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**The association between calcium intake, osteoporosis
knowledge and osteoporosis health beliefs among
post-menopausal women**

A thesis presented in partial fulfilment of the requirements for
the degree of Master of Science in
Nutrition and Dietetics
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Abstract

Background: Osteoporosis is the most prevalent metabolic bone disease globally. It is caused by excessive loss of bone mineral density (BMD), with a subsequent increase in fracture risk. The condition is costly in terms of healthcare and older adult quality of life. Older women are most likely to experience the onset of osteoporosis due to the cessation of oestrogen production during menopause. Though prevalence is thought to be underestimated, as much as 35.5% of females over 50 years of age are living with osteoporosis in most western countries. Compelling evidence exists that onset can be arrested among older females through ongoing diet and lifestyle choices to mitigate menopausal related loss of BMD. However, randomised control trials of various interventions designed to support positive bone health behaviours have delivered mixed long-term results. This indicates that engagement in positive bone health behaviours is complex. It is thought that actions may also be influenced by health beliefs rather than knowledge of osteoporosis. Health beliefs are also thought to change according to age, gender, and ethnicity. Previous New Zealand-based studies on osteoporosis bone health behaviours and beliefs have focussed on pre-menopausal women. Subsequently, the associations between osteoporosis knowledge, health beliefs, and bone health behaviours, among the vulnerable population of post-menopausal women are largely unknown.

Objectives: To investigate the relationship between the bone health behaviour of calcium intake, osteoporosis knowledge, and health beliefs amongst post-menopausal New Zealand women.

Methods: This study is a secondary data analysis of a cohort of 66 post-menopausal females from the “Footprint” study. Surveys completed by the participants included the osteoporosis knowledge test, the osteoporosis health belief survey, demographic questions, and a calcium food frequency questionnaire. Pearson’s and Spearman’s rho correlations were used to determine the relationship between calcium intake and the independent variables. Linear regression is used to identify predictors of calcium intake.

Results: A weak negative correlation was found between the perception of severity ($r_s = -0.301$, $p = 0.017$) and calcium intake, as well as a weak positive correlation with university level of education ($r_s = 0.355$, $p = 0.008$). Following linear regression analysis, the benefits of exercise ($\beta = 0.430$, $p = 0.007$) was identified as the only health belief construct to predict calcium intake, accounting for 17.2% of the variation.

Conclusions: The findings of this study suggest that there may be an association between calcium intake and health beliefs around osteoporosis in older women in New Zealand; however, further research with a larger sample size would be required to support these results.

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List of Abbreviations

BHQ	Bone health questionnaire
BMD	Bone mineral density
BMI	Body Mass Index
DXA	Dual-energy X-ray absorptiometry
DDD	Day diet diary (can be 3,5, 7 depending on study)
EAR	Estimated average requirement
FFQ	Food frequency questionnaire
HBM	Health belief model
IU	International units
IOF	International Osteoporosis Foundation
METS	Metabolic equivalent of task
mg	Milligram
MoH	Ministry of Health
NZ	New Zealand
OHB	Osteoporosis health beliefs
OHBS	Osteoporosis health belief scale
OKT (OKT-r)	Osteoporosis knowledge test (revised)
ONZ	Osteoporosis New Zealand
RCT	Randomised control trial
PA	Physical activity
PBM	Plant based milks
RDI	Required dietary intakes
SPSS	Statistical package for social science

Chapter 1. Introduction

1.1 Background

Osteoporosis is a chronic condition characterised by excessive loss of bone mass, resulting in fragile, brittle bones at risk of fractures (Arnett, 2015; Osteoporosis New Zealand, 2017). Since natural loss of bone mass density (BMD) is expected with age, the onset of osteoporosis is often insidious. Diagnosis is frequently missed until a fracture occurs; therefore, prevalence is thought to be underestimated (Watts et al., 2012; Sedlak et al., 2007).

Osteoporosis affects both males and females, and its prevalence is increasing globally. Approximately 12.5% of men and 35.5% of women over 50 years of age are currently at risk of the onset of osteoporosis (Watt et al., 2012; Wu et al., 2021). The disproportionate representation among postmenopausal women is due to the intimate relationship between a menopausal decrease in oestrogen levels and bone health. Oestrogen, being a key regulator of bone metabolism as well as a sex hormone, reduces production following menopause resulting in up to 20% loss of BMD (Pouresmaeili et al., 2018; Sedlak et al., 2007). Subsequently, women are at high risk of osteoporosis following this important life change. Globally, the prevalence of osteoporosis is projected to increase from 153 million cases reported in 2010 to an estimated 310 million by 2040 (International Osteoporosis Foundation (IOF), 2023). This increase is also reflected in New Zealand (NZ); Accident Compensation Corporation (ACC) claims have increased by 47% since 2013 for fractures related to bone fragility (ACC, 2021). The cost of treating and rehabilitating older adult fractures is significant both financially and in terms of quality of life. In 2021, ACC reported a cost of NZD\$193 million to treat and rehabilitate those with osteoporotic-related fractures (ACC, 2021). Importantly, the most common fracture sites are at the hip, vertebrae, or wrist bones, all skeletal locations that greatly influence independent function. In consequence, the occurrence of fractures can be debilitating and potentially impact long-term independence (ACC, 2021). This can result in long-term nursing care or more severe consequences for those who sustain a hip fracture (Goodpaster et al., 2006; Ioannidis et al., 2009).

Despite some inevitable loss of bone density with age, osteoporosis is largely a preventable condition (ACC, 2021; Arnett, 2015; Pouresmaeili et al., 2018). The Ministry

of Health (MoH) in NZ publishes diet and lifestyle recommendations to promote bone health throughout adulthood. These include specific guidelines for weight-bearing exercise as well as recommendations to promote dietary inclusion of vitamin D and calcium (MoH, 2013, 2020). Equally, the public health organisation, Osteoporosis NZ is committed to promoting health messages, especially targeting those at important life stages with respect to bone health, such as the female menopause (Osteoporosis New Zealand, 2017). However, several intervention studies have indicated that knowledge is not necessarily associated with subsequent behaviour change (Green et al., 2020; McLeod & Johnson, 2011; Nguyen, 2014; Sedlak et al., 2007; Terrio & Auld, 2002). This indicates that knowledge alone cannot predict the adoption of positive diet and lifestyle behaviours. The Health Belief Model (HBM) is one theory of health behaviour that can be used to increase understanding of an individual's engagement with a positive bone behaviour (Boston University School of Public Health, 2022).

This model is used to explain how an individual's beliefs about osteoporosis, as well as the barriers or promoters of adopting health behaviours and their own motivation, can lead to the subsequent engagement of positive bone behaviours (Boston University School of Public Health, 2022). It consists of seven constructs and posits that an individual may engage in a health behaviour in the presence of certain perceptions. This includes a sufficiently high level of perceived threats from the condition, in conjunction with a strong perceived benefit, in adopting the behaviour, along with a low level of perceived barriers and appropriate cues to action.

Though osteoporosis health beliefs (OHB) have been well researched, results tend to be diverse regarding the predictors of health behaviours (McLeod & Johnson, 2011; Nguyen, 2014). This is due to the tendency that identified beliefs from the model are specific to the sample population's culture, gender, and life stage (Boston University School of Public Health, 2022; Luger, 2013). Previous studies have noted differences in perceptions between genders (Chelf et al., 2022; Doheny et al., 2007; Johnson et al., 2008) and age groups (Janiszewska et al., 2016; Piehowski et al., 2010; von Hurst & Wham, 2007). Furthermore, perceptions can be influenced by family history (Endicott, 2013), ethnicity (Swaim et al., 2008), and even diet habits (Gammage et al., 2009). Previous NZ based studies investigating the relationship between calcium intake, osteoporosis knowledge, and health beliefs have focussed on South Asian females in

Auckland (Tsai, 2008) or young female university students (Fekau, 2021). One study comparing the health beliefs of different age groups of women identified that older women were more likely to agree with the statement that calcium-rich products contained more cholesterol (von Hurst & Wham, 2007). This indicates that post-menopausal women may be at risk of inadequate calcium intake. Additionally, the previous NZ adult nutrition survey reported a daily calcium intake of 775 mg for females aged between 51 and 70 years (MoH & University of Otago, 2011). This is considerably less than the daily estimated average requirement (EAR) of 1,110 mg for women in this age group.

1.2 Purpose of the Study

Little is known about post-menopausal women's OHB, knowledge of osteoporosis, or current engagement in the positive bone health behaviour of calcium intake. Previous NZ based studies have focussed on younger females. The study by von Hurst and Wham (2007) investigated the health beliefs of different age groups of women; however, the eldest group comprised of 40–49-year-olds. This study indicated that older females may experience perceived barriers to calcium intake. The post-menopause period signifies a time when engagement in protective bone behaviours is important to mitigate the loss of BMD due to loss of oestrogen production. Investigating the relationship between health beliefs and knowledge of osteoporosis, along with current calcium intake would support an understanding of the perceptions of post-menopausal women, influencing bone health behaviours. This could also aid in the future design of appropriate interventions to increase engagement in positive bone health behaviours.

1.3 Aim

This study aims to investigate potential associations between the calcium intake of post-menopausal females in NZ in relation to their knowledge of osteoporosis and health beliefs. The study will also investigate the calcium intake of this age group.

1.4 Objective

1. To determine if an association exists between osteoporosis knowledge, osteoporosis health beliefs and the engagement of calcium intake as a positive health behaviour.

1.5 Hypothesis

H₁ There is an association between osteoporosis knowledge, health beliefs and the subsequent engagement of calcium intake as a positive bone health behaviour.

1.6 Thesis Structure

This study is divided into four chapters. **Chapter one** is the introduction, comprising of the background, purpose, aim, objectives, hypotheses, and research contributions to this study. **Chapter two** is a literature review of the most relevant and recent literature around osteoporosis and the use of the HBM to investigate OHB. **Chapter three** is the research manuscript; this includes the abstract, introduction, methods, results, and discussion of the study findings. **Chapter four** contains the conclusion, impact of the research, strengths, limitations, and recommendations of the study based on the study findings. Following the **references**, the **appendices** contain the additional supporting material within the study, including the participant information sheets, ethics approval, survey tools used in the study, calcium food frequency questionnaire, average calcium content and, participant answers to individual survey questions for the revised osteoporosis knowledge questionnaire, and osteoporosis health belief survey.

1.6 Researcher Contributions

Table 1.1

Summary of Researcher's Contributions to Study

Research topic and study design	Dr. Janet Weber A/Prof Louise Brough
Data Collection and handling	Dr. Jasmine Thompson Elizabeth Reynolds
Data entry, statistical analysis, interpretation and thesis writing	Colette Nicholson
Chapter review, editing and direction	Dr. Janet Weber A/ Prof Louise Brough

Chapter 2. Literature review

2.1 Introduction

This chapter focusses on the topic of osteoporosis, its risk factors, and its significance as a public health concern. Tools to assess knowledge and engagement behaviours will be discussed before reviewing the literature around osteoporosis health beliefs (OHB) and engagement with protective bone behaviours, specifically calcium intake.

2.1.1 Definition of Osteoporosis

Bone is a multifunctional and dynamic organ. It continually maintains the balance between providing a functional skeletal frame, responding to physiological homeostatic demands for minerals, and storage of blood cells (Arnett, 2015; Sözen et al., 2017). The most common consequence of an unstable bone metabolism is osteoporosis (Kemmak et al., 2020; Khosla & Riggs, 2005; Sözen et al., 2017). This major non-communicable disease is defined by loss of bone mineral density (BMD), resulting in the deterioration of bony microarchitecture and increasing fragility. Osteoporosis is commonly diagnosed, following assessment by dual-energy X-ray absorptiometry (DXA) at the femoral neck and reported as a T-score. The World Health Organisation quantitatively defines osteoporosis as the T-score of BMD, 2.5 standard deviations or more, below the T-score of BMD of healthy young adults (World Health Organization, 2013)

2.1.2 Presentations of Osteoporosis

There are four types of osteoporosis (NIH, 2018). The most common, primary osteoporosis is caused by the multifactorial processes of ageing in conjunction with predisposing factors (Pouresmaeili et al., 2018; Sözen et al., 2017). In contrast, secondary osteoporosis occurs as a consequence of a pre-existing health condition, where bone metabolism is influenced by either the condition or treatment medication. This can occur in conditions such as diabetes, renal failure, hyperthyroidism, and malnutrition illnesses where a decline of endocrine function or nutrient absorption occurs (Raisz, 2005). Osteoporosis can also be caused by a rare genetic mutation resulting in osteogenesis imperfecta (Boudin et al., 2016; NIH, 2018). Equally rare is the paediatric condition idiopathic juvenile osteoporosis (Boudin et al., 2016; NIH, 2018). Primary osteoporosis represents the majority of cases and due to its preventable

nature, poses a major public health challenge (Kemmak et al., 2020; NIH, 2018; Salari et al., 2021).

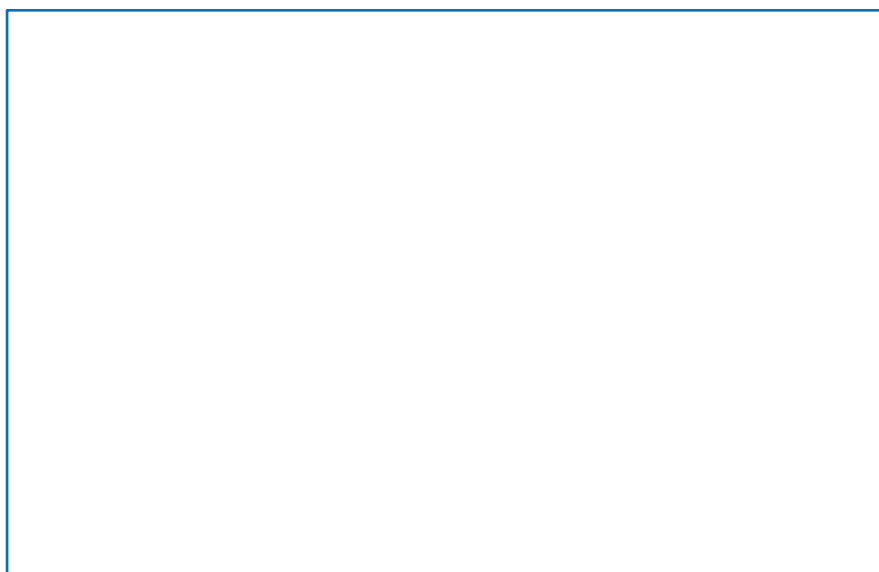
2.2 Understanding Bone Metabolism

Bone, as an organ, maintains a delicate homeostasis between different functions, with the ability to generate or dissociate its components as required. The cycle of bone formation (deposition) and breakdown (resorption) is controlled by dedicated bone cells: osteoblasts, osteocytes, and osteoclasts (Arnett, 2015). Osteoblast production of osteoid (flexible collagen type 1 fibres) is then mineralised with calcium phosphate (hydroxyapatite) to form bone matrix. Osteocytes, bound within the bone matrix, are thought to regulate mineralisation as well as trigger the action of the osteoclasts for bone resorption. This function also permits osteocyte control of phosphate and calcium homeostasis (Arnett, 2015).

BMD relies on the metabolic balance of bone formation and bone resorption; to maintain thickness and strength while continuously responding to different signalling mechanisms (Arnett, 2015; Khosla & Riggs, 2005). Bone, is able to act as the reservoir for 99% of the body's calcium and store phosphate. These minerals are released when required for essential physiological processes (Vannucci et al., 2018). This constant cycle of deposition and resorption, as seen in Figure 2. is called bone remodelling, and continues throughout the lifespan (Arnett, 2015; Wilson-Barnes et al., 2022).

Figure 2.1

Stages of Bone Formation and Resorption (Source: Liang et al., 2021)

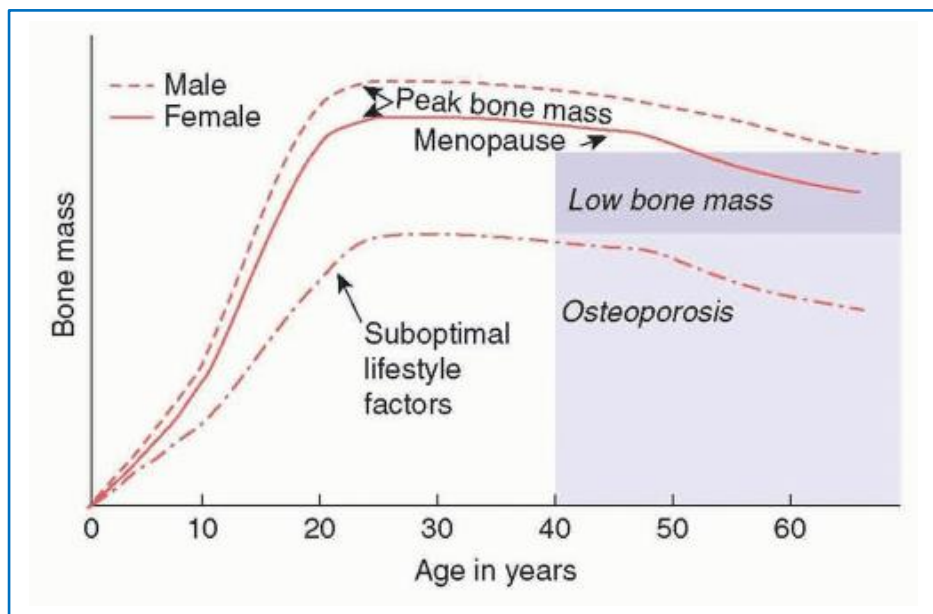


2.2.2 Peak Bone Mass

The bone health of older adults is influenced by the development of bone from childhood to young adulthood (Bonjour et al., 2009; Heaney et al., 2000). During this time, bones reach their definitive length and BMD is known to increase until a maximum peak bone mass (PBM) is achieved. This normally occurs during early adulthood to the late twenties (Gordon et al., 2017; Heaney et al., 2000). It has been reported that an increase of one standard deviation of BMD at PBM can reduce the risk of subsequent primary osteoporosis by 50% (Bonjour et al., 2009). Figure 2.2. illustrates the trajectory between male and female bone density throughout the lifespan (Rozenberg et al., 2020). Following PBM, slow, progressive age-related loss occurs naturally; however, there are also several risk factors that contribute to premature loss of BMD (Pouresmaeili et al., 2018; Sözen et al., 2017).

Figure 2.2

Bone Mass Across the Lifespan for Males and Females (Source: Rozenberg et al., 2020)



2.3 Risk Factors Associated with Primary Osteoporosis

Later-life onset of primary osteoporosis is associated with several identified modifiable and non-modifiable risk factors. These individually, can influence the equilibrium of bone deposition and resorption, the risk of excessive loss of BMD, and the subsequent development of osteoporosis (Pouresmaeili et al., 2018; Raisz, 2005; Wilson-Barnes et

al., 2022). Management strategies frequently seek to minimise the influence of these factors and delay the loss of BMD.

2.3.1 Longevity

Though bone accumulation ceases following attainment of PBM, bone is continually being remodelled. However, with age, the equilibrium alters slightly to favour bone resorption (Arnett, 2015; Weaver et al., 2016). Longitudinal studies point to a consistent pattern of bone loss in both sexes after 40 years of age, with cortical and trabeculae thinning and increased cortical porosity exponentially increasing the risk with longevity (de Villiers & Goldstein, 2022; Sedlak et al., 2007).

