a delicious food, I find it very difficult to keep from eating it, even if I have just finished eating 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 meals and two snacks day.

- ◯ True
- ◯ False

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

- ◯ True
- ◯ False

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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

9. Since I am often hungry, I sometimes wish that while I am 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 weight loss diets more than once.

- ◯ True
- ◯ False

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

- ◯ 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 foods.

- ◯ True
- ◯ False

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

- ◯ True
- ◯ False

17. It is not hard for me to leave some food on my plate after I have finished eating.

- ◯ True
- ◯ False

18. At certain times of the day, I get hungry because I have gotten used to eating 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 sad or depressed, 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 really delicious food, I often get so hungry that I have to eat it right away

- ◯ True
- ◯ False

24. I often stop eating when I am not really full as a conscious way 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

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 way 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

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

- ◯ 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

Love Them Bones - Three Factor Eating Questionnaire

Part II

Please answer the following questions by selecting 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 5 kg affect the way you live your life?

Not at all	Slightly	Moderately	Very Much
○	○	○	○

40. How often do you feel hungry?

Only at meal times	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
○	○	○	○

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 your food choices and what you eat?

Not at all	Slightly	Moderately	Extremely
○	○	○	○

44. How frequently do you avoid stocking your pantry with tempting foods?

Almost never	Seldom	Usually	Almost always
○	○	○	○

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

Unlikely	Slightly unlikely	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 would you skip dessert offered 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?

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 behavior ? ‘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.’

1	2	3	4
Not like me	A little like me	Pretty good description of me	Describes me perfectly
○	○	○	○

Thank you for completing the survey. Please check to be sure you answered all of the questions

Appendix I: Footprint and Love them Bones 3-Day-diet-diary

MASSEY UNIVERSITY
COLLEGE OF HEALTH
TE KURA HAUORA TANGATA

School of Food and Nutrition
Massey Institute of Food Science and Technology,
College of Health

Footprint/Love Them Bones Study

3 DAY DIET RECORD

INSTRUCTIONS:
Please record all foods and drinks soon after they are consumed so you don't forget and list only one food item per line.

Record your diet intake for 3 d; including two weekdays and one weekend day.

Be as specific as possible when describing each food/meal or drink/beverage, the way it was prepared or cooked (if it was cooked), and the amount that you ate or drank. Include methods used to prepare the food, *for example: fresh, frozen, stewed, fried, baked, canned, broiled, raw or braised.* For canned foods indicate the liquid in which it was canned and the amount of this that you ate or if you drained off the liquid, *for example: heavy syrup, light syrup, fruit juice, spring water, vegetable oil, brine.* Record the amounts of oils and condiments you add and use in cooking *for example: butter and spreads, vegetable oils, salad dressing, etc*. Remember to record water (tap or bottled) and other beverages.

Remember to report only the amount that you actually ate, not the total amount prepared. Record all amounts in household measures, *for example: g, mL, tablespoon (tbsp) (= 15mL), teaspoon (tsp) (=5mL), cups (=250mL), slices or units (described on the packet).* Include brand names whenever possible, or bring in the Nutrition Label from pre-packaged meals. Do not alter your normal diet during the time you keep this diary.

SUBJECT ID: _____ Day of the Week: _____ Date: _____

TIME	**FOOD ITEM** and **METHOD of PREPARATION**	**AMOUNT** EATEN

SUBJECT ID: _____ Day of the Week: _____ Date: _____

TIME	**FOOD ITEM** and **METHOD of PREPARATION**	**AMOUNT** EATEN

SUBJECT ID: _____ Day of the Week: _____ Date: _____

TIME	**FOOD ITEM** and **METHOD of PREPARATION**	**AMOUNT** EATEN

Day of the Week: _____ Date: _____

TIME	**FOOD ITEM** and **METHOD of PREPARATION**	**AMOUNT** EATEN

Appendix G: Chi-Square associations Between Meeting NRVs and Meeting EAGs

	Fruit	Vegetables	Grain	Calcium-Rich	Protein-Rich
Fibre	Chi-square = 15.25 Df= 1 *P*= <0.001	Chi-square = 5.39 Df = 1 *P*=0.020	Chi-square = 1.087 Df = 1 *P*=0.969	Chi-square = 1.030 Df = 1 *P*=0.310	Chi-square = 0.584 Df = 1 *P*=0.445
Folate	Chi-square = 2.999 Df = 1 *P*=0.083	Chi-square = 2.152 Df = 1 *P*=0.142	Chi-square = 0.183 Df = 1 *P*=0.669	Chi-square = 4.444 Df = 1 *P*=0.035	Chi-square = 1.415 Df = 1 *P*=0.234
Thiamin	Chi-square = 0.887 Df = 1 *P*=0.346	Chi-square = 1.121 Df = 1 *P*= 0.290	Chi-square = 0.280 Df = 1 *P*=0.596	Chi-square = 2.115 Df = 1 *P*=0.146	Chi-square = 0.079 Df = 1 *P*=0.779
Calcium	Chi-square = 5.278 Df = 1 *P*=0.022	Chi-square = 0.049 Df = 1 *P*=0.825	Chi-square = 2.013 Df = 1 *P*=0.156	Chi-square = 8.667 Df = 1 *P*=0.003	Chi-square = 0.215 Df = 1 *P*=0.643