2.3.2 Genetic Predisposition and Ethnicity

Genetic factors may account for 60-80% of the risk of developing osteoporosis (Weaver et al., 2016). One cohort study observed that post-menopausal women were four times more likely to be diagnosed with osteoporosis if they had a family history of osteoporosis and twice as likely if they had experienced an earlier fracture (Bijelic et al., 2019). Interestingly, this study also discovered that 41% of the experimental group had experienced early menopause compared to only 19% of the control group. Equally, there is evidence that vitamin D receptor gene variations exist, which ultimately affect calcium absorption and subsequent mineralisation of bone (Lips & van Schoor, 2011; Raisz, 2005). Furthermore, ethnicity has also been identified as a predisposing factor, with a higher incidence of osteoporosis diagnosed among Caucasian and Asian populations (Mohd-Tahir & Li, 2017; Wu et al., 2021).

2.3.3 Female Gender

Women have a lifetime osteoporosis fracture risk of 40-50%, which is significantly higher than the fracture risk of 13-22% for males (Salari et al., 2021; Sözen et al., 2017; The North American Menopause Society, 2021). Several theories are posited for this predisposition. Females with smaller and thinner bones than males achieve lower levels of PBM in early adulthood than males (Gordon et al., 2017; Weaver et al., 2016). Lifestyle factors can also contribute, such as the choice of weight-bearing exercise, which positively influences bone accumulation (Gordon et al., 2017). Importantly, women achieve skeletal maturity earlier than men, leading to earlier BMD losses.

Furthermore, following the period of PBM, women lose 0.96% of BMD annually, compared to 0.82% for men (Khosla & Riggs, 2005).

Additionally, menopause is a major factor in the loss of BMD. Oestrogen has been identified as a key regulator of bone metabolism (Raisz, 2005). During menopause, women normally experience a dramatic decrease in oestrogen levels with a subsequent 20% loss of BMD (de Villiers & Goldstein, 2022). The effects of increasing age together with the effects of menopause can dramatically lower BMD in Caucasian women, with the prevalence of osteoporosis estimated at 14% of those aged between the ages of 50-59 years, 22% for those between 60-69 years, and 39% between 70-79 years of age (Melton & Joseph, 1995).

2.3.4 Previous fracture

A high association exists between an initial fracture, the risk of re-fracture, and bone fragility in older men and women (Abey-Nesbit et al., 2019; Jacqueline et al., 2007). One cohort study reported that 43% of the sample diagnosed with osteoporosis had experienced a previous fracture, compared to 21% of the comparison group (Bijelic et al., 2019). Significantly, both men and women are at almost twice the risk of experiencing a further fracture (RR 1.86) compared to those who are fracture-free (Jacqueline et al., 2007).

2.3.5 Modifiable Risk Factors

Factors directly related to individual choices occupy a significant niche in the prevention of later life onset of osteoporosis. Modifiable risk factors associated with the onset of primary osteoporosis involve practices around diet and lifestyle. These choices can affect adult PMB by 20-40% (Weaver et al., 2016) and equally delay premature loss of BMD in later life (Wilson-Barnes et al., 2022). Many factors around diet quality, intake of macro- and micro-nutrients, and food patterns were assessed by Weaver et al. (2016) on behalf of the American National Osteoporosis Foundation. The systematic review used a four-grade (A-D) system to assess the quality of evidence based on the number and type of included studies for each factor. Studies demonstrating the strongest evidence were graded at level A. Subsequent factors with declining levels of evidence were graded in descending order of B, C or D. The benefit of calcium intake and physical activity (PA) demonstrated level A evidence. Factors assigned Level B evidence included

the benefit of vitamin D intake and dairy consumption (dietary pattern). Level C evidence was applied to the detriment of smoking. Whereas the detriment of alcohol to BMD was assigned level D evidence. Subsequent guidelines for older adults reflect the recommendations in this review (Cosman et al., 2014). The following discussion on nutritional and lifestyle choices is structured according to pertinent factors for adults within the guidelines.

2.3.6 Calcium Intake

Dietary calcium is an essential element and performs different functions within the body. It is integral to bone metabolism and has a critical role in biological functions, which take priority over calcium bone stores (Arnett, 2015; Vannucci et al., 2018). Significantly, serum calcium maintains a consistent and narrow range between 2.12 - 2.62 mmol/L, which is strictly maintained homeostatically. When serum calcium concentrations slip below this range, osteoclast function is upregulated with subsequent bone resorption to release calcium stores (Arnett, 2015; Khosla & Riggs, 2005).

A diet with adequate calcium intake is recommended regardless of age to maximise PBM (Bonjour et al., 2009) and reduce loss of BMD in later life (Weaver et al., 2016; Wilson-Barnes et al., 2022). Maintaining calcium intake to the EAR is well known to reduce BMD losses during menopause (The North American Menopause Society, 2021; Thulkar et al., 2016; Weaver et al., 2016). Importantly, the years of menopause are afflicted not only by reduced hormonal control of BMD but also by an age-related decrease in the absorption of dietary calcium (Cosman et al., 2014). The New Zealand (NZ) daily recommended dietary intake (RDI) for women over 50 years of age increases from 1000 mg to 1300 mg per day to support these changes (MoH & University of Otago, 2011).

2.3.7 Vitamin D

Amongst several biological roles, Vitamin D (cholecalciferol) is vital for promoting absorption of calcium and phosphate, supporting bone health (Lips & van Schoor, 2011). It is a prohormone primarily produced within the skin following sun exposure, though small amounts can also be absorbed via diet. When a vitamin D deficiency occurs, calcium absorption is reduced with subsequent bone resorption. Among the numerous factors relating to vitamin D deficiency, age-related loss of dermal capacity to

synthesise vitamin D can increase the risk of osteoporosis in over 65-year-olds (Hill et al., 2013; Wilson-Barnes et al., 2022). Cholecalciferol supplementation is routinely recommended to women of this age group to reduce premature loss of BMD (Cosman et al., 2014; LeBoff et al., 2022; Wilson-Barnes et al., 2022).

A previous meta-analysis of 30 RCTs reported that the effectiveness of vitamin D supplementation is influenced by age, ethnicity, menopause status, baseline serum 25-hydroxy vitamin D (25(OH)D) concentration and dosing frequency (Reid et al., 2014). Additionally, vitamin D supplementation has also been recognised as protective to bone health due to its promotive effects on muscle strength and decreasing falls risk (Dawson-Hughes, 2012). One meta-analysis of 8 RCTs among 2426 participants calculated 20% reductions in falls following supplementation with 700-1000 IU per day of cholecalciferol (Bischoff-Ferrari, 2010).

2.3.8 Dietary Patterns

Several different dietary patterns have been identified as important influences on bone health (Weaver et al., 2016; Wilson-Barnes et al., 2022). A meta-analysis conducted by the Osteoporosis Foundation assigned level B evidence for the benefit of dairy consumption towards BMD (Weaver et al., 2016). A further meta-analysis of six RCTs among a total of 614 participants using BMD measurements at the lumbar spine, femoral neck, and total hip identified a small but statistically significant increase in BMD with dairy consumption (Shi et al., 2020). Other acknowledged dietary patterns that benefit BMD include the Mediterranean diet (Movassagh & Vatanparast, 2017) and diets high in fruit and vegetables (Hardcastle et al., 2011; Movassagh & Vatanparast, 2017; Wilson-Barnes et al., 2022). Conversely, diets high in highly processed foods and confectionary have been associated with lower BMD (Hardcastle et al., 2011).

The influence of different diets on BMD may arise from the homeostatic role of bone in the acid-base balance of the body. This function becomes increasingly important for older adults when renal function is less robust. It is theorised that even slight declines in pH toward metabolic acidosis for prolonged periods stimulate bone resorption to release calcium and rebalance the acid-base balance. (Hardcastle et al., 2011; Movassagh & Vatanparast, 2017). Diets high in fruit and vegetables exert a much-

reduced acid load compared to diets high in meat, processed foods, fat, and sugar (Hardcastle et al., 2011).

2.3.9 Low Body Mass Index (BMI)

A low BMI under 20 kg/m² is associated with greater BMD loss and increased fracture occurrence, regardless of age or sex (De Laet et al., 2005; Morin et al., 2009; Thulkar et al., 2016). One retrospective cohort study of 8254 women between the ages of 40-59 years noted a 19% increased risk for each standard deviation decrease in weight (Morin et al., 2009). Whereas, a longitudinal study examining the long-term consequences of eating disorders on BMD, ascertained that 54.2% of women with anorexia nervosa had osteoporosis, with a further 20.8% exhibiting signs of osteopenia (Zipfel et al., 2001).

2.3.10 Weightbearing Exercise

Weight-bearing PA is a key influence on bone metabolism, tilting the balance towards bone formation throughout the life cycle (Weaver et al., 2016). Consistent engagement with PA from primary school to college has been demonstrated to yield increased bone stiffness measurements in college students compared to those with inconsistent engagement with PA (Yung et al., 2005). This optimises PBM (Heaney et al., 2000; Yung et al., 2005).

Equally, mechanical loading remains an important stimulus for mature bone remodelling (Arnett, 2015). Heavy loads and impacts trigger osteoblast activity, laying down new matrix to strengthen the bone tissue (Arnett, 2015). Exercise magnitude, rate, and frequency can all influence bone formation (Yung et al., 2005). Significantly, one large cohort study of 9423 women over 75 years of age, identified that regular 4-6 hours of moderate weight-bearing activity per week, such as brisk walking or golf, could increase bone strength (Morin et al., 2009). Additionally, an increase in muscle strength resulted in a reduction in falls (Morin et al., 2009).

2.3.11 Smoking

Smoking exerts a multifactorial influence on bone metabolism. It can directly decrease and indirectly influence BMD via its effect on other risk factors such as reduced BMI, hormone activity, and reduction of calcium absorption (Cusano, 2015; Jacqueline et al., 2007; Weaver et al., 2016). Though the mechanisms of this influence are unclear, the

prevalence of fracture risk amongst male and female smokers is well documented, with a 26% to 80% increased risk of fracture amongst established smokers (Cosman et al., 2014; Cusano, 2015; Wilson-Barnes et al., 2022).

2.3.12 Alcohol Consumption

The mechanisms between the use of alcohol and its effect on BMD appear to be complex, with evidence towards the positive and negative effects of consumption. A meta-analysis of 18 studies of alcohol consumption in relation to hip fracture risk reported a RR of 0.88 for light drinkers (less than 12.5g of alcohol per day), with the RR rising to 1.71 for those drinking 50g of alcohol per day (Zhang et al., 2015). A further cohort study of 3,313 postmenopausal women examined the relationship between alcohol consumption and DXA measured BMD at the lumbar spine and femur. There was a matched group of non-drinkers, compared to alcohol consumers, classified into three groups: light (≤ 5 units/week) to heavy (≥ 9 units/week). Light drinkers exhibited higher BMD values than non-drinkers, whereas heavy drinkers had a RR of 1.7 for developing osteoporosis (Jang et al., 2017).

2.3.13 Summary of risk factors

Osteoporosis is often considered to be a natural consequence of ageing. Though longevity is a known non-modifiable risk factor for loss of BMD, the onset of osteoporosis is not an inevitable consequence (Beck et al., 2017; Pinheiro et al., 2020). Diet and lifestyle choices influence premature loss of BMD and have been identified as key to preventing the onset of primary osteoporosis (Cosman et al., 2014; Khosla & Riggs, 2005; Osteoporosis New Zealand (ONZ), 2017; Sözen et al., 2017; The North American Menopause Society, 2021).

2.4 Global Prevalence and Economic Burden of Osteoporosis

2.4.1 Prevalence and Personal Burden

Osteoporosis is the most common metabolic bone disease globally, affecting 23.1% of all women and 11.7% of men (Salari et al., 2021). For those over 50 years of age, one-third of women and one-fifth of men are thought to have osteoporosis (Kemmak et al., 2020; Lorentzon et al., 2022; Wu et al., 2021). Globally, there are 8.9 million attributed fragility fractures annually (de Villiers & Goldstein, 2022; IOF, 2023). The most consequential

fracture sites include the vertebra and the hip (33% and 6.5%, respectively, of diagnosed fractures) (Abey-Nesbit et al., 2019).

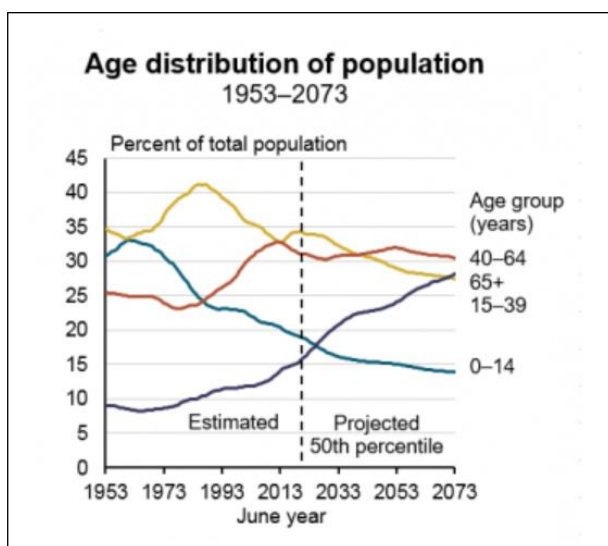
The location and severity of fractures often lead to profound consequences, with poor long-term prognoses for individuals. Significantly, 10-20% of previous community-based older adults require long-term nursing care following an osteoporotic fracture (Ioannidis et al., 2009). The mortality rates after a hip fracture can be as high as 20-24% within the first year (Goodpaster et al., 2006). Additionally, fewer than 50% of those who sustain a hip fracture regain their normal level of weight-bearing independence (Mohd-Tahir & Li, 2017; Watt et al., 2012).

2.4.2 Cost of Treatment

Healthcare costs to treat osteoporotic fractures are considerable. Together, North America and Europe spend \$6500 billion annually on treatment and rehabilitation (Kemmak et al., 2020). A single hip fracture has a global mean healthcare cost of \$43,669 USD to treat. Locally, the NZ Accident Compensation Company (ACC) reported a cost of \$195 million in 2021 for treatment of fragility fractures (ACC, 2021). Importantly, this is predicted to rise to \$400 million by 2035 (Brown et al., 2011; IOF, 2023). This escalation is in part due to the proportion of ageing adults in NZ (Figure 2.3). Currently, 17.5% of the population (860,160 people) is over 65 years old. However, this is expected to increase to 22-26% of the population by 2048 (1.46 million) (Stats NZ, 2022).

Figure 2.3

Projected Increase in NZ population: 2020- 2073
 (Source: Stats NZ Tatauranga Aotearoa, 2022)



2.4.3 Public Health Messages in New Zealand

Public health strategies in NZ focus on health messages to promote bone protective behaviours such as optimising calcium and vitamin D intake amongst menopausal women to prevent premature loss of BMD (ONZ, 2017). The focus is to raise public awareness through information resources such as “osteoporosis and you,” targeted to improve osteoporosis knowledge and subsequent behaviour engagement (ONZ, 2017). The Ministry of Health (MoH)(2020) published eating and activity guidelines for adults to support bone health. These recommendations include daily RDI of 1300mg of calcium are advised for women over 50 years of age, whereas activity guidelines of 30 minutes of moderate exercise is recommended five times a week (MoH, 2020b). However, since 2013, there has been a 47% increase in ACC claims due to fragility fractures by 65-plus-year-olds (ACC, 2021). This indicates a potential to increase engagement with positive bone behaviours.

2.5 Evaluating Engagement in Bone Health Behaviours

2.5.1 Measuring Health Beliefs, Osteoporosis Knowledge, and Calcium Intake

A variety of intervention studies have analysed the association between increasing knowledge of protective bone behaviours and behaviour change with unpredictable results (Morfeld et al., 2017; Nguyen, 2014; Rubæk et al., 2022; Ryan et al., 2013; Sedlak et al., 2007). These studies indicated that increasing knowledge is important but may not lead to long-term behaviour change. Therefore, developing an understanding of perceptions around osteoporosis and its predictors to support behaviour change may be more effective for intervention design (Luger, 2013; McLeod & Johnson, 2011; Nguyen, 2014). Osteoporosis-specific tools informed by the health belief model (HBM) and osteoporosis knowledge have been developed and validated to explore and understand perceptions of bone health behaviours.

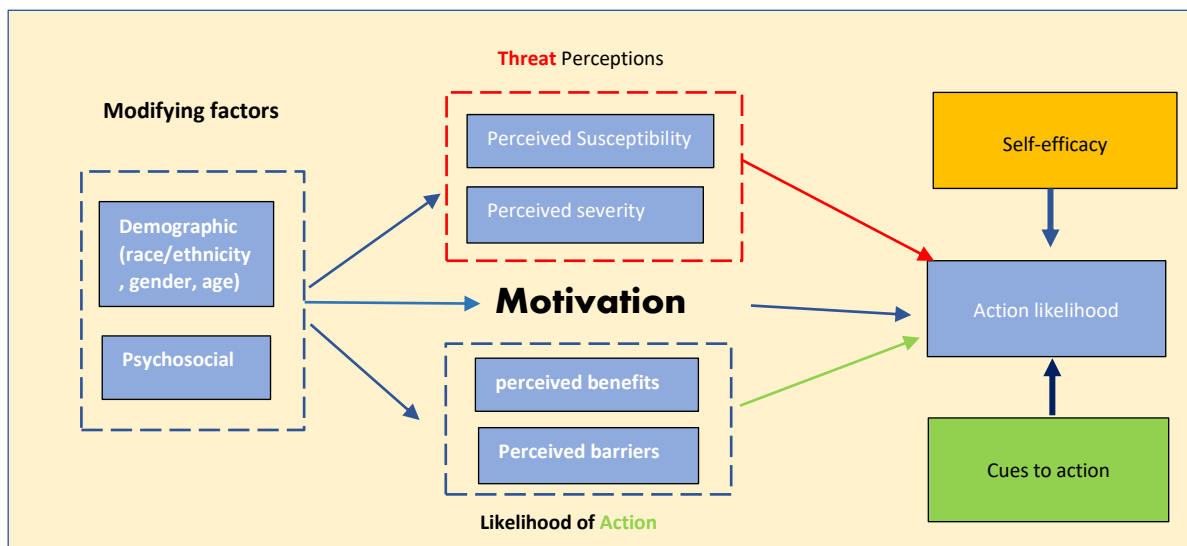
2.5.2 Health Belief Model

The HBM was developed in the 1950s by social psychologists Hochbaum and Rosenstock to better understand the lack of active public engagement with available public health services (Boston University School of Public Health, 2022). The model seeks to explain health behaviours and predict why people engage with intervention strategies. In this theory, an individual might engage in a positive health behaviour if

they perceive themselves to be susceptible, their perception of the condition is sufficiently severe, they see a strong benefit in behaviour change, and perceived barriers to taking action are low (Brown et al., 1983; Champion & Skinner, 2008). The model investigates how these four constructs, along with cues to action (e.g., health messages, information brochures, phone reminders, etc.), and health motivation relate to each other and influence behaviour change, as seen in Figure 2.4. The construct of self-efficacy was later added.

Figure 2.4

The Health Belief Model (Source: Luger, 2013)



2.5.3 The Osteoporosis Health Belief Scale

The HBM is widely used to investigate people’s beliefs around osteoporosis and how these perceptions relate to the adoption of key positive bone health behaviours (McLeod & Johnson, 2011; Nguyen, 2014). Informed by the original constructs of the HBM, the Osteoporosis Health Belief Scale (OHBS) was developed to measure the perceptions of older adults toward osteoporosis and explain changes in positive behaviours such as calcium intake and exercise. During its development, it was validated using a cohort of 201 women between 35 and 95 years of age (Kim et al., 1991). This tool consists of a 42-item questionnaire with seven dimensions based on the HBM constructs. Each subscale has six statements with Likert-scale responses ranging from strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5).

The total score range for each subscale is 6-30 leading to a possible 35-210 for the overall score. In theory, higher scores are thought to indicate more likely engagement with bone-protective behaviours. The dimensions are described as:

- Perceived Susceptibility: defined as an individual's belief in the likelihood that they may develop the disease within their lifecycle. Do they perceive themselves as vulnerable to an eventual diagnosis of osteoporosis?
- Perceived severity: defined as the individual's estimation of the seriousness of the condition and how it will affect their life if left untreated. How much would their quality of life deteriorate if diagnosed with osteoporosis?
- Perceived benefits: defined by the individual's perception of the benefit of adopting a health behaviour and how they feel about:
 - Exercise for bone health to prevent osteoporosis.
 - Calcium intake: does the respondent perceive calcium to prevent or mitigate the onset of osteoporosis?
- Perceived barriers: defined as the potential negative aspects of a health action.
 - These could include environmental barriers that the individual perceives reduce access or opportunity to engage in exercise.
 - Or perceptions which prevents calcium intake e.g., perception that calcium rich foods are expensive or unhealthy e.g., high in fat.
- Perceived health motivation: defined as the ability for the individual to take responsibility for their health and seek out health information and support.

OHBS permits the assessment of potential behavioural influences. Subsequent interventions can then be designed to target specific perceptions and support behaviour change. Some examples of interventions include group counselling sessions to decrease barriers (Evenson & Sanders, 2016; Jung et al., 2011); infographics on spinal fractures to increase perceptions of severity; or DXA scans to increase perceptions of susceptibility (Nguyen et al., 2012; Ryan et al., 2013; Sedlak et al., 2007).

2.5.4 The revised osteoporosis knowledge test (OKT-r)

The OKT (and revised version, OKT-r) was designed to measure the general depth of knowledge of risk factors as well as bone protective behaviours in cohort populations. The OKT-r questionnaire consists of 32 items over the two subscales of exercise and

nutrition. These subscales share 14 common items around risk factors and general knowledge (Gendler et al., 2015). Answers are either correct or incorrect, with a final total of 32. The tool identifies knowledge gaps. The revised questionnaire includes additional questions on vitamin D. Some questions were also reworded to accommodate new evidence around osteoporosis on types of exercise and risk factors (Gendler et al., 2015).

2.5.5 Measuring Health Behaviours

Calcium intake is an important bone health behaviour to monitor due to its significance in the prevention of osteoporosis (Weaver et al., 2016). Therefore, it is commonly measured in studies investigating the association of OHB with positive bone behaviours. Though a variety of methods exist to assess individual dietary intake, calcium-specific food frequency questionnaires (FFQ) have gained increasing favour amongst in population studies (Macdonald et al., 2014; Ong et al., 2017; Sebring et al., 2007).

2.5.6 Calcium-Specific Food Frequency Questionnaire

This questionnaire has three components: a list of commonly consumed foods (containing the nutrient of interest), an assigned portion (e.g., 1 cup full, 1 teaspoon, etc.), and a frequency category. Importantly, FFQs must be designed to be relevant for the sample population and contain sufficient inclusion of calcium-containing products (Clover et al., 2007; Houston, 2014; Willett & Lenart, 2013). A variety of FFQs have been used with varying numbers of items ranging from 5, 25, 51, 87, 124, and 161 to estimate calcium intake and have been validated against 3–5-day diet diaries (DDD) (Clover et al., 2007; Ong et al., 2017; Pritchard et al., 2010; Sebring et al., 2007). Overall, a moderate correlation coefficient between the two methods has been reported for assessing large samples from a population (Clover et al., 2007; Fekau, 2021; Ong et al., 2017; Sebring et al., 2007). The main advantages of FFQs are reduced respondent burden, reduced time to collect and analyse data, and increased study engagement, with a subsequent larger number of data sets. The calcium specific FFQ used for this study has already been validated on a previous sample of young female NZ (Fekau, 2021).

2.5.7 Literature Investigating Osteoporosis Health Beliefs.

This section will focus on the literature exploring the use of the osteoporosis health belief survey to investigate health beliefs around the condition. Inclusion criteria for the studies included use of OHBS with either or both the OKT/OKT-r and calcium intake measurement in developed countries. Figure 5. illustrates the criteria for the literature search.

Figure 2.5

Search Criteria, Filters, and Databases for the Literature Review

<p>Date Searched: January 2023- November 2023</p> <p>Search terms: “Menopaus*” OR “post-menopause” OR “older wom*” OR “female”. AND “osteoporosis health beliefs” AND “behaviour” OR “calcium” OR “bone behaviours” AND “knowledge” AND “osteoporosis”</p> <p>Filters: last 10 years, last 20 years, In English language, Humans</p> <p>Article databases: Scopus, Massey university Discover tool, PubMed, Google scholar.</p>

Table 2.1. illustrates the recruited studies for this literature review, which include six cohort studies examining the OHB amongst cohorts of different ages, genders, and family medical histories. A further five studies investigate the association between health beliefs and calcium intake to ascertain potential predictors of calcium intake, and the remaining 11 studies assess the effect of HBM led interventions. Some of the intervention studies measured outcomes such as calcium intake, while others simply assessed changes in beliefs. The table illustrates the heterogeneity of research aims and reporting. The different types of studies were included to ensure full consideration of research using this model within individual perceptions of osteoporosis.

Table 2.1

Summary of Cohort and Intervention Studies using the Osteoporosis Health Belief Survey to Investigate Osteoporosis Related Health Beliefs.

Studies exploring health beliefs in populations using the OHBS tool			
Reference, year, country	Participants	Methodology	Main results
Chelf et al., 2022 USA	n= 173 81 males 92 females 35–50 age range	Cross sectional study Aim: To examine gender-based differences in OHB Tools: OHBS OKT	OKT scores <ul style="list-style-type: none"> • Exercise: F¹ 11.23 Vs M² 9.96, • Ca²⁺ ³ knowledge: F 11.94 vs M 10.36 OHBS ⁴ (main differences) Reported means: F Vs M <ul style="list-style-type: none"> • Sus: F 18.23 Vs M 13.94 • Sev: F 17.55 Vs M 16.89 • BeEx: F 25.93 Vs M 23.59 • HM: F 23.64 Vs M 22.96 • Correlations: +ve HM: BeEx (r=-0.434, p <0.001); -ve HM: BrEx (r = 0.385, p<0.001)
Doheny et al., 2007 USA	n =444 218 females 226 males ≥50 age range	Cohort study Aim: Examine gender differences in Knowledge, OHB and DXA T-scores Tools: OHBS OSES OKT DXA	OKT :71.2% men and 47.2% women scored less than 70% OHBS (main differences) <ul style="list-style-type: none"> • Women vs men ↑⁵ perceived Sev and ↑Sus (17.11 vs 14.45). • HM W 23.41 Vs M 24.09 • BaCa²⁺: W 12.41 Vs M 13.15 • BaEx: W 12.42 Vs M 11.48 • Self-efficacy of exercise: W 401.97 Vs M 453.39 • F Vs M = ↑ knowledge, ↑severity, ↑susceptibility, ↓barriers to calcium intake and ↓⁴motivation to engage in OP⁵ preventive behaviours.
1. Female (F) 2. Male (M) 3. OHBS Constructs: Susceptibility (Sus); Severity (Sev); Benefits Exercise (BeEx); Calcium (BeCa ²⁺); Barriers Exercise (BrEx); Barriers Calcium; Health Motivation (HM) 4. ↑ = more or increase. ↓ = Less or decrease 5. Osteoporosis (OP)			

Reference, year, country	Participants	Methodology	Main results
Gammage, Klentrou & Macke 2009 Canada	n =517 F = 346 M = 171 17-21 age range 4 groups High dietary restraint (HR) (f=92, m=48) Low dietary restraint (LR) (f= 93, m= 44)	Cohort Study Aim: To investigate relationship of dietary restraint (DR), OKT and OHBS Low Restrainers (LR) Vs High Restrainers (HR) Tools: OKT OHBS SES Dutch eating questionnaire	OKT LR F: M Vs HR F: M 14.61 (2.38), 14.54 (3.37) Vs 13.68 (3.23), 14.30 (3.48) OHBS (Scores with significant differences) For Females: HR scores significantly higher than LR <ul style="list-style-type: none"> Sus ($F(1, 183) = 7.12, p = .008, \eta^2 = .04$) Sev ($F(1, 183) = 4.26, p = .004, \eta^2 = .02$) CaBa²⁺ ($F(1, 183) = 5.67, p = 0.018, \eta^2 = .03$) HM ($F(1, 183) = 5.13, p = 0.025, \eta^2 = .03$) HR higher scores for CaBa ²⁺ may be due to perception that calcium products are high in cholesterol and calories. For males: <ul style="list-style-type: none"> BeEx HR 3.89 and LR 4.28
Johnson et al., 2008 Canada	n=300 F = 150 M= 150 3 age groups n1= 100, 18 - 25 n2 =100, 30 - 50 n3 =100, 50+	Cohort study Aim: Examine OHBS of different gender and ages. Tools: Demographic questionnaire OHBS	OKT N/A OHBS Gender ↑ influence on association between variables than age Scores n1 F, M: n2 F, M: n3 F,M (only 3 constructs reported) <ul style="list-style-type: none"> Sus: 10.86, 8.58: 13.60, 10.56: 14.50, 11.42 Sev: 15.58, 13.84: 14.94: 15.44: 15.82,15.76 HM: 19.20, 20.24: 19.22, 19.92: 20.24, 19.20 14% F > 50 had been diagnosed with OP Sus ↑ F (> 50) 14.50 vs (18-30) 10.86 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Similar across groups</div>
Janiszewska Et al., 2017 Poland	n=300 females 45–65 age range Assessment via OBHS OSES	Cohort study Aim Examine OHBS and self-efficacy differences between Pre Vs Post-menopausal females. Tools: OBHS OSES	OKT N/A OHBS Sus 15.60 (27.3% believed they were at risk, 5% had a moderate score) Sev 17.22 (70% had a moderate, F56-65 > severity <55 years old) BeEx 22.35 BeCa ²⁺ 22.65 BaEx 16.85 C 15.44 HM 21.27 Correlation: ↑level education ↓ in barriers to exercise and Ca ²⁺ intake.

Reference, year, Country	Participants	Methodology	Main results
von Hurst & Wham, 2007 New Zealand	n= 622 females 20-49 age range	Cross sectional study Aim: Investigate female knowledge and beliefs around susceptibility and attitudes toward preventative behaviours Tools: Osteoporosis OKT OHBS	OKT- average 16.4 or 63% (moderate) <ul style="list-style-type: none"> F young have the lowest knowledge mean score. OHBS <ul style="list-style-type: none"> Sus - low score -no difference between groups Sev – low and no difference between groups BeCa²⁺ & BeEx: high scores, no significant difference. BaEx ↑ young women Vs older women. BaCa²⁺: No difference in scores between groups HM ↑ Older women 77% found Calcium foods rich in cholesterol. Significant correlation between knowledge & health motivation Predictors of HM were BeEx & Ba Ca²⁺ barriers were the negative predictors.
Studies investigating the relationship between health beliefs using a OHBS and measuring calcium intake			
Fekau, 2021, New Zealand.	N=130 females 19 -30 age range	Cohort study Aim: determine association between Ca ²⁺ intake, OKT and OHBs Tools: OKT OHBS OSES 3DDD ⁶ Calcium FFQ	Calcium intake FFQ *2 (662mmg, 692mg) 3DDD = 771mg OKT mean score = 58% OHBS mean score = 124.5- moderate <ul style="list-style-type: none"> Susc15/30 - moderate Sev 19/30 - moderate BeEx 22/30 -high BaEx 10/30 - low BeCa²⁺ 22/30 - high BaCa²⁺ 13/30 - low HM = 22/30 - high 9% respondents found milk high in cholesterol. Ca²⁺ intake predictors: 1. OKT, 2. Sev
6. 3-day diet diary (3-DDD)			

Reference, year, Country	Participants	Methodology	Main results
Gammage, & Klentrou, 2011, Canada.	N=150 Females grades 8 -10	Cohort study Aim: to investigate if expanded HBM could predict health behaviours Ca ²⁺ intake and exercise. Tools OHBS OSES OKT Rapid assessment method calcium (RAM) (PAQ-A) PA Questionnaire – Adolescents	Mean calcium intake = 1315mg/day (50% did not meet recommendations) OKT mean score = 48.7% OHBS <ul style="list-style-type: none"> • Calcium intake negatively correlated with sus (-0.22); Ba Ca²⁺ (0.30) and BaEx (-0.15). • Calcium intake positively correlated with PA (0.15); HM (0.22); knowledge (0.2); Calcium (0.33) and exercise self-efficacy (0.27). • Predictors Ca²⁺ intake: 1. knowledge, 2. calcium self-efficacy and 3. barriers accounted for 16% of variation. • Perceived sev, sus, BeEx and Be Ca²⁺ not predictors of calcium intake or PA.
Piehowski et al., 2010 (USA)	n= 203 females 4 age groups n= 44 (20–39.9) n= 65 (40–49.9) n= 65 (50–59.9) n= 29 (60+) Premenopausal (pre M) and postmenopausal (post M) women Pre-M = 110 Post-M = 93	Cross sectional design Aim: comparison of OHB over between 4 cohorts & pre/post menopause Tools: <ul style="list-style-type: none"> • OHBS surveys • Calcium HBS • Calcium FFQs • Anthropometric measurements 	<ul style="list-style-type: none"> • Calcium mean intake across age groups = 974mg • OKT N/A • OHBS age groups in order young to old <ul style="list-style-type: none"> ○ Sev 2.98; 3.11, 2.87, 2.76 ○ Sus 2.75; 2.84; 2.75; 2.74 ○ HM 3.68; 3.74; 3.89; 3.95 ○ Ba Ca²⁺ 2.02; 2.07; 1.93; 1.96 ○ Be Ca²⁺ 3.39; 3.37; 3.57; 3.92 • Pre-M: Be Ca²⁺ 3.73 ± 0.51, Post 3.62 ± 0.60, • Pre-M: Ba Ca²⁺ 2.08 ± 0.70, Post 1.99 ± 0.61, • Pre-M women ↑ perceived serious Vs Post-menopausal • Post-M women ↑ perceived health motivation and greater benefits

Reference, Year, Country	Participants	Methodology	Main results
Swaim, Barner & Brown, 2008 (USA)	n=187 females 65+ age range	Cohort study Aim: Investigate between OHB and engagement of +ve bone behaviours Tools: Calcium FFQ PA survey for older adults OHBS OSES	Calcium intake: mean 1604.7 mg calcium /day. 36% consumed < RDI OKT N/A OHBS <ul style="list-style-type: none"> • Sus (3.1, 0.7) and severity (3.4, 0.7) neutral beliefs • +ve correlation Self-efficacy and Ca²⁺ intake and PA levels • -ve correlation self-efficacy of calcium intake = BMI, Caucasian • inadequate calcium intake more likely if Caucasian or ↑ BMI • BMI, age and Caucasian inversely related to exercise self-efficacy. • Demographics 39.6% American Mexican, 32.6% Caucasian
Tsai, 2008 (New Zealand)	n=102 Female 20-49 age range	Cohort study Aim: To investigate OHB and association with Ca ²⁺ intake in South Asian female NZ population Tools: OKT OHBS 4-day food dairy	Calcium intake= 685 mg /day - (RDI 1000mg) OKT- mean score 15.1 out of 26 (58%) OHBS <ul style="list-style-type: none"> • Sus - low 17 • Sev - high - 19.3 • Be Ca²⁺ - perceived higher benefits • Ba Ca²⁺- 13.4 (16% thought milk high in cholesterol) • HM- high score - 22.4 (Increased with age) • Predictors Ca²⁺ intake: BaCa²⁺, HM and use of supplements (any)
Studies investigating the effect of interventions based on OHB and subsequent change in beliefs (+/- assessment of behaviour change).			
Babatunde, Himburg, Newman, Campa & Dixon. 2011, USA	n= 110 Men and women > 50 years old Male n = 11 Female n = 99 IG n = 59 CG n = 51	RCT: 6 weeks, pre/post test Aim: Test OHB intervention Tools OKT OHBS SES Rapid Assessment method (RAM) calcium	Calcium intake T0 - T1 ⁷ IG ⁸ = 874mg - 1430mg Vs CG ⁷ 817mg - 778mg OKT T0 - T1: IG = 9.6 - 13.6 Vs CG = 8.4 - 8.9 OHBS T0 - T1: IG Vs CG <ul style="list-style-type: none"> • Sus: 17.2 - 19.8 Vs 15.9 - 16.6 • Be Ca²⁺: 24.3- 25.9 Vs 23.8 - 25.1 • Little change in Ba Ca²⁺, Sev and HM Significant ↑ in self-efficacy.

7. Pre-test measurements T0 - Next test measurement T1, T2, T3, T4 according to how many measures taken during the intervention.

8. Intervention group (IG), Control group (CG)

Reference, year, Country	Participants	Methodology	Main results
Endicott, 2013 USA	n=37 Female 42-52 age range Osteoporosis Family history (OPFH) = 18 No Osteoporosis Family History (NOPFH) = 19	Intervention pre-test/post-test educational program Aim: Assess impact of familial history on knowledge, health beliefs, and self-efficacy Tools: OKT OHBS OSES	Calcium intake N/A OKT Pre-test T1, post-test T2 <ul style="list-style-type: none"> OPFH T1 12.8; ↑ T2 25.8 NOPFH T1: 12.2 ↑T2 26.11 No difference in knowledge between groups OHBM constructs <ul style="list-style-type: none"> OPFH: ↑ exercise benefits (T126.33; T2 27.89) NOPFH: ↑ calcium benefits (T1 23.68; T2 26.00) Non-significant results OPFH more susceptible than NOPFH (non-significant) ↑self-efficacy post-test both groups
Evenson & Saunders 2016, USA	n= 153 Female = 112 Male= 41 18-23 age range 3 groups CG IG1 = theory intervention IG2 = Activity based intervention	RCT 8 weeks Pre/post-test 3 measurements Aim: determine type of intervention best suited for both men and women and assess Vitamin D (VD) knowledge, OHB and measure dietary intake of VD Tools: OKT-D (include vitamin D) Expanded (E)OHBS 3DDD calcium +vitamin D SES-D (vitamin D)	Calcium Intake 1078mg/day Vitamin D intake 224IU/day OKT-D increase from 57% - 72% across groups. Significant difference between CG and IG (theory intervention) OHBS <ul style="list-style-type: none"> BeEx F (2,149) = 17.62, p < .001 Be Ca²⁺ intake F (1,149) = 19.90, p < .001 Benefits of Vitamin D intake F (1,149) = 37.16, p < .001 No significant differences between groups No differences between genders Predictor for calcium = Ba Ca²⁺ accounting 11.2% variation Predictor for vitamin D intake = ↑Self-efficacy for calcium intake accounting for 7.3% variation
Kalkım & Dağhan 2017 Turkey	n= 73 Female 30-45 age range IG = 37 CG = 36	Pretest-post-test RCT 2 groups IG/CG Aim: Evaluate 6-month intervention program on OKT and Ca ²⁺ intake	Calcium intake Baseline (T0): Final (T3) <ul style="list-style-type: none"> IG: (T0) 859.83 (T3) 1274.02 CG: (T0) 910.50 (T3) 1274.02 Change in OKT Baseline (T0): Final (T3) <ul style="list-style-type: none"> IG: T0= 9 - T3 23.08 Vs CG T0: 9.83 -T3: 10.05

Reference, year, Country	Participants	Methodology	Main results
Kalkım & Dağhan 2017 Turkey (Continued from previous)		4 education sessions, text messages and 24 weeks counselling. x4 DCP ⁹ Tools: OKAT OHBS OSES Calcium and exercise estimation	OHBS scores Change IG Vs CG: T0 to T3 <ul style="list-style-type: none"> Sus: IG: T0:19.00 - T3:28.43 Vs CG T0 :18.77 – T3:19.13 Sev: IG: T0: 18.35 - T3:27.91 Vs CG: T0: 18.66 – T3:18.69 BeEx: IG: T0 :21.70 - T3: 28.43 Vs CG: T0: 22.41 – T3: 18.69 Be Ca²⁺: IG: T0: 21.27 - T3: 29.40 Vs CG T0: 21.38 – T3: 21.44 BaEx: IG: T0: 15.51 – T3: 7.54. Vs CG: T0: 15.66 – T3: 14.75 Ba Ca²⁺: IG: T0: 14.51- T3: 29.40, Vs CG 13.94 – T3: 21.44 IG ↑ Ca²⁺intake ↑OKT ↑ OHB Vs CG Self-efficacy best predictor of behaviour change
Kolac & Yıldız 2022 Turkey	N=82 Female 50-65 age range IG = 41 CG = 41	12-week RCT pre-test post- test design 3 DCPs Aim: Assess intervention effect on postmenopausal women (PMW) OHB and Knowledge Tools: OHBS OKT	Calcium intake n/a OKT scores Change T0 – T3. <ul style="list-style-type: none"> IG: 17.63 - 27.17 CG 16.95 -19.90 OHBS scores Change from T0 – T3 (only total scores supplied) <ul style="list-style-type: none"> IG: 135.17 - 144.14 CG: 139.92 - 141.87 Self-efficacy identified as predictor of +ve bone health behaviour.
Jung, Ginis, Phillips, & Lordon 2011, Canada	18-19 years olds n= 133	Placebo double blind controlled RCT 52-weeks with DCP at 0, 1, 8, 25, and 52 weeks Aim: assess effect positive messages on Ca ²⁺ intake Tools BMD measurement 3 DDD OHBS	Calcium intake <ul style="list-style-type: none"> IG = baseline 927mg/day- 1144mg/day by week52 CG = 891mg/day - 813 mg/day week 52 OKT = N/A OHBS comparison between IG and CG ↑ Self efficacy ↑ Benefits ↓Sus ↓ Perceived barriers. Self-efficacy was the only HBM construct to improve significantly more in the experimental condition versus control. No predictors found for calcium intake. ↑ Ca²⁺intake with +ve messages over normal resources

9. Data collection point (DCP)

Reference, year, Country	Participants	Methodology	Main results
Lein, Clark, Turner, Kohler, Snyder, Morgan, & Schoenberger 2014, USA	n=150 female 19-25 age range Intervention 1 (Theory only) n= 100 Intervention 2 (Theory + QUS) n=50	Intervention trial, no control repeated measures: T0, T1, &T2 Aim: To assess whether a theory-based intervention could affect bone health behaviours. Tools: Calcium FFQ OBHS	Calcium intake (mg) T0-T3 IG1 = 606.3 - 835.7 Vs IG2 = 532.2 - 804.7 Both groups had increase in intake with no difference between groups. OKT = N/A OHBS <ul style="list-style-type: none"> • Susceptibility: T0- T3: IG1 = 2.73 - 2.76 Vs IG2 = 2.54 - 2.49 • Severity T0- T3: IG1 = 2.93 - 3.02 Vs IG2 = 2.98 - 3.01 • Calcium Barriers: T0- T3: IG1 = 1.94 - 1.87 Vs IG2 = 1.91- 1.87 Since significant increase in calcium intake in both groups main result is that tailored messages sufficient extra information from scans not required.
Murimi, 2008 USA	n= 167 Females 45-54 age range	Intervention study (no control) Aim: 1. To evaluate OHB and demographic factors on Ca ²⁺ intake; 2. Assess effect of intervention on Ca ²⁺ intake. 2 DCPs: T0 – T2 Tools: Questionnaires Calcium FFQ OHBS	Calcium intake (Mg/day) T0-T1: 992- 1109 OKT n/a OHBS (% of respondents who perceived themselves) <ul style="list-style-type: none"> • 33% Sus • 80.2% Sev • 87.7% Be Ca²⁺ • 87.5% perceived few barriers to calcium intake. • General ratings on OHBS 4.6 within a range of 1.0 - 6.0 • Predictors of Ca²⁺intake Perception of the benefits of calcium supplements, level of education and no. of dependant
Nguyen Vu, H, Wang Ze, Waigandt A C, 2013 USA	n=109 Females 18-21 age range CG: n= 56 IG: n= 53	RCT (2 weeks) 2DCP T0 & T2 Aim: Assess effect of intervention aimed ↑ Perception severity Tools: OHBS OSES Calcium FFQ	Calcium intake(serves/day). CG: T1:2.69 - T2:2.84 Vs IG: T1:3.05 - T2: 2.82 <ul style="list-style-type: none"> • No significant results found between group differences for any of the constructs of 11 variables examined. • Intervention not effective in increasing calcium intake • Education did not increase perceived susceptibility or severity. • Perceived barriers increased.

Reference, year, Country	Participants	Methodology	Main results
Pinar & Pinar 2020 Turkey	n=66 Females 18-49 age range IG = 38 CG = 28	RCT 4DCPs T0, 3, 6 & 12M Aim: Assess effect of intervention of education & counselling on bone health behaviours Tools: Ca ²⁺ & 25OH (serum samples) DXA OKT OHBS	OKT Significant change in IG IG 16.22 – TT3 22.6 Vs CG T0: 15.30 – T3: 15.95 HBMS significant change in every domain IG <ul style="list-style-type: none"> • Sus T1: 20.26 - T3:23.06 • Sev T1: 21.64 - T3:25.55 • BeEx T1: 16.42 - T3: 25.85 • BeCa²⁺ T1: 15.66 - T3: 28.67 • BaEx T1: 22.42 - T3: 15.58 • Ba Ca²⁺ T1: 19.00 - T3: 13.15 • HM T1: 22.91 - T3: 26.24 • Behaviour change (reported actions) evident at 12 months. • Changes in serum ca2+ and 25 OH not stat sig no other measures • No statistically significant change any CG results.
Sedlak et al., 2008 (USA)	n=203 Females 50-65 age range IG =101 CG =102	RCT 3DCP T0, T1,6M & T2,12M Aim: Examine effect personal knowledge of BMD via DXA scans, +ve bone behaviours & OHB Tools: DXA scan OHBS OKT OSES OPBS (osteoporosis preventing behaviours survey)	Calcium intake IG ↑ in-take 0-6 months Vs CG <ul style="list-style-type: none"> • IG (T1) 606.51 mg ↑ (T3) IG 836.22 mg • CG (T1) 620.29 mg ↓(T3) CG 750.15 mg OKT <ul style="list-style-type: none"> • IG (T1) 16.39 ↑ T3 17.85 • CG (T1) 16.46 ↑ T3 17.44 • Personal knowledge received through the DXA scan led to increased calcium intake due to ↑ Sus and Sev. • In IG group 41% found to be osteopenic, 17% osteoporotic. • -ve correlation; Sus -.184 (p<0.01) • Decrease in Ba Ca²⁺ intake .184 (p <0.01) • ↑Not sustained, intake dropped by 12-month DCP • No clinically significant increase in exercise.

2.6 Research investigating Osteoporosis Health Beliefs

2.6.1 knowledge of osteoporosis in relation to health behaviours

The OKT is used widely when assessing OHB. This permits identification of gaps in knowledge that may influence health behaviours (Chelf et al., 2022; Doheny et al., 2007; Endicott, 2013; Kalkım & Dağhan, 2017; Kolac & Yıldız, 2022; Sedlak et al., 2007; Tsai, 2008; von Hurst & Wham, 2007). Older women generally demonstrated slightly more knowledge about osteoporosis than younger participants (Janiszewska et al., 2016; von Hurst & Wham, 2007). Additionally, gender differences also exist, with women being more knowledgeable about osteoporosis than men (Chelf et al., 2022; Doheny et al., 2007).

2.6.2 Increasing Knowledge to Support Protective Bone Behaviours

Strategies to increase osteoporosis knowledge with the hypothesis that this will increase subsequent engagement of protective bone health behaviours was extensively explored (Babatunde et al., 2011; Doheny et al., 2007; Endicott, 2013; Jung et al., 2011; Kalkım & Dağhan, 2017; Kolac & Yıldız, 2022; Nguyen et al., 2012; Pinar & Pinar, 2020; Sedlak et al., 2007). These interventions were designed to increase knowledge within a dimension of the HBM, such as increasing the perception of severity through comparison images of osteoporotic and normal bones (Nguyen et al., 2012). These studies had mixed results depending on the target construct within the intervention (Deo et al., 2013; Doheny et al., 2007; Endicott, 2013; Murimi, 2001; Nguyen et al., 2012; Pinar & Pinar, 2020). One study using DXA scans to increase knowledge and perceived susceptibility through personal visual aids measured an initial increase in reported calcium intake, but this effect declined after the six-month remeasurement and again at the subsequent 12-month review (Sedlak et al., 2007). One other study identified a positive correlation between increase in knowledge and a sustained increase in calcium intake with an intervention that increased perceptions of severity and reduced calcium barriers. Though a significant increase in calcium intake was measured, the follow-up measurements were limited to 6 months (Kalkım & Dağhan, 2017). A further systematic review of interventions using educational resources to increase calcium intake demonstrated unpredictable results (Ryan et al., 2013). It was noted that successful interventions identified targeted the appropriate health belief predictor of behaviour change for the sample demographic. This permitted subsequent design of an

intervention which would more likely elicit behaviour engagement (Ryan et al., 2013). This indicates that behaviour change is not dependant solely on the increase in knowledge, and it is useful to identify predictors of positive bone behaviours before introducing an intervention. Equally, people require age and gender-specific motivators to engage in behaviour change.

2.6.3 Health Beliefs in Relation to Positive Bone Health Behaviours

Perceived threats (severity and susceptibility). According to the HBM, a person needs to perceive themselves as susceptible and the consequences of the health condition have to be severe enough to seek behaviour change (Brown et al., 1983). As perceived threats, they are often classified together. A few studies discovered low levels of both constructs among participants (Chelf et al., 2022; Deo et al., 2013; Nguyen et al., 2012; von Hurst & Wham, 2007). However, participants may also attach very different values to each construct (Janiszewska et al. 2016; Johnson et al., 2008; Murimi, 2001; Tsai, 2008). One study based in NZ amongst South Asian women found that women may have a moderate perception of the seriousness of osteoporosis and a conversely low perception of susceptibility (Tsai, 2008). Additionally, Janiszewska et al. (2016) identified that 70% of the women in the sample had a moderate perception of severity, yet only 5% had a moderate perception of susceptibility. Gender comparison studies reported similar results: men consistently have lower perceptions of susceptibility compared to women (Chelf et al., 2022; Doheny et al., 2007; Johnson et al., 2008; Nayak et al., 2010). However, study results between female age groups demonstrated more heterogeneity. One study found no differences across different age groups of women (von Hurst & Wham, 2007), whereas another found that premenopausal women perceived greater seriousness and susceptibility than post-menopausal women (Piehowski et al., 2010).

Interestingly, none of the studies identified susceptibility as a predictor for calcium intake, but the perception of severity has been associated with calcium intake (Fekau, 2021). However, intervention studies focussing on increasing knowledge through the perception of severity (alone) in either sex or age group yielded no statistically significant results in sustained uptake of bone protective behaviours (Murimi, 2001; Nguyen & Wang, 2012; Sedlak et al., 2007). This indicates that though perceptions of

severity and susceptibility contribute to an individual's health beliefs, the relationship between these perceptions and subsequent behaviour change is not well understood.

Perceived Benefits and Barriers of Positive Health Behaviours. Within the context of osteoporosis, perceived benefits and barriers relate to calcium intake and exercise. These four constructs allow investigation of perceptions around calcium intake or exercise and can illuminate interesting perceptions. One NZ study on a female cohort discovered that 77.2% of respondents agreed with the statement “calcium-rich foods have too much cholesterol.” This sample composed of three age groups, with the oldest age group (40–49-year-olds) most likely to agree with this belief (statistically significant $p= 0.002$) (von Hurst & Wham, 2007). Interestingly, another study also based in NZ, this time on a South Asian cohort with a mean age of 40.6 years, identified that only 16% of the participants' thought that milk was high in cholesterol (Tsai, 2008). Additionally, a further NZ study of 18-30-year-olds noted that only 9% of the sample agreed with this statement (Fekau, 2021). This supports the theory that health perceptions differ according to the age and ethnicity of the population of interest.

Further age-related differences in perceived benefits and barriers to both exercise and calcium intake exist. One study found a higher level of exercise barriers in younger women compared to the older participants (von Hurst & Wham, 2007). This finding was supported in another study, where post-menopausal women demonstrated higher perceived benefits and lower perceptions of barriers compared to pre-menopausal participants (Piehowski et al., 2010). A few studies also discovered an association between participant demographics such as having a higher level of education with lower perceived barriers to calcium intake and exercise (Janiszewska et al., 2016; Murimi, 2001; von Hurst & Wham, 2007).

Intervention studies aiming to increase calcium intake by increasing osteoporosis knowledge of benefits and reducing barriers exhibited positive short-term results (Kalkim & Dağhan, 2017; Kolac & Yıldız, 2022; Pinar & Pinar, 2020). One study used a positive educational support and an exercise training intervention. At the six-month review, an increase in perception of calcium benefits was reported from 21.27 up to 29.40 (out of 30), along with a simultaneous increase in daily calcium intake from 860mg up to 1274 mg. Importantly, a decrease in barriers was also noted (Kolac &

Yıldız, 2022). This indicates that increasing perceptions of benefits and decreasing perceptions of barriers can be useful to support calcium intake.

Health Motivation. The individual's ability to seek support or independently practice positive health behaviours is measured by the construct of health motivation. Importantly, a high perception of this construct is thought to lead to subsequent adoption of a recommended health behaviour (Ljubičić et al., 2022). Chelf (2022) noted statistically significant correlations between exercise benefits, barriers, and health motivation. The moderate negative correlation between barriers to exercise and health motivation is stronger than the positive correlation with exercise benefits. This indicates that barriers might have a greater impact on health motivation and therefore, health behaviours.

Differences in perceptions according to gender and age also impact health motivation (Doheny et al., 2007; Johnson et al., 2008). Younger women appeared to have lower health motivation than men, despite having a higher perception of severity, susceptibility, and osteoporosis knowledge (Doheny et al., 2007). However, this may change with age. Johnson et al. (2008) reported that older women demonstrated higher levels of health motivation compared to both older men and younger women. This observation was supported in other studies (Piehowski et al., 2010; Tsai, 2008; von Hurst & Wham, 2007). This indicates that health motivation changes with age and differs between genders. A previous NZ study noted this difference between younger and older women; however, further investigation of how this difference translated to engagement with health behaviours is unknown due to a lack of measurement of either exercise or calcium intake (von Hurst & Wham, 2007).

2.6.4 Predictors of Positive Health Behaviours

Among the literature reviewed, 13 studies included measurement of calcium intake to permit investigation of the predictors for positive bone health behaviours. Identified predictors for calcium intake included health motivation (Chelf et al., 2022), perception of benefits for calcium (Murimi, 2001; Tsai, 2008; von Hurst & Wham, 2007), lack of barriers (Murimi, 2001; Tsai, 2008), severity (Fekau, 2021) and exercise benefits (Kalkim & Dağhan, 2017). However, some studies did not identify any predictors (Jung et al., 2011; Lein et al., 2014; Nguyen & Wang, 2012; Pinar & Pinar, 2020; Sedlak et al.,

2007). Additionally, a few studies highlighted isolated demographic factors as predictors. Negative predictors of BMI and/or Caucasian ethnicity were identified (Swaim et al., 2008), whereas positive predictors included increased levels of education and number of dependents (Murimi, 2001). This indicates the complexity of health behaviours and the ongoing need to investigate how health beliefs may explain engagement with positive bone health behaviours.

2.6.5 Summary

Osteoporosis is a complex and insidious health condition with a number of risk factors. It has become a significant health concern in NZ due to the negative consequences for quality of life, the cost of treatment, and an increasing older adult population. Since identified lifestyle habits such as exercise, calcium and vitamin D intake can significantly reduce the risk, there is a growing emphasis on prevention strategies. Postmenopausal women have a high risk of depleted BMD and therefore, are a key target group for interventions to delay the onset of osteoporosis.

Population engagement with behaviour change, such as increasing calcium intake, is unpredictable and does not seem to be associated with an increase in knowledge. Instead, use of the HBM can facilitate an understanding of perceptions towards osteoporosis and the predictors of behaviour change. Previous studies have noted that health beliefs can change according to the population, gender, and age group. There have been previous NZ based studies investigating the associations between health beliefs, knowledge, and calcium intake. However, these focussed on women younger than 50 years of age (Fekau, 2021; Tsai, 2008; von Hurst & Wham, 2007). The health perceptions of post-menopausal women in NZ therefore remain largely unknown. This study will support a better understanding of the health perceptions of NZ postmenopausal women using the OKT and OHBS in relation to calcium intake using a NZ validated calcium specific FFQ (Fekau, 2021). The evidence from this study will support future potential intervention strategies to support positive bone health among post-menopausal women in NZ.

Chapter 3: Manuscript

Associations between osteoporosis knowledge, health beliefs and bone promotive behaviours in post-menopausal women in New Zealand (NZ)

3.1 Abstract Background: Osteoporosis is the most prevalent metabolic bone disease globally. Estimated to affect 35.5% of women over 50 years of age, with increasing incidence associated with the ageing population of most western countries. Several preventative strategies, such as calcium intake, have been identified to reduce the onset of osteoporosis in post-menopausal women. However, increasing knowledge of osteoporosis to promote engagement with positive bone health behaviours has produced inconsistent results. Health beliefs may be an important influence to investigate in relation to engagement in behaviours, such as calcium intake.

Objective: To investigate the relationship between calcium intake, osteoporosis knowledge, and osteoporosis health beliefs (OHB) among post-menopausal women in NZ.

Methods: This study reports on the calcium intake, osteoporosis knowledge test results, and OHB of a cohort of 66 post-menopausal women. It is a secondary analysis of data collected from a calcium-specific food frequency questionnaire (FFQ) and survey data from the “Footprint” study. The surveys used included a bone health (BH) questionnaire, the revised osteoporosis knowledge test (OKT-r) and the osteoporosis health belief survey (OHBS).

Results: A weak negative correlation was found between the perception of severity ($r_s = -0.301$, $p = 0.017$) and calcium intake. Linear regression was used to detect predictors of calcium intake. The final model accounted for 17.2% of the variation with the benefits of exercise being the only health belief construct to predict calcium intake ($\beta = 0.430$, $p = 0.007$).

Conclusions: The findings of this study suggest that there is an association between calcium intake and health beliefs around osteoporosis. However, further research would be required with a larger sample size to support these results.

Key words: post-menopause, women, osteoporosis, health beliefs, knowledge, calcium intake, bones

3.2 Introduction

Osteoporosis is a chronic condition characterised by excessive loss of bone mass, resulting in fragile, brittle bones at risk of fracture (Arnett, 2015; Osteoporosis New Zealand (ONZ), 2017). Since natural loss of bone mass density (BMD) is expected with age, the onset of osteoporosis is often insidious. Diagnosis is frequently missed until a fracture occurs; therefore, prevalence is thought to be underestimated (Watt et al., 2012; Sedlak et al., 2007).

Osteoporosis affects approximately 12.5% of men and 35.5% of women over 50 years of age (Watts et al., 2012; Wu et al., 2021). The disproportionate representation among postmenopausal women is due to the intimate relationship between a menopausal decrease in oestrogen levels and bone health. This decline in oestrogen production following menopause can result in up to a 20% loss of BMD (Pouresmaeili et al., 2018; Sedlak et al., 2007). Globally, the prevalence of osteoporosis is projected to increase from 153 million cases reported in 2010 to an estimated 310 million by 2040 (International Osteoporosis Foundation (IOF), 2023). This rise is reflected in NZ, with an increase of ACC fragility fracture, and related claims by 47% since 2013 (ACC, 2021). The cost of treating and rehabilitating older adult fractures is significant. In 2021, ACC reported a cost of NZD\$193 million to treat and rehabilitate those with osteoporotic-related fractures. Importantly, the most common fracture sites are at the hip, vertebrae, or wrist bones, skeletal locations that greatly influence independent function. In consequence, the occurrence of fractures can be debilitating and potentially impact long-term independence (ACC, 2021).

Despite some inevitable loss of bone density with age, osteoporosis is largely a preventable condition (ACC, 2021; Arnett, 2015; Pouresmaeili et al., 2018). The Ministry of Health (MoH) in NZ publishes diet and lifestyle recommendations to promote bone health throughout adulthood. These include specific guidelines for weight bearing exercise as well as recommendations to promote dietary inclusion of adequate intakes of both vitamin D and calcium (MoH, 2013, 2020). Equally, the public health organisation ONZ is committed to promoting health messages. Targeting interventions

towards those at important life stages with respect to bone health, such as the female menopause (ONZ, 2017). However, increasing knowledge is not always associated with subsequent behaviour change (Green et al., 2020; McLeod & Johnson, 2011; Nguyen, 2014; Sedlak et al., 2007; Terrio & Auld, 2002). This indicates that knowledge alone cannot predict the adoption of positive diet and lifestyle behaviours. The Health Belief Model (HBM) is one theory of health behaviour which can be used to increase understanding of an individual's engagement with positive bone behaviours. (Boston University School of Public Health, 2022).

The HBM model identifies health beliefs that can act as barriers or promoters of health behaviours (Boston University School of Public Health, 2022). Known differences in individual health beliefs depending on different factors have led to the development of research tools and surveys to permit investigation into OHB (Boston University School of Public Health, 2022; Luger, 2013). Previous studies have identified differences in perceptions between genders (Chelf et al., 2022; Doheny et al., 2007; Johnson et al., 2008) and age groups (Janiszewska et al., 2016; Piehowski et al., 2010; von Hurst & Wham, 2007). Furthermore, perceptions can be influenced by family history (Endicott, 2013), ethnicity (Swaim et al., 2008), and even diet habits (Gammage et al., 2009). Previous NZ based studies on calcium intake in relation to osteoporosis knowledge and health beliefs have been focussed on South Asian females in Auckland (Tsai, 2008) or young female university students (Fekau, 2021).

Nationally, little is known about the perceptions of post-menopausal women towards calcium intake to support bone health. However, there is an increasing national trend of osteoporotic fragility fractures. Using osteoporosis specific survey tools based on the HBM would permit exploration of the perceptions and knowledge of post-menopausal women. Measurement of calcium intake would facilitate investigation into the relationship between health beliefs, knowledge and engagement with a bone-promotive behaviour. This would increase understanding of older women's engagement behaviours towards osteoporosis prevention and potentially guide future design of interventions supporting positive bone behaviours.

3.3 Method

3.3.1 Study Design

This study is a secondary analysis of data collected from the cross-sectional, observational “Footprint” study. It investigates the association between calcium intake and health beliefs and knowledge of osteoporosis amongst post-menopausal women in NZ.

The original study aimed to assess the bone health of post-menopausal runners in contrast to an age-matched sedentary group, with the additional objective of exploring OHB and dietary habits. Data collection was conducted in the North Island of NZ between 2017 and 2019. The present analysis focusses on the survey data collected in relation to health beliefs and dietary habits, as per Figure 3.1.

Figure 3.1

Overview of Study

Footprint Overview

N=66

- Post-menopausal women

Research tools.

- Bone health questionnaire (BHQ) with calcium specific food frequency questionnaire (FFQ)
- Osteoporosis health belief survey (OHBS)
- Revised osteoporosis knowledge test OKT-r

3.3.2 Sample Size

The sample size for the current study was calculated using G*power version 3.1 using the linear multiple regression fixed model as the statistical test, with an effect size of 0.15, α -err probability of 0.05, power (1- β err prob) of 0.08 and 8 predictors to be included in the regression analysis. This resulted in a required sample size of 109 participants.

3.3.3 Participants and Recruitment

Healthy postmenopausal women (defined as being five or more years since last menstruation) were recruited by advertising at marathon events, running clubs, local

news, social media, church groups and via the electoral roll. The potential participants contacted the research team by phone or email to express their interest and were sent an information sheet (Appendix A). Prior to enrolment, they completed a health screening form (Appendix B). Participants were included if they were post-menopausal and in general good health. Participants were recruited into two categories: sedentary or active. Those in the sedentary category demonstrated a physical activity (PA) level of less than 7000 steps per day (Health and Wellbeing Queensland and Wellbeing SA, 2024). This was measured using a pedometer. The data of both recruited groups was used for the current study.

Participants were excluded if they had osteoporosis or a medical condition that might adversely affect bone metabolism. The flow chart of the study with inclusion and exclusion criteria can be found in Appendix C. Successful participants completed a consent form (Appendix D). An appointment at the Human Nutrition Research Unit (HNRU) was subsequently arranged to complete questionnaires and tasks related to the larger study.

3.3.4 Ethical Approval and Considerations

The application for ethical approval was granted by the Massey University Human Ethics Committee (MUHEC), application number SOA17/07 (Appendix E). During recruitment, participants were sent an initial information sheet with details of the research aims, research purpose, participant tasks, time commitment involved, data management, participant rights during the study, and researcher contact details. Participants were informed that their contribution was voluntary, and they could withdraw at any time during the study. Once enrolled, all identifiable information was replaced with an identification number to ensure confidentiality, and all information pertaining to the study was stored on a secure server with password protection and sole access by the study researchers. The study information sheet is enclosed in Appendix A.

3.3.4 Data Collection

Each participant completed the three following questionnaires during the visit to HNRU at Massey University, Manawatu campus. All questionnaires were pretested using cognitive interviewing and revised as required prior to data collection. The participants

were given the option to complete the forms online, using Survey Monkey, or in hard copy, which was then scanned and stored on the secure server.

Bone health questionnaire (BHQ). This questionnaire comprised of 71 questions over six sections, covering medical history, reproductive history, lifestyle behaviours, the calcium specific FFQ, PA, and demographic questions. This study reports on the analysis carried out on 8 of the 71 questions, covering family history relating to osteoporosis, several demographics, PA, supplement use, and the FFQ. The questions used for this study from the BHQ can be found in Appendix F.

Calcium specific FFQ. Within the BHQ was a 20-item calcium-specific questionnaire derived from the 30-item calcium specific FFQ by Magkos et al. (2006) and the NZ women's FFQ (NZWFFQ). This FFQ was validated previously on a young (18–23-year-old) NZ female population, finding a moderately positive correlation to the 3-day diet diary method ($r_s = 0.450$, $p = 0.00$) (Fekau, 2021). The structure of this FFQ asks the participant to state the frequency of stated serving sizes of consumed foods, as either per day, week, month, or infrequently. The serving sizes are described in an easily visualised manner, e.g., handful, cup, tablespoon, matchbox size.

Revised Osteoporosis Knowledge Test (OKT-r). An updated version of the original OKT was used in the current study. The revision was completed by the original researchers to reflect changes in osteoporosis knowledge (Gendler et al., 2015). Following pre-testing of the questionnaire for the current study, three questions were omitted due to potential confusion in the NZ context. Two of these questions focussed on the recommended dietary intakes (RDI) of calcium and vitamin D, while the third was about a high BMI as a risk factor. The questionnaire for the current study (attached in Appendix G) consisted of 29 questions over four domains. The risk domain has 10 questions, exercise domain six questions, the nutrition domain has 10 questions, and the general domain has three questions. All the questions were multiple choice, with the initial 10 risk questions having a choice of more likely, less likely, neutral, or I don't know. Whilst the other 19 questions proposed a choice of three potential answers. The potential maximum score is 29, with 1 point allocated per correct answer. Levels of knowledge have been categorised previously as low (below 50%), moderate (51-69) and high (over 70%) (Chan et al., 2019; Fekau, 2021; Nguyen & Wang, 2012).

Permission was granted for the use of the OKT in the current study (Gendler et al., 2015).

Osteoporosis Health Belief Survey (OHBS). This questionnaire developed by Kim, Horan, and Gendler (1991) is based on the constructs of the HBM. This tool consists of a 42-item questionnaire with seven subscales comprising of six statements. The participant picks a Likert-scale response ranging from strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). The total range of scores for each subscale is 6-30, with total scores ranging from 35-210. In theory, higher scores indicate more likely engagement with bone protective behaviours (Kim et al., 1991). The full questionnaire can be referred to in Appendix H.

3.3.5 Data Entry and Statistical Analysis

Survey data. Completed surveys were downloaded, checked, sorted, and then scanned to allocated data files organised by an identification number. The data from the OHBS, OKT-r, and BH surveys were entered into the IBM statistical package for social science (SPSS) version 29.0.10. Questionnaire responses using Likert scales were recoded for analysis, with missing data coded 999 and excluded from the data analysis.

Levels of PA were assigned to the participant descriptions in the BHQ and guided by the Sedentary Behaviour Network, the compendium of physical activities (Ainsworth et al., 1993), and the MoH activity guidelines (MoH, 2020; Tremblay et al., 2017). All descriptions were coded as sedentary (PA \leq 3 metabolic equivalent of task (METs) \leq 150 minutes per week), moderate (PA = 3 METs 150-300 or PA = 3-6 METs 75-150 minutes per week), or vigorous (PA 3-6 METs \geq 150 minutes per week) and subsequently recoded 1,2 or 3 respectively for SPSS analysis. Three examples for each level were randomly picked and cross-checked by a second researcher according to the agreed description. All the data sets were checked and cleaned before the calculation of scores, percentages, and statistical analysis.

Calcium specific FFQ. The calcium content of each item on the 20-item FFQ had been analysed during the previous validation study using Foodworks 10 (Xyris software Pty, Brisbane, Australia) based on the NZ food files of 2016 (Fekau, 2021). An average calcium content had already been calculated for each item, e.g., “1 matchbox of hard cheese” was assigned 288 mg, represented by the average calcium content of

several types of cheese. The 20-item FFQ and the rationale for average calcium per FFQ category are enclosed in Appendices F and I. The frequency of stated amounts of the food item was converted into a daily amount. For example, if the respondent wrote that they consumed 1 serve of 1 matchbox of hard cheese per week, the amount was divided by 7 to yield the amount in mg per day. The sum of daily intakes from each food represented the respondent's daily intake of calcium. These totals were then transferred to SPSS to be tested for normality, descriptive statistics, parametric, non-parametric tests, and regression analysis.

3.3.6 Statistical Analysis

All statistical analysis was carried out using IBM SPSS version 29.0.1.0. Variables were checked for normality using the Shapiro-Wilk and the Kolmogorov-Smirnov tests. If testing yielded a p-value greater than 0.05, the data was regarded as normal. Non-normal data testing with a p-value below 0.05 was initially (natural) log transformed and retested for normal distribution. If the data still yielded a p value below 0.05, it was regarded as non-parametric.

Normal data was reported as a mean (\pm standard deviation (SD)), log transformed data meeting a normal distribution was represented by the geometric mean with 95% confidence intervals, and non-normal data was reported by the median with 25th and 75th quartiles. Categorical data was reported as frequencies and percentages.

Internal consistency of the OKT-r constructs and OHBS dimensions were tested using Cronbach's alpha. A value of > 0.7 was considered acceptable for the scales comprising of six questions (Tavakol & Dennick, 2011). Cronbach's alpha can be used to compare individual scores to the overall score. This identifies whether the alpha level would increase and therefore the reliability of the questionnaire if the question was omitted (Taber, 2018; Tavakol & Dennick, 2011). Each subscale was also tested to determine if removal of an item would result in an increase in the alpha value.

Bivariate correlations were carried out. Pearson's correlation coefficient was used for parametric data and Spearman's Rho for non-parametric data to investigate the relationships between the independent variables. Additionally, bivariate correlation using Spearman's Rho was used to investigate the relationship between the dependent variable of calcium intake and the independent variables. These included the health

belief constructs (health motivation, susceptibility, severity, calcium benefits, calcium barriers, exercise benefits, exercise barriers), and family history. supplement use, level of educational attainment and OKT.

Multiple linear regression was used to test the association between the independent variables and calcium intake and identify predictors. The categorical variables of family history, level of education, use of supplements, use of fortified foods, and level of activity were converted into dummy variables to allow inclusion for regression analysis.

Multicollinearity was assessed using a correlation matrix, and heteroscedasticity was checked visually, assessing residual graphs. None of the variables were identified to violate assumptions. None of the independent variables demonstrated strong correlations (≥ 0.8) (Field., 2018). Enter method of linear regression was used to test the association between the dependent variable of calcium intake and the independent variables. Reporting for statistical significance was set at $p = < 0.05$.

3.4 Results

The purpose of this study was to investigate the association between engagement in the bone protective behaviour of calcium intake, knowledge of osteoporosis, and the OHB of post-menopausal women. Sixty-six women completed the OHBS and OKT-r questionnaires, whereas 62 respondents completed the BH questionnaire containing the calcium specific FFQ.

3.4.1 Demographics

The participants ($n = 66$) were aged 53 -76 years old with a mean age of 62 (± 5.2), 71% of the sample were 65 years old or younger. Table 3.1 illustrates the participant's characteristics. The majority of the sample, 67.7%, were employed; 80.6% identified as NZ European and 62.9% had achieved either an undergraduate or postgraduate degree. Only 11.3% had a previous history of osteopenia or a stress fracture. Focussing on lifestyle habits and engagement with positive bone behaviours; 69.4% were meeting the MoH activity guidelines of ≥ 150 minutes of exercise weekly. Additionally, 53.2% were using a dietary supplement.

Table 3.1*Participant Characteristics and Lifestyle Habits*

Characteristic	Total n=62 (100%)
Age range (years)	53- 76
Ethnicity	
NZ European	50 (80.6)
Māori	1 (1.6)
Pasifika	2 (3.2)
Other Caucasian	9 (11.3)
Level of education	
Non tertiary	23 (37.1)
Tertiary	39 (62.9)
Current employment status	
Employed full or part-time	42 (67.7)
Retired	17 (27.4)
Student	1 (1.6)
Unemployed	2 (3.2)
Family history of osteoporosis	19 (30.6)
Personal medical history	
Osteopenia	4 (6.5%)
Stress fracture	3 (4.8%)
Physical activity levels per week	
Sedentary (≤ 150 minutes per week)	19 (30.6)
Moderate (150 – 300minutes per week)	27 (43.5)
Vigorous activity (≥ 300 minutes per week)	16 (25.8)
Current use of supplements	33 (53.2)

3.4.2 Calcium Intake (n= 61)

The calcium specific FFQ illustrated a range of daily intake from 166g to 2353mg per day. The geometric mean of participant 's intake was 804mg (705, 916). Interestingly, 74.2% of the sample did not meet the AUSNZ daily estimated average requirement (EAR) of 1,100 mg (National Health Research Council & Department of Health and

Ageing New Zealand MoH, 2017). Focussing on other lifestyle habits such as the PA of those who did meet the EAR for calcium intake, 25% were sedentary, 37.5% reported as moderate, and 37.5% were vigorous. This means that 75% of those who met the calcium EAR also achieved the MoH activity guidelines as well (MoH, 2020). Looking at the percentage contribution of food items to overall intake (the full graph presented in Appendix J), the main sources of calcium intake are hard cheese (21.8%), yoghurt (15.1%) and milk drinks (14.3%). Conversely, focussing on non-dairy foods, green vegetables supplied 8.19%, bread 4.1%, tinned fish 1.7%, almonds 4.5%, and chocolate 2.3%. Overall, dairy products supplied the participants with 70.7% of their calcium intake.

3.4.3 The revised Osteoporosis Knowledge Test (OKT-r) (n = 66)

The participants demonstrated a moderate level of knowledge, with an overall mean OKT-r score of 18.1 (\pm 4.6) 62% (Table 3.2). The level of knowledge between participants varied greatly, yielding a range from 8 to 27 out of 29 questions answered correctly. Cronbach’s alpha test for internal consistency was 0.709 for the exercise subscale, 0.730 for the nutrition subscale, and 0.760 for the entire OKT-r questionnaire. Focussing on individual questions, all scores remained within a close range of each subscale score, indicating an acceptable level of internal consistency.

Table 3.2

OKT-r Scores with Central Values and Score Interpretation

Domain	Median (25 th ,75 th)	Mean (\pm SD)	%	Interpretation
OKT-r Score	19 (15, 22)	18.1 (4.6)	62%	Moderate
Exercise subscale score	13 (9, 14)		68%	Moderate
Nutrition subscale score	15 (12,18)	14.6 (3.7)	64%	Moderate

Domains of the OKT-r. The full table of results for each question is presented in Appendix K. None of the individual domains demonstrated a normal distribution, so central tendencies are discussed as medians (25th and 75th percentiles).

Risk Domain. knowledge of risk factors for osteoporosis showed a range of correctly answered questions from 0 to 10, with a median of 6 (5,8) or 60%. There was high awareness that having a family history, an eating disorder, being menopausal, and

taking steroids (89.4%, 87.9%, 84.8% and 72.7%, correct respectively) increased the risk of osteoporosis. Conversely, 78.8% did not know that elderly men were at risk of osteoporosis and 54.5% were unaware that surgery to remove ovaries increased the risk. Whereas only 62.1% of the participants knew that dairy products reduced risk.

Exercise Domain. Respondents returned a median score of 4 (2,5) or 67% and a range of 0 to 6 answered correctly within this domain. The majority of respondents (>62% in each question) knew the types of activities and the intensity required to support bone health. However, most were unsure of frequency, with 66.7% of respondents returning an incorrect answer for the recommended number of 30-minute sessions of exercise recommended per week to reduce the risk of osteoporosis.

Nutrition Domain. The median score attained in the nutrition domain was 6 (5,8) or 60%, with a score range of 0–10 out of 10. Amongst the questions, a high rate of respondents correctly recognised that dairy was a good source of calcium, with 97% identifying cheese out of three food choices, 97% choosing yoghurt in a further question and 83.1% correctly identifying ice cream as a source of calcium. Additionally, 83.1% correctly identified the appropriate rationale for calcium supplement use. Conversely, 89.9% were unaware of the amount of milk required to meet the RDI of calcium and less was known about vitamin D. Most, 56.1%, of the sample knew that vitamin D was required to absorb dietary calcium; however, only 24.2% correctly identified salmon as a good source of dietary vitamin D.

General Domain. The general domain consists of three questions relating to peak bone mass, diagnosis, and medical management for osteoporosis. The median score for this domain was 2 (2,3) or 67%, with a range of 0-3 out of 3. The majority (78.8%) of participants correctly identified DXA scans as the method of diagnosis. Some confusion seemed to exist around the management of osteoporosis, with only 66.7% aware that medications could be used to treat osteoporosis.

OKT-r Results Summary. The respondents demonstrated a moderate level of knowledge, with a mean of 18.1 out of 29. Overall, 22.7% achieved a low score ($\leq 50\%$), 42.5% achieved a moderate score (50-69%), and 34.8% achieved a high score (≥ 70).

3.4.3 Osteoporosis health belief survey scores (n = 64)

The OHBS consists of seven constructs. Each construct has a possible score of 30, with a total possible score of 210. Table 3.3 presents the mean (\pm SD) or median (25th, 75th) of the total score and each construct. The mean total score was moderate at 124.6 (\pm 13.1) or 59%. In the reporting of answers from the OHBS agreement levels e.g., “agree” and “strongly agree,” were combined to facilitate reporting; however, the table of responses for each category of agreement can be found in Appendix L. Internal consistency of each six-question construct was tested using Cronbach’s α , with results yielding an acceptable range of ≥ 0.7 (Taber, 2018). The α levels were as follows; susceptibility: 0.900, severity: 0.829, exercise benefits: 0.870, calcium benefits: 0.871, exercise barriers: 0.864, calcium barriers: 0.838, and health motivation: 0.817. Individual construct questions had minimal margins of difference from the total construct value.

Table 3.3

The Osteoporosis Health Belief Survey (OHBS) results with interpretation.

Constructs	Median (25 th ,75 th)	Mean (\pm SD)	%	Interpretation
OHBS Score (n=64)	124 (117,132)	124.6 (\pm 13.1)	59	Moderate
Susceptibility (n=66)	16 (12,21)	16.4 (\pm 5.2)	55	Moderate
Severity (n=66)	16 (14,20)	16.7 (\pm 3.8)	56	Moderate
Exercise Benefit (n=66)	24 (23,27)		80	High
Calcium Benefit (n=65)	23 (19.5,24)		77	High
Exercise Barriers (n=65)	10 (6.50,14)		33	Low
Calcium Barriers (n=65)	12 (10,14)		40	Low
Health Motivation (n=65)	23 (22, 25)		77	High

Perceived Susceptibility

Perceived susceptibility refers to the individual’s personal belief that they might develop osteoporosis later in their own health journey. The participants in the present study had a moderate belief that they could develop osteoporosis, with a mean score of 16.4 (\pm 5.2) out of 30 and a range between 6 and 28. However, looking at individual questions, only 21.2% felt they were highly susceptible to osteoporosis. Whereas 30.3% agreed with “your family history makes it more likely that you will get osteoporosis.”

Perceived Severity. Severity refers to consequences related to developing osteoporosis. The participants had a moderate perception, with a mean construct score of 16.7 ± 3.8 and a range between 8 and 25. Though 51.6% agreed that the thought of getting osteoporosis scared them, only 36.3% of participants perceived osteoporosis to be a serious health condition, 19.7% thought it might be disabling, and 22.7% agreed that it might be expensive to have the condition.

Exercise Benefits. The construct of exercise benefits indicates how much the participant believes that exercise promotes bone health. The participants demonstrated a high level of agreement, with a median of 24 (23, 27) out of 30 (range between 8 and 30). There was a high level of agreement with all statements. The statement with the highest level of agreement at 90.9% was “regular exercise prevents problems that would happen from osteoporosis.” The statement with the lowest level of agreement at 72.7% was “regular exercise cuts down the chances of broken bones.”

Calcium Benefits. The construct of calcium benefits explores the degree to which participants believe calcium can benefit bone health. Similar to exercise benefits, there was a high geometric mean score of 23 (19.5, 24) with a range of 10-29. However, there was some uncertainty around the rationale of calcium intake in regard to osteoporosis. Most (80%) were in agreement the statement “taking in enough calcium prevents problems with osteoporosis” and 83% agreed that there was a lot to gain from taking calcium to prevent osteoporosis, yet 51.7% agreed that calcium can prevent painful osteoporosis. Equally, only 41.5% agreed with the statement “you would not worry as much about osteoporosis if you took in enough calcium.”

Exercise barriers. This construct measures the barriers participants might perceive could prevent them from engaging in regular exercise. The participants exhibited low agreement with the statements of potential barriers, with a median of 10 (6.5, 14) and a range of 6-20. The participants did not appear to have many barriers to exercise. Only 16.9% agreed that it was difficult for them to develop a new habit of exercising regularly, and 13.9% agreed that exercising regularly would not fit into their daily routines.

Calcium barriers. Participants' perceived difficulties in consuming adequate calcium was explored in this set of questions. The participants reported a low level of barriers towards calcium intake, with a median of 12 (10, 14) and a range of 6-21. Focussing on the questions, 84.6% disagreed with the statement "you do not like calcium-rich foods," 86.2% disagreed that they had to give up other foods to eat calcium-rich foods. Conversely, only 4.6% agreed that calcium-rich foods had too much fat.

Health motivation. The construct of health motivation measures the individual's perception of their ability to monitor, seek advice and support good health. The participants perceived a high level of health motivation, with a median of 23 (22, 25) and a range between 13 and 30. There were a variety of levels of agreement with the responses. The majority, 95.3%, agreed that it was important for them to be healthy; 80% agreed they had a well-balanced diet, and 76.9% felt that they followed health recommendations. However, only 38.5% agreed they seek regular health check-ups.

3.4.4 Associations Between Independent Variables and Calcium Intake.

The correlation between calcium intake and the independent variables is presented in Table 3.4. Focussing on demographics, a tertiary level of education has a significant, weak positive correlation with calcium intake. Whereas severity had a significant, weak negative correlation with calcium intake. No other variable had a statistically significant correlation with calcium intake.

Table 3.4*Spearman's Rho Correlation for Calcium and the Independent Variables.*

Variables	r_s	P-Value
<i>Demographic</i>		
Family history	-.067	.602
Use of supplements	.005	.273
Tertiary level of education	.355**	.008
<i>OKT-r</i>		
Total score	.053	.680
<i>OHBS Constructs</i>		
Susceptibility	.212	.099
Severity	-.301*	.017
Exercise benefits	.206	.109
Calcium Benefits	.136	.294
Exercise barriers	.045	.733
Calcium Barriers	-.103	.430
Health Motivation	-.091	.484

* Correlation significant at the 0.05 level (2-tailed)

**Correlation significant at the 0.01 level (2-tailed)

3.4.6 Correlation Between Independent Variables

The correlation matrix below in Table 3.5 exhibits several weak and moderate correlations of statistical significance between the independent variables. It is useful to note that the perception of severity exhibited a positive, moderate correlation with calcium barriers (moderate, $r = 0.433$, $p = <0.01$). Exercise benefits exhibited statistically significant correlations, with a moderate positive correlation with health motivation ($r = 0.410$, $p = <0.01$) as well as positive weak correlations with OKT-r scores ($r = 0.353$, $p = 0.004$). Additionally, OKT-r also demonstrated a weak negative correlation with calcium barriers ($r = -0.320$, $p = 0.09$).

Table 3.5*Correlation Matrix of Independent Variables (Pearson's Correlation Coefficient in bold)*

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Susceptibility		-.014 †	.008	.104	.301*	.075	.042	.190	.184	.026	.188
2. Severity			.026	.309*	.111	.433**	.131	-.125	-.172	.081	-.279*
3. Exercise Benefits				.190	-.506**	-.241	.410**	.343**	.188	.298*	.294*
4. Calcium Benefits					.088	.260*	.143	-.116	.284	.097	-.242
5. Exercise Barriers						.313*	-.352**	-.133	-.012	-.198	.005
6. Calcium Barriers							-.254*	-.320**	-.063	-.063	-.200
7. Health Motivation								.156	.212	.158	.023
8. OKT-r									.381**	.380**	.266*
9. Family history										.273*	.076
10. Supplement use											.083
11. Tertiary education											

† Numbers in bold Pearson's correlation coefficient

* Correlation significant at the 0.05 level (2-tailed)

**Correlation significant at the 0.01 level (2-tailed)

3.4.7 Multiple Linear Regression

Multiple linear regression was used to investigate the association between the constructs of the OHBS, OKT-r and the dependant variable of calcium intake (Table 3.6). Only exercise benefits proved to be a significant predictor of calcium intake ($\beta = 0.430$, $p = 0.007$). The model of variance accounted for 17.2% of the variation in calcium intake ($r^2_{adj} = 0.172$; $p = 0.011$). The perception of severity was close to being a significant predictor of calcium intake ($\beta = -0.276$, $p = 0.052$). None of the other five constructs (susceptibility, calcium benefits, exercise barriers, calcium barriers, health motivation) or the OKT-r, were significant.

Table 3.6*Multiple Linear Regression Analysis of Variables Predicting Calcium Intake.*

Variable	Beta	SE	β	p
Susceptibility	.021	.013	.222	.099
Severity	-.038	.019	-.276	.052
Exercise benefits	.066	.023	.430	.007
Calcium benefits	-.029	.021	-.195	.174
Exercise barriers	.024	.018	.204	.190
Calcium Barriers	-.007	.021	-.047	.754
Health Motivation	-.020	.020	-.138	.313
OKT-r	-.003	.015	-.027	.849

1.The final model variance was r^2 -adj =0.172; p=0.011

3.4.8 Summary of Findings

This study demonstrated several findings around calcium intake and its association between knowledge of osteoporosis and related health beliefs. The sample had a geometric mean calcium intake of 804mg (705, 916). Further analysis showed that 74.2% of the sample did not meet the NZ MoH daily recommended EAR of 1,100mg. However, 75% of those who met the EAR also achieved the MoH PA guidelines. Additionally, the cohort had a moderate level about knowledge around osteoporosis, with a mean score of 62%. Osteoporosis knowledge was not found to be associated with calcium intake. However, in this study, a weak negative correlation was found between the perception of severity and calcium intake. Additionally, exercise benefits was identified as a predictor of calcium ($\beta = 0.430$, $p = 0.007$) The final model of linear regression accounts for 17.2% of the variance in calcium intake.

3.5 Discussion

The results identified constructs that link OHB to calcium intake. No association was identified between OKT-r results and calcium intake. This discussion will focus on the results around calcium intake before moving onto the findings of the OKT-r and the health beliefs constructs.

3.5.1 Calcium Intake

This study identified that 74.2% of the cohort had intakes below the NZ daily calcium EAR of 1,100mg. The estimated average intake assessed from the calcium specific FFQ was 804mg. This is similar to the findings of the 2008/09 NZ adult nutrition survey of 775mg for females aged between 51 and 70 years (MoH & University of Otago, 2011). One further study based in NZ, with a participant mean age of 71.1 (± 5) also measured a similar calcium intake of 866mg (Bristow et al., 2019). On investigating the 25.8% of the cohort who met the calcium EAR, it was identified that 75% of this subgroup demonstrated either moderate or vigorous levels of PA. This level of PA meets the MoH guidelines of at least 180 minutes of weightbearing activity weekly (MoH, 2020). Equally, it was identified that 18% of the cohort were actively engaged in two bone-protective behaviours.

Dairy products contributed to 70.7% of daily calcium intake; however, diet trends have changed considerably since the data was collected in 2017. An increasing consumer trend to move away from dairy to plant-based milks (PBM), cheese, and yoghurt has greatly changed dietary habits. The NZ purchase of plant-based-milks PBM almost tripled between 2017 and 2019 (Westpac, 2023). NZ consumption of PBM increased from 29.06 million kilograms in 2018 to 45.73 million kilograms in 2023, and the market is set to increase by 11.22% annually up to 2030 (Statistica, 2024). This could influence calcium intake since PBM can have a different nutritional profile to cow's milk (Smith et al., 2022). Though PBM may be fortified with calcium, content may be inconsistent due to the need to shake the milk before serving (Smith et al., 2022). Furthermore, plant-based yoghurts are often not fortified with calcium (Czifra et al., 2024). Conversely, an increasing influence on calcium intake is the expanding popularity of calcium-fortified dairy products. A market currently increasing by 2.9% annually (Future Market Insights, 2024). These trends will impact on the current daily calcium intake of postmenopausal women in NZ.

3.5.2 OKT-r

The cohort of this study showed a moderate level of osteoporosis knowledge, with a mean of 18.1, or 62%. This level of knowledge is consistent with other studies in which older women demonstrated more knowledge about osteoporosis than younger women

(Terrio & Auld, 2002; von Hurst & Wham, 2007). The mean score in this study was also higher than previous studies focussing on younger females (Fekau, 2021; Gammage & Klentrou, 2011; Kolac & Yıldız, 2022; Tsai, 2008).

However, the OKT-r results demonstrated several gaps and strengths within the cohort's knowledge base. Most participants recognised dairy foods, e.g., yoghurt (97%), cheese (97%) and ice-cream (83.1%) as sources of calcium. However, only 45.5% identified broccoli over chicken and grapes. Conversely, only 10.1% knew how much calcium was recommended by correctly answering 3 glasses of milk for this question. Additionally, there seemed to be limited knowledge of the role of vitamin D in bone health and its dietary sources. Only 56.1% knew vitamin D was required to absorb calcium, and 24.2% correctly identified salmon as a source of vitamin D over spinach and cheese. These findings echo a recent study amongst young female students in NZ. In this case, 5.4% recognised the number of glasses of milk to meet recommendations, 52.3% knew the role of vitamin D, and 19.2% identified salmon as a source of vitamin D (Fekau, 2021). This indicates gaps in the depth of knowledge across age groups, around positive dietary behaviours which could support bone health. Potentially, there is a general lack of diet-related knowledge of osteoporosis prevention in New Zealand (NZ). It might also indicate confusion due to the wording of the questions; for example, respondents might know the daily RDI of calcium but be confused about having to redefine this as "glasses of milk."

Similarly, the lack of knowledge depth was also apparent within the exercise subscale. Most participants correctly identified the correct weightbearing exercises and 65.2% recognised the correct exercise intensity. However, only 33.3% correctly identified the amount of exercise to be 5 * 30-minute sessions per week. This is again comparable to the previous study of young NZ students, in which 40% correctly identified the correct number of minutes (Fekau, 2021). This indicates a general lack of familiarity with the NZ PA guidelines, which specifically recommends moderate intensity, 5* 30-minute sessions per week (MoH, 2013, 2020a).

3.5.4 OHMS

In this study, the participants achieved a mean score for the OHBS of 124.6, or 59%, which is a moderate level of health beliefs. Focussing on the different constructs, the

participants demonstrated moderate levels of susceptibility and severity, high levels of health motivation, exercise, and calcium benefits, with correspondingly low barriers to exercise and calcium intake. The following will discuss the constructs in their framework groups.

Perceived Threats. The mean score for perceived susceptibility was 16.4, or 55%. This low, moderate score seems to reflect several other OHBS studies (Evenson & Sanders, 2016; Fekau, 2021; Nguyen et al., 2012; von Hurst & Wham, 2007).

Unsurprisingly, younger females appear to have low levels of perceived susceptibility to this perceived older adult condition. Nguyen et al. (2013) reached this very conclusion due to a lack of engagement with the study intervention amongst female college students. Whereas Fekau (2021) reported a mean score of 50% for this construct among a cohort of 18–23-year-olds.

This lower perception of susceptibility among the over-50-year-olds is also consistent with previous studies (Babatunde et al., 2011; Doheny et al., 2007; Evenson & Sanders, 2016; Janiszewska et al., 2016; Swaim et al., 2008). One study discovered premenopausal women perceived themselves to be more susceptible than postmenopausal women (Piehowski et al., 2010). Though perceptions of susceptibility and family history have previously been linked (Endicott, 2013; Johnson et al., 2008), no such association was found between susceptibility and family history in the current study ($r = 0.184$, $p = 0.152$).

Equally, the cohort reported a low sense of severity, with a low moderate score of 16.7, or 56%. This level of perceived severity was considerably lower than in several studies. Babatunde et al. (2011) reported preintervention scores of 18.1 and 19.8 for their groups of > 50-year-olds. Whereas Murimi (2008) reported a score of 80.2% in this construct. Previous NZ based studies on younger age groups both reported higher scores of 19.3 (Tsai, 2008) and 19 (Fekau, 2021). Additionally, it has been previously reported that women over 55 years of age normally have a greater perception of severity than younger women (Janiszewska et al., 2016). The low perception of severity may be due to the higher level of PA reported among the participants. The 2022/3 NZ health survey (MoH, 2023) reported that 43.8% of females in this age group met the PA guidelines; however, 69.3% of this cohort achieved this level of PA.

There was also a statistically significant, moderately positive correlation between severity and calcium barriers ($r = 0.433$, $p = <0.01$). Conversely, a negative weak correlation was ascertained between severity and calcium intake ($r = -0.301$, $p = 0.017$). This result does challenge the HBM theory, which posits that calcium intake would be more likely with increased perceived threats. However, a negative correlation between calcium intake and the perception of susceptibility has been previously identified in other studies (Gammage & Klentrou, 2011; Sedlak et al., 2007). This could indicate a general perception that taking calcium might offset the severity of the symptoms of osteoporosis.

Barriers and Benefits. The benefits of calcium intake score at 23 (77%) and exercise at 24 (80%) were high. Whereas the barriers to calcium intake at 12 (40%) and to exercise at 10 (33%) were low amongst the sample population. This is similar to previous studies, which also identified high benefits and low barriers to positive bone protective behaviours (Babatunde et al., 2011; Fekau, 2021; Murimi, 2001; Nguyen et al., 2012; Tsai, 2008). However, not all studies report the same tendencies. Kalkım and Dağham (2017) measured moderate barriers to exercise before starting their behaviour change intervention in a Turkish population. The control group retained their level of barriers to exercise, whereas the intervention group reduced their perception of exercise barriers by the final data collection event.

Calcium barriers have been identified as a negative predictor in several studies for calcium intake (Evenson & Sanders, 2016; Gammage et al., 2009; Gammage & Klentrou, 2011). Gammage et al. (2009, 2011) in two separate studies with different cohorts noted high calcium barriers amongst dietary restrainers and identified this construct as a negative predictor of calcium intake. In a NZ sample, von Hurst and Wham (2007) noted high barriers to calcium intake among a cohort of women of different age groups. In their group, 77% perceived calcium-containing products to be high in cholesterol, and the construct was a negative predictor of health motivation. However, in the current study 4.6% agreed that calcium products contained too much fat. Similarly, a further recent study of young women (Fekau, 2021) discovered only 9% of respondents agreed with this statement. This sharp contrast may indicate a change in perceptions in NZ over time or indicate the increasing variety of calcium-rich goods available commercially since the study of von Hurst and Wham (2007).

Health Motivation. This sample population of postmenopausal women returned a high level of health motivation of 23 (77%), which is reflective of similar findings for older women (Babatunde et al., 2011; Johnson et al., 2008). Furthermore, older women often have higher levels of health motivation when compared to younger women (Janiszewska et al., 2016; Johnson et al., 2008; Piehowski et al., 2010; von Hurst & Wham, 2007). Though Tsai (2008) found health motivation to be a predictor for calcium intake, the current study identified no such association between calcium intake and health motivation. However, health motivation demonstrated a moderate positive correlation with exercise benefits ($r = 0.410$, $p = <0.01$) and weak negative correlations with exercise barriers ($r = -0.352$, $p = 0.004$) and calcium barriers ($r = -0.254$, $p = 0.041$). This indicates that those who had high motivation would perceive fewer barriers to adopting positive bone health behaviours.

Demographic Variables. Level of education, supplement use, and family history were also analysed within the correlation matrix. The current study, like previous research investigating the link between behaviours and family history, found no associations (Endicott, 2013). However, weak positive correlations were identified between family history with OKT-r scores as well as family history with general supplement use. Equally other weak positive correlations between supplement use and OKT-r scores were noted. On further bivariate correlation with calcium intake, it was found that supplement use was not associated with this health behaviour. This contrasts with previous studies in which the use of non-specific dietary supplements was identified as a positive predictor of calcium intake (Murimi, 2001; Tsai, 2008). Interestingly, having a tertiary level of education demonstrated a weak positive correlation with OKT-r scores, exercise benefits and calcium intake. This reflects a study by Janiszewska et al. (2016) in which level of education was associated with calcium intake. The same study also identified self-efficacy as the main predictor of calcium intake. In the current study, 62.9% had at least a bachelor's degree, whereas the national average is 34% (OECD, 2019). This would have influenced the correlation between level of education and the other variables as well as calcium intake.

3.5.5 Predictors of Calcium Intake

In the current study, exercise benefits is the only statistically significant predictor of calcium intake ($\beta = 0.430$, $p = 0.007$), with the final model of variance accounting for

17.2% of the variance in dietary calcium intake. This contrasts somewhat with previous NZ studies investigating associations between OHB and calcium intake (Fekau, 2021; Tsai, 2008). Tsai (2008) identified calcium barriers, health motivation, and the use of dietary supplements as predictors of calcium intake. Whereas Fekau (2021) identified OKT-r and the perception of severity as predictors of calcium intake. It should be acknowledged that these studies, though based in NZ, were focussed on different female populations. The former investigated a South Asian population and the latter, young university students in Manawatu. This demonstrates the specificity of health beliefs to the age group and cultural demographic of the sample population of interest. Focussing on this sample of post-menopausal women, it is pertinent to consider the findings of other studies which included this age group. Terrio et al. (2002) identified that knowledge was not associated with calcium intake and identified self-efficacy as an important predictor. This is the final construct of OHB, which requires a separate investigative tool. This finding has been supported by other studies that included the use of the self-efficacy survey tool (Evenson & Sanders, 2016; Gammage & Klentrou, 2011; Janiszewska et al., 2016; Kolac & Yıldız, 2022). This highlights the need consider all model constructs when investigating OHB.

Chapter 4: Conclusions and Recommendations

4.1.1 Conclusion

The overall aim of this study was to investigate the association between osteoporosis knowledge, health beliefs, and bone health behaviours (calcium intake) among post-menopausal women. To do this, the calcium intake of a cohort of 66 participants in this demographic was analysed, along with the completed OKT-r and OHBS results. The geometric mean daily calcium intake of the group is 804mg. This is below the Ministry of Health (MoH) recommended EAR of 1,100mg. This result was similar to the age-matched sample from the 2008/09 NZ adult nutrition survey (MoH & University of Otago, 2011). In relation to osteoporosis behaviours, it is a concern that 74.2% of the sample did not meet the EAR. Following bivariate correlation and linear regression, knowledge is not correlated with calcium intake as a bone health behaviour, nor has it been identified as a predictor of calcium intake. The perception of severity and calcium intake have been shown to negatively correlate. This reverse finding has been noted before in relation to threat perceptions and the engagement of a health behaviour. Potentially, in the current study, it indicates that the participants engaging in bone health behaviours may have a diminished sense of severity towards the consequences of osteoporosis. Otherwise, the perception of the benefits of exercise was the sole predictor of calcium intake. This indicates that health beliefs are associated with the adoption of health behaviours. However, these findings differ from other New Zealand (NZ) based studies which identified different predictors for calcium intake. This may be due to differences in age and ethnicity among the different cohorts. This study highlights the complexity of health beliefs in relation to osteoporosis health behaviours.

4.1.2 Research Impact

Though the results of this study may indicate an association between health beliefs and the adoption of health behaviours, these findings should be interpreted with caution. The sample in this study are highly educated, with 62.9% of the cohort educated at least to a university graduate level. This is above the 34% average of New Zealanders who this level of education. There is also a higher level of reported activity, with 69.3% meeting the MOH weekly activity guidelines, more than the national average of 43.7% for this gender (MoH, 2023). The majority (91.9%) of the sample identified as NZ

European and other Caucasian, which is not representative of the ethnic proportions of NZ. These participant attributes mean that the results are not generalisable, and the analysis may have been influenced by the dominant attributes of this sample. However, there are several learning points identified from this study that will be useful for further larger NZ studies on the influence of health beliefs in relation to osteoporosis protective bone behaviours.

4.1.3 Strengths

This was the first NZ study, which has investigated the relationship between osteoporosis health beliefs, knowledge, and calcium intake among post-menopausal women. An increasingly important area of research due to the high risk of osteoporosis onset for women over 50 years of age. The study reaffirms the findings of previous international studies. Postmenopausal women demonstrate different health beliefs to pre-menopausal women, meaning that they are influenced by different predictors of behaviour change to their younger counterparts. This supports an increased understanding of the engagement of osteoporosis health behaviours amongst NZ females of this age group.

Furthermore, the current study has identified several common gaps in knowledge, such as the NZ nutrient reference values in calcium intake, dietary sources of vitamin D, alternative sources of calcium in vegetables, sardines and additionally, MOH exercise guidelines (number of minutes weekly). Additionally, the analysis was also able to identify areas for improvement in data collection and directions for further studies.

4.1.4 Limitations

Sample Population and Missing Data. This study was a secondary analysis of a larger age-matched control study between active and sedentary women. This meant that those with varying levels of activity in between were excluded, due to the criteria of the original study. This also meant that the number of participants meeting physical activity guidelines was higher than the national average. Additionally, the study had a smaller than optimal sample size. This may have caused the study to be underpowered. Subsequently, the magnitude of the correlations is small and unreliable. A further limitation was missing data in the survey replies. This meant that although there are 66

sets of data, missing data in sections decreased the number of sets for analysis. The OKT-r has 66 sets, whereas the BHQ and OHBS have 62, and there are only 61 sets for analysis of the FFQ. Equally, some questions were not answered appropriately. The BHQ contains questions on supplements and the use of fortified products, which request details such as brand, dose and frequency of use. However, these details were frequently omitted by the respondents with answers simply including the type of supplement i.e., “Vitamin D.”

Data Collection Tools. Equally important is the inclusion of tools to investigate all HBM constructs. The current study was unable to investigate the construct of self-efficacy and its association with engagement behaviour, due to the absence of the osteoporosis self-efficacy scale questionnaire from the data collection tools. This survey measures the participant’s level of self-efficacy in relation to the performance of health behaviours and is a useful tool to use alongside the OHBS and the OKT-r. The review of literature indicated the value of self-efficacy in relation to behaviour change.

Additionally, the age of the data, which was collected in 2017-2019, is a further study limitation. Dietary habits have since changed with more dairy options due to increased commercial variety and popular trends such as alternative plant-based milks. This may mean that the data collected is now out of date compared to current trends in consumption and calcium intake in post-menopausal women. Further investigations into calcium intake would require an update of the calcium specific FFQ to reflect the changes in consumer consumption of alternative dairy products.

4.1.5 Recommendations

This leads to several recommendations for subsequent studies in this area of research.

Sample Population and Data Collection. Further study would require a larger sample size. The required calculated sample size was 109 participants. Additionally, guided support during completion, of the surveys should also be considered to ensure the respondents have completed all sections and provided sufficient detail to support accurate analysis.

Data Collection Tools. Revise the current questionnaires. The OKT-r had two questions which reduced the internal integrity, and also had the highest number of

incorrect answers: (nutrition 1 and exercise 1) “How much milk to meet the recommended amount of calcium” and “To strengthen bones, it is recommended that a person exercises at moderate intensity for 30 minutes at least...”. These had an 89.4% and 66.7% incorrect response rate, respectively. These two questions would benefit revision and pretesting before being used in the OKT-r. The revision could be tested with a pilot group or focus group to determine comprehension of the question. Inclusion in the self-efficacy survey would also be recommended for future studies.

Calcium specific FFQ. This tool also requires revision to include items such as plant-based milks, calcium-fortified dairy products, and calcium supplements. Since the current FFQ has already been validated for a younger female population, it would be valuable to validate the calcium specific FFQ for the older female population as well. This would require the FFQ to be completed twice as well as a 3-day diet diary for a reliable 5-step validation process.

4.1.6 Future Studies

This study provides evidence that health beliefs are linked to the engagement of positive bone behaviours among post-menopausal women. Additionally, since research findings differ from previous NZ based studies on different populations, this indicates that health beliefs are specific to a population. The small sample size of this study potentially affected the effect size and reliability of the correlations. This strengthens the case for further study to investigate the association between osteoporosis health beliefs and osteoporosis prevention behaviours such as exercise and calcium intake in this high-risk group.

References

- Abey-Nesbit, R., Schluter, P. J., Wilkinson, T., Thwaites, J. H., Berry, S. D., & Jamieson, H. A. (2019). Risk factors for hip fracture in New Zealand older adults seeking home care services: A national population cross-sectional study. *BMC Geriatrics, 19*(1), 93. <https://doi.org/10.1186/s12877-019-1107-1>
- ACC. (2021). Healthcare: Preventing fragility fractures. Retrieved 29/10/2022 <https://www.acc.co.nz/newsroom/stories/preventing-fragility-fractures/>
- Ainsworth, B. E., Haskell, W. L., Leon, A. S., Jacobs, D. R., Montoye, H. J., Sallis, J. F., & Paffenbarger, R. S. (1993). Compendium of physical activities: Classification of energy costs of human physical activities. *Medicine and Science in Sports and Exercise, 25*(1), 71-80. <https://doi.org/10.1249/00005768-199301000-00011>
- Arnett, T. (2015). Basics of bone biology. *Osteoporosis Review, 23*(2), 12-16.
- Babatunde, O. T., Himburg, S. P., Newman, F. L., Campa, A., & Dixon, Z. (2011). Theory-driven intervention improves calcium intake, osteoporosis knowledge, and self-efficacy in community-dwelling older black adults. *Journal of Nutrition Education & Behavior, 43*(6), 434-440. <https://doi.org/10.1016/j.jneb.2010.07.004>
- Beck, B. R., Daly, R. M., Singh, M. A. F., & Taaffe, D. R. (2017). Exercise and Sports Science Australia (ESSA) position statement on exercise prescription for the prevention and management of osteoporosis. *Journal of Science and Medicine in Sport, 20*(5), 438-445. <https://doi.org/https://doi.org/10.1016/j.jsams.2016.10.001>
- Bijelic, R., Milicevic, S., & Balaban, J. (2019). The influence of non-preventable risk factors on the development of osteoporosis in postmenopausal women. *Mater Sociomed, 31*(1), 62-65. <https://doi.org/10.5455/msm.2019.31.62-65>
- Bischoff-Ferrari, H. (2010). Vitamin D in fracture prevention and muscle function and fall prevention. *Vitamin D: Physiology, Molecular Biology, and Clinical Applications, 669-677*. https://doi.org/10.1007/978-1-60327-303-9_35
- Bonjour, J.-P., Chevalley, T., Ferrari, S., & Rizzoli, R. (2009). The importance and relevance of peak bone mass in the prevalence of osteoporosis. *Salud publica de Mexico, 51*, s5-s17. <https://doi.org/http://www.insp.mx/salud>
- Boston University School of Public Health. (2022). *Behavioural change models: The health belief model*.

<https://sphweb.bumc.bu.edu/otlt/MPHModules/SB/BehavioralChangeTheories/BehavioralChangeTheories2.html>

- Boudin, E., Fijalkowski, I., Hendrickx, G., & Van Hul, W. (2016). Genetic control of bone mass. *Molecular and Cellular Endocrinology*, 432, 3-13.
<https://doi.org/https://doi.org/10.1016/j.mce.2015.12.021>
- 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>
- Brown, N., Muhlenkamp, A., Fox, L., & Osborn, M. (1983). The relationship among health beliefs, health values, and health promotion activity. *Western Journal of Nursing Research*, 5(2), 155-163. <https://doi.org/https://journals-sagepub-com.ezproxy.massey.ac.nz/doi/pdf/10.1177/019394598300500205>
- Brown, P., McNeill, R., Leung, W., Radwan, E., & Willingale, J. (2011). Current and future economic burden of osteoporosis in New Zealand. *Applied Health Economics and Health Policy*, 9(2), 111-123. <https://doi.org/10.2165/11531500-000000000-00000>
- Champion, V. L., & Skinner, C. S. (2008). The health belief model. *Health behavior and health education: Theory, research, and practice*, 4, 45-65.
[file:///C:/Users/colet/Downloads/SkinnerCSTheHealthBeliefModel%20\(1\).pdf](file:///C:/Users/colet/Downloads/SkinnerCSTheHealthBeliefModel%20(1).pdf)
- Chan, C. Y., Subramaniam, S., Chin, K.-Y., Ima-Nirwana, S., Muhammad, N., Fairus, A., Ng, P. Y., Jamil, N. A., Abd Aziz, N., & Mohamed, N. (2019). Levels of knowledge, beliefs, and practices regarding osteoporosis and the associations with bone mineral density among populations more than 40 years old in Malaysia. *International Journal of Environmental Research and Public Health*, 16(21). <https://doi-org.ezproxy.massey.ac.nz/10.3390/ijerph16214115>
- Chelf, S., Davis, R. E., Bass, M. A., Ford, M. A., Firouzabadi, A. D., Leo, J. T., & Nahar, V. K. (2022). Osteoporosis knowledge and health beliefs among middle-aged men and women in the Southern United States. *Journal of Osteopathic Medicine*, 122(9), 453-459. <https://doi.org/doi:10.1515/jom-2022-0011>
- Czifra, A. J., Batty, R., Beck, K. L., & von Hurst, P.R. (2024). An audit of plant-based, ultra processed vegan foods in New Zeland. *Proceeding of the Nutrition Society*, 83(OCE1), E31. doi:10.1017/S0029665124000491

- Clover, E., Miller, M., Bannerman, E., & Magarey, A. (2007). Relative validation of a short food frequency questionnaire to assess calcium intake in older adults. *Australian and New Zealand Journal of Public Health, 31*(5), 450-458.
<https://doi.org/https://doi.org/10.1111/j.1753-6405.2007.00117.x>
- Cosman, F., de Beur, S. J., LeBoff, M. S., Lewiecki, E. M., Tanner, B., Randall, S., & Lindsay, R. (2014). Clinician's guide to prevention and treatment of osteoporosis. *Osteoporosis International, 25*(10), 2359-2381. <https://doi.org/10.1007/s00198-014-2794-2>
- Cusano, N. E. (2015). Skeletal effects of smoking. *Current Osteoporosis Reports, 13*(5), 302-309. <https://doi.org/10.1007/s11914-015-0278-8>
- Dawson-Hughes, B. (2012). Serum 25-hydroxyvitamin D and muscle atrophy in the elderly. *Proceedings of the Nutrition Society, 71*(1), 46-49.
<https://doi.org/10.1017/S0029665111003260>
- de Laet, C., Kanis, J. A., Odén, A., Johanson, H., Johnell, O., Delmas, P., Eisman, J. A., Kroger, H., Fujiwara, S., Garnero, P., McCloskey, E. V., Mellstrom, D., Melton, L. J., Meunier, P. J., Pols, H. A. P., Reeve, J., Silman, A., & Tenenhouse, A. (2005). Body mass index as a predictor of fracture risk: A meta-analysis. *Osteoporosis International, 16*(11), 1330-1338. <https://doi.org/10.1007/s00198-005-1863-y>
- de Villiers, T. J., & Goldstein, S. R. (2022). Bone health 2022: An update. *Climacteric, 25*(1), 1-3. <https://doi.org/10.1080/13697137.2021.1965408>
- Deo, P., Nayak, R., & Rajpura, J. (2013). Women's attitudes and health beliefs toward osteoporosis screening in a community pharmacy. *Journal of Osteoporosis, 2013*, 650136. <https://doi.org/10.1155/2013/650136>
- Doheny, M. O., Sedlak, C. A., Estok, P. J., & Zeller, R. (2007). Osteoporosis knowledge, health beliefs, and DXA T-Scores in men and women 50 years of age and older. *Orthopaedic Nursing, 26*(4), 243-250.
<https://doi.org/10.1097/01.NOR.0000284654.68215.de>
- Endicott, R. D. (2013). Knowledge, health beliefs, and self-efficacy regarding osteoporosis in perimenopausal women. *Journal of Osteoporosis, 2013*, 853531. <https://doi.org/10.1155/2013/853531>
- Evenson, A. L., & Sanders, G. F. (2016). Educational intervention impact on osteoporosis knowledge, health beliefs, self-efficacy, dietary calcium, and vitamin D intakes in

young adults. *Orthopaedic Nursing*, 35(1), 30-36. <https://doi.org/DOI:10.1097/NOR.0000000000000211>

Fekau, S. (2021). *Associations between calcium intake, osteoporosis knowledge and osteoporosis health beliefs among young adult women in the Lower North Island, New Zealand* [Masters, Massey University]. <http://hdl.handle.net/10179/17564>

Field., A. (2018). *The spine of statistics. Discovering statistics using IBM SPSS statistics.* sage.

Future Market Insights. (n.d). *Fortified milk and milk products market outlook (2022-2032)* <https://www.futuremarketinsights.com/reports/fortified-milk-and-milk-products/market#:~:text=Newly%20released%20data%20from%20Future,growth%20of%202.9%25%20in%202022.>

Gammage, K. L., Francoeur, C., Mack, D. E., & Klentrou, P. (2009). Osteoporosis health beliefs and knowledge in college students: The role of dietary restraint. *Eating Behaviors*, 10(1), 65-67. <https://doi.org/10.1016/j.eatbeh.2008.10.006>

Gammage, K. L., & Klentrou, P. (2011). Predicting osteoporosis prevention behaviors: Health beliefs and knowledge. *American Journal of Health Behavior*, 35(3), 371-382. <https://doi.org/10.5993/AJHB.35.3.10>

Gendler, P. E., Coviak, C. P., Martin, J. T., Kim, K. K., Dankers, J. K., Barclay, J. M., & Sanchez, T. A. (2015). Revision of the osteoporosis knowledge test: Reliability and validity. *Western Journal of Nursing Research*, 37(12), 1623-1643.

Goodpaster, B. H., Newman, A. B., Park, S. W., Harris, T. B., Kritchevsky, S. B., Nevitt, M., Schwartz, A. V., Simonsick, E. M., Tylavsky, F. A., & Visser, M. (2006). The loss of skeletal muscle strength, mass, and quality in older adults: The health, aging and body composition study. *Journals of Gerontology*, 61(10), 1059-1064-1064. <https://doi.org/10.1093/gerona/61.10.1059>

Gordon, C. M., Zemel, B. S., Wren, T. A. L., Leonard, M. B., Bachrach, L. K., Rauch, F., Gilsanz, V., Rosen, C. J., & Winer, K. K. (2017). The determinants of peak bone mass. *The Journal of Pediatrics*, 180, 261-269. <https://doi.org/10.1016/j.jpeds.2016.09.056>

Green, E. C., Murphy, E. M., & Gryboski, K. (2020). The Health Belief Model. *The Wiley Encyclopedia of Health Psychology* (pp. 211-214). <https://doi.org/https://doi.org/10.1002/9781119057840.ch68>

- Hardcastle, A. C., Aucott, L., Fraser, W. D., Reid, D. M., & Macdonald, H. M. (2011). Dietary patterns, bone resorption and bone mineral density in early post-menopausal Scottish women. *European Journal of Clinical Nutrition*, *65*(3), 378-385.
<https://doi.org/10.1038/ejcn.2010.264>
- Health and Wellbeing Queensland and Wellbeing SA. (2024). *10,000 Steps*.
<https://www.10000steps.org.au/articles/healthy-lifestyles/counting-steps/#:~:text=Sedentary%20is%20less%20than%205%2C000,than%2010%2C000%20steps%20per%20day>
- Heaney, R. P., Abrams, S., Dawson-Hughes, B., Looker, A., Marcus, R., Matkovic, V., & Weaver, C. (2000). Peak bone mass. *Osteoporosis International*, *11*(12), 985.
<https://doi.org/10.1007/s001980070020>
- Hill, T. R., Aspray, T. J., & Francis, R. M. (2013). Vitamin D and bone health outcomes in older age. *Proceedings of the Nutrition Society*, *72*(4), 372-380.
<https://doi.org/10.1017/S0029665113002036>
- Houston, Z. L. (2014). Development and validation of a semi-quantitative food frequency questionnaire to assess dietary intake of adult women living in New Zealand: a thesis presented in partial fulfillment of the requirements for the degree of Masters of Science in Nutrition and Dietetics, Massey University, Albany, New Zealand (Doctoral dissertation, Massey University).
<https://mro.massey.ac.nz/items/ea13e833-f8aa-4012-befb-68e5290c0fe8>
- International Osteoporosis Foundation. (2023). *Fragility fractures: Epidemiology*.
<https://www.osteoporosis.foundation/health-professionals/fragility-fractures/epidemiology>
- Ioannidis, G., Papaioannou, A., Hopman, W. M., Akhtar-Danesh, N., Anastassiades, T., Pickard, L., Kennedy, C. C., Prior, J. C., Olszynski, W. P., Davison, K. S., Goltzman, D., Thabane, L., Gafni, A., Papadimitropoulos, E. A., Brown, J. P., Josse, R. G., Hanley, D. A., & Adachi, J. D. (2009). Relation between fractures and mortality: Results from the Canadian Multicentre Osteoporosis Study. *Canadian Medical Association Journal*, *181*(5), 265-271. <https://doi.org/10.1503/cmaj.081720>
- Jacqueline, R., Bliuc, D., Nguyen, T. V., & Eisman, J. A. (2007). Risk of subsequent fracture after low-trauma fracture in men and women. *JAMA*, *297*(4), 387-394.
<https://doi.org/10.1001/jama.297.4.387>

- Jang, H.-D., Hong, J.-Y., Han, K., Lee, J. C., Shin, B.-J., Choi, S.-W., Suh, S.-W., Yang, J.-H., Park, S.-Y., & Bang, C. (2017). Relationship between bone mineral density and alcohol intake: A nationwide health survey analysis of postmenopausal women. *PLOS ONE*, *12*(6), e0180132. <https://doi.org/https://doi-org.ezproxy.massey.ac.nz/10.1371/journal.pone.0180132>
- Janiszewska, M., Firlej, E., Dziedzic, M., & Żołnierczuk-Kieliszek, D. (2016). Health beliefs and sense of one's own efficacy and prophylaxis of osteoporosis in peri- and post-menopausal women [journal article]. *Annals of Agricultural and Environmental Medicine*, *23*(1), 167-173. <https://doi.org/10.5604/12321966.1196875>
- Johnson, S., McLeod, K., Kennedy, W., & McLeod, L. (2008). Osteoporosis health beliefs among younger and older men and women. *Health Education & Behavior*, *35*(5), 721-733. <https://doi.org/DOI:10.1177/1090198107301331>
- Jung, M. E., Martin Ginis, K. A., Phillips, S. M., & Lordon, C. D. (2011). Increasing calcium intake in young women through gain-framed, targeted messages: A randomised controlled trial. *Psychology & Health*, *26*(5), 531-547. <https://doi.org/10.1080/08870441003611544>
- Kalkım, A., & Dağhan, Ş. (2017). Theory-based osteoporosis prevention education and counseling program for women: A randomized controlled trial. *Asian Nursing Research*, *11*(2), 119-127. <https://doi.org/https://doi.org/10.1016/j.anr.2017.05.010>
- Kemmak, A. R., Rezapour, A., Jahangiri, R., Nikjoo, S., Farabi, H., & Soleimanpour, S. (2020). Economic burden of osteoporosis in the world: A systematic review. *Medical Journal of the Islamic Republic of Iran*, *34*, 154. <https://doi.org/10.34171/mjiri.34.154>
- Khosla, S., & Riggs, B. L. (2005). Pathophysiology of age-related bone loss and osteoporosis. *Endocrinology and Metabolism Clinics*, *34*(4), 1015-1030. <https://doi.org/10.1016/j.ecl.2005.07.009>
- Kim, K. K., Horan, M. L., Gendler, P., & Patel, M. K. (1991). Development and evaluation of the osteoporosis health belief scale. *Research in Nursing & Health*, *14*(2), 155-163. <https://doi.org/https://doi.org/10.1002/nur.4770140210>
- Kolac, N., & Yıldız, A. (2022). The effect of health belief model-based short interviews in women in the postmenopausal period on the prevention of osteoporosis: A

- randomized controlled trial. *International Journal of Nursing Practice*.
<https://doi.org/10.1111/ijn.13121>
- LeBoff, M. S., Greenspan, S. L., Insogna, K. L., Lewiecki, E. M., Saag, K. G., Singer, A. J., & Siris, E. S. (2022). The clinician's guide to prevention and treatment of osteoporosis. *Osteoporosis International*, *33*(10), 2049-2102.
<https://doi.org/10.1007/s00198-021-05900-y>
- Lein, D. H., Clark, D., Turner, L. W., Kohler, C. L., Snyder, S., Morgan, S. L., & Schoenberger, Y.-M. M. (2014). Evaluation of a computer-tailored osteoporosis prevention intervention in young women. *American Journal of Health Education*, *45*(1), 3-11.
<https://doi.org/10.1080/19325037.2013.853003>
- Liang, W., Wu, X., Dong, Y., Chen, X., Zhou, P., & Xu, F. (2021). Mechanical stimuli-mediated modulation of bone cell function: Implications for bone remodeling and angiogenesis. *Cell and Tissue Research*, *386*.
<https://doi.org/10.1007/s00441-021-03532-6>
- Lips, P., & van Schoor, N. M. (2011). The effect of vitamin D on bone and osteoporosis. *Best Practice & Research Clinical Endocrinology & Metabolism*, *25*(4), 585-591.
<https://doi.org/https://doi.org/10.1016/j.beem.2011.05.002>
- Ljubičić, M., Sarić, M. M., Klarin, I., Rumbak, I., Barić, I. C., Ranilović, J., El-Kenawy, A., Papageorgiou, M., Vittadini, E., Bizjak, M. Č., & Guiné, R. (2022). Motivation for health behaviour: A predictor of adherence to balanced and healthy food across different coastal Mediterranean countries. *Journal of Functional Foods*, *91*, 105018. <https://doi.org/https://doi.org/10.1016/j.jff.2022.105018>
- Lorentzon, M., Johansson, H., Harvey, N. C., Liu, E., Vandenput, L., McCloskey, E. V., & Kanis, J. A. (2022). Osteoporosis and fractures in women: The burden of disease. *Climacteric*, *25*(1), 4-10. <https://doi.org/10.1080/13697137.2021.1951206>
- Luger, T. M. (2013). Health beliefs/health belief model. In M. D. Gellman & J. R. Turner. *Encyclopedia of Behavioral Medicine* (pp. 907-908). Springer New York.
https://doi.org/10.1007/978-1-4419-1005-9_1227
- Macdonald, H. M., Garland, A., Burr, J., Strachan, A., Wood, A. D., Jamil, N. A., McLernon, D., & Black, A. J. (2014). Validation of a short questionnaire for estimating dietary calcium intakes. *Osteoporosis International*, *25*(6), 1765-1773.
<https://doi.org/10.1007/s00198-014-2694-5>

- McLeod, K. M., & Johnson, C. S. (2011). A systematic review of osteoporosis health beliefs in adult men and women. *Journal of Osteoporosis*, 2011. <https://doi.org/https://doi-org.ezproxy.massey.ac.nz/10.4061/2011/197454>
- Melton, I., & Joseph, L. (1995). Perspectives: How many women have osteoporosis now? *Journal of Bone and Mineral Research*, 10(2), 175-177. <https://doi.org/https://doi.org/10.1002/jbmr.5650100202>
- Ministry of Health. (2013). *Guidelines on physical activity for older people (aged 65 years and over)*. Ministry of Health Wellington. file:///E:/guidelines-on-physical-activity-older-people-jan13-v3.pdf
- Ministry of Health. (2020). *The 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. (2023). *Annual update of key results 2022/23: New Zealand health survey*. Annual Update of Key Results 2022/23: New Zealand Health Survey | Ministry of Health NZ. <https://www.health.govt.nz/publication/annual-update-key-results-2022-23-new-zealand-health-survey>
- Ministry of Health, & University of Otago. (2011). *A focus on nutrition: Key findings of the 2008/09 New Zealand adult nutrition survey*. [frohttps://www.health.govt.nz/system/files/documents/publications/a-focus-on-nutrition-v2.pdf](https://www.health.govt.nz/system/files/documents/publications/a-focus-on-nutrition-v2.pdf)
- Mohd-Tahir, N. A., & Li, S. C. (2017). Economic burden of osteoporosis-related hip fracture in Asia: A systematic review. *Osteoporosis International*, 28(7), 2035-2044. <https://doi.org/10.1007/s00198-017-3985-4>
- Morfeld, J.-C., Vennedey, V., Müller, D., Pieper, D., & Stock, S. (2017). Patient education in osteoporosis prevention: A systematic review focusing on methodological quality of randomised controlled trials. *Osteoporosis International*, 28(6), 1779-1803. <https://doi.org/10.1007/s00198-017-3946-y>
- Morin, S., Tsang, J. F., & Leslie, W. D. (2009). Weight and body mass index predict bone mineral density and fractures in women aged 40 to 59 years. *Osteoporosis International*, 20(3), 363-370. <https://doi.org/10.1007/s00198-008-0688-x>
- Movassagh, E. Z., & Vatanparast, H. (2017). Current evidence on the association of dietary patterns and bone health: A scoping review. *Advances in Nutrition*, 8(1), 1-16. <https://doi.org/https://doi.org/10.3945/an.116.013326>

- Murimi, M. (2001). Short-Term Nutrition Intervention Increases Calcium Intake Among 45-54 Year Old Women. *Journal of Nutrition For the Elderly*, 20(3), 1-12.
https://doi.org/10.1300/J052v20n03_01
- National Health Research Council, A. G., & Department of Health and Ageing New Zealand Ministry of Health. (2017). Nutrient reference values for Australia and New Zealand. <https://www.nhmrc.gov.au/sites/default/files/images/Nutrient-reference-aus-nz-executive-summary.pdf>
- Nayak, S., Roberts, M. S., Chang, C.-C. H., & Greenspan, S. L. (2010). Health beliefs about osteoporosis and osteoporosis screening in older women and men. *Health Education Journal*, 69(3), 267-276.
- Nguyen, V. H. (2014). An assessment of osteoporosis health beliefs based on the health belief model. *International Journal of Health Promotion and Education*, 52(2), 105-115. <https://doi.org/10.1080/14635240.2014.893138>
- Nguyen, V. H., & Wang, Z. (2012). Osteoporosis knowledge of students in relevant healthcare academic programs. *Journal of Osteoporosis*, 2012, 383412.
<https://doi.org/10.1155/2012/383412>
- Nguyen, V. H., Wang, Z., & Waigandt, A. C. (2012). The Development of an osteoporosis prevention education intervention. *American Journal of Health Education*, 43(4), 209-217. <https://doi.org/10.1080/19325037.2012.10599237>
- NIH. (2018). *Juvenile osteoporosis*. National Institute of Health,.
<https://www.bones.nih.gov/health-info/bone/bone-health/juvenile/juvenile-osteoporosis>
- OECD. (2019). *Education at a glance: New Zealand*.
https://www.oecd.org/education/education-at-a-glance/EAG2019_CN_NZL.pdf
- Ong, A. M., Weiler, H. A., Wall, M., Goltzman, D., Whiting, S. J., Daskalopoulou, S. S., & Morin, S. N. (2017). A 51-item calcium-focused food frequency questionnaire is a reliable tool to assess dietary calcium intake in postmenopausal women. *Nutrition Research*, 43, 33-42.
<https://doi.org/https://doi.org/10.1016/j.nutres.2017.05.006>
- Osteoporosis New Zealand. (2021). Clinical standards for fracture liaison services in New Zealand. Retrieved 01/11/2022 from
<https://www.osteoporosis.foundation/news/osteoporosis-new-zealand-publishes-new-clinical-standards-fracture-liaison-services-20210917>

- Piehowski, K. E., Nickols-Richardson, S. M., Clymer, E. K., & Roberto, K. A. (2010). Osteoporosis health beliefs in women differ by menopausal status and across age cohorts. *Family and Consumer Sciences Research Journal*, 38(3), 345-355.
<https://doi.org/https://doi.org/10.1111/j.1552-3934.2009.00029.x>
- Pinar, G., & Pinar, T. (2020). The impact of health belief model based educational intervention on women's knowledge, beliefs, preventive behaviors and clinical outcomes about osteoporosis. *SAGE Open*, 10(3), 2158244020941473.
<https://doi.org/DOI:10.1177/2158244020941473>
- Pinheiro, M. B., Oliveira, J., Bauman, A., Fairhall, N., Kwok, W., & Sherrington, C. (2020). Evidence on physical activity and osteoporosis prevention for people aged 65+ years: A systematic review to inform the WHO guidelines on physical activity and sedentary behaviour. *International Journal of Behavioral Nutrition and Physical Activity*, 17(1), 150. <https://doi.org/10.1186/s12966-020-01040-4>
- Pouresmaeili, F., Kamalidehghan, B., Kamarehei, M., & Goh, Y. M. (2018). A comprehensive overview on osteoporosis and its risk factors. *Ther Clin Risk Manag*, 14, 2029-2049. <https://doi.org/10.2147/tcrm.S138000>
- Raisz, L. G. (2005). Pathogenesis of osteoporosis: Concepts, conflicts, and prospects. *The Journal of Clinical Investigation*, 115(12), 3318-3325.
<https://doi.org/10.1172/JCI27071>
- Reid, I. R., Bolland, M. J., & Grey, A. (2014). Effects of vitamin D supplements on bone mineral density: A systematic review and meta-analysis. *The Lancet*, 383(9912), 146-155. [https://doi.org/DOI:https://doi.org/10.1016/S0140-6736\(13\)61647-5](https://doi.org/DOI:https://doi.org/10.1016/S0140-6736(13)61647-5)
- Rozenberg, S., Bruyère, O., Bergmann, P., Cavalier, E., Gielen, E., Goemaere, S., Kaufman, J. M., Lapauw, B., Laurent, M. R., De Schepper, J., & Body, J. J. (2020). How to manage osteoporosis before the age of 50. *Maturitas*, 138, 14-25.
<https://doi.org/https://doi.org/10.1016/j.maturitas.2020.05.004>
- Rubæk, M., Hitz, M. F., Holmberg, T., Schønswandt, B. M. T., & Andersen, S. (2022). Effectiveness of patient education for patients with osteoporosis: A systematic review. *Osteoporosis International*, 33(5), 959-977.
<https://doi.org/10.1007/s00198-021-06226-5>

- Ryan, P., Schlidt, A., & Ryan, C. (2013). The impact of osteoporosis prevention programs on calcium intake: A systematic review. *Osteoporosis International*, 24(6), 1791-1801. <https://doi.org/10.1007/s00198-012-2259-4>
- Salari, N., Ghasemi, H., Mohammadi, L., Behzadi, M. h., Rabieenia, E., Shohaimi, S., & Mohammadi, M. (2021). The global prevalence of osteoporosis in the world: A comprehensive systematic review and meta-analysis. *Journal of Orthopaedic Surgery and Research*, 16(1), 609. <https://doi.org/10.1186/s13018-021-02772-0>
- Sebring, N. G., Denkinger, B. I., Menzie, C. M., Yanoff, L. B., Parikh, S. J., & Yanovski, J. A. (2007). Validation of three food frequency questionnaires to assess dietary calcium intake in adults. *Journal of the American Dietetic Association*, 107(5), 752-759. <https://doi.org/https://doi.org/10.1016/j.jada.2007.02.007>
- Sedlak, C. A., Doheny, M. O., Estok, P. J., Zeller, R. A., & Winchell, J. (2007). DXA, health beliefs, and osteoporosis prevention behaviors. *Journal of Aging and Health*, 19(5), 742-756. <https://doi.org/10.1177/0898264307304303>
- Shi, Y., Zhan, Y., Chen, Y., & Jiang, Y. (2020). Effects of dairy products on bone mineral density in healthy postmenopausal women: A systematic review and meta-analysis of randomized controlled trials. *Archives of Osteoporosis*, 15(1), 48. <https://doi.org/10.1007/s11657-020-0694-y>
- Smith, N. W., Dave, A. C., Hill, J. P., & McNabb, W. C. (2022). Nutritional assessment of plant-based beverages in comparison to bovine milk. *Frontiers in Nutrition*, 9, 957486. <https://doaj.org/article/88143584c64c4beb9b814475f2584333>
- Sözen, T., Özışık, L., & Başaran, N. (2017). An overview and management of osteoporosis. *European Journal Rheumatology*, 4(1), 46-56. <https://doi.org/10.5152/eurjrheum.2016.048>
- Statistica. (2024). *Milk substitutes: New Zealand*. <https://www.statista.com/outlook/cmo/food/dairy-products-eggs/milk-substitutes/new-zealand#revenue>
- Stats NZ Tataurangi Aotearoa. (2022). *Estimated population of New Zealand: By age group*. [https://www.stats.govt.nz/information-releases/national-population-projections-2022base2073/#:~:text=New%20Zealand's%20population%20\(5.13%20million,and%205.85%20million%20in%202033.](https://www.stats.govt.nz/information-releases/national-population-projections-2022base2073/#:~:text=New%20Zealand's%20population%20(5.13%20million,and%205.85%20million%20in%202033.)
- Swaim, R. A., Barner, J. C., & Brown, C. M. (2008). The relationship of calcium intake and exercise to osteoporosis health beliefs in postmenopausal women. *Research in*

- Social and Administrative Pharmacy*, 4(2), 153-163.
<https://doi.org/https://doi.org/10.1016/j.sapharm.2007.03.004>
- Taber, K. S. (2018). The use of Cronbach's Alpha when developing and reporting research instruments in science education. *Research in Science Education*, 48(6), 1273-1296. <https://doi.org/10.1007/s11165-016-9602-2>
- Tavakol, M., & Dennick, R. (2011). Making sense of Cronbach's alpha. *International Journal Medical Education*, 2, 53-55. <https://doi.org/10.5116/ijme.4dfb.8dfd>
- Terrio, K., & Auld, G. W. (2002). Osteoporosis knowledge, calcium intake, and weight-bearing physical activity in three age groups of women. *Journal of Community Health*, 27(5), 307-320. <https://doi.org/10.1023/A:1019840709367>
- The North American Menopause Society. (2021). Management of osteoporosis in postmenopausal women: The 2021 position statement of The North American Menopause Society. *Menopause*, 28(9), 973-997.
<https://doi.org/10.1097/gme.0000000000001831>
- Thulkar, J., Singh, S., Sharma, S., & Thulkar, T. (2016). Preventable risk factors for osteoporosis in postmenopausal women: Systematic review and meta-analysis. *Journal of Mid-life Health*, 7(3), 108-113. <https://doi.org/10.4103/0976-7800.191013>
- Tremblay, M. S., Aubert, S., Barnes, J. D., Saunders, T. J., Carson, V., Latimer-Cheung, A. E., Chastin, S. F. M., Altenburg, T. M., Chinapaw, M. J. M., Altenburg, T. M., Aminian, S., Arundell, L., Atkin, A. J., Aubert, S., Barnes, J., Barone Gibbs, B., Bassett-Gunter, R., Belanger, K., Biddle, S., . . . on behalf of, S. T. C. P. P. (2017). Sedentary Behavior Research Network (SBRN) – Terminology consensus project process and outcome. *International Journal of Behavioral Nutrition and Physical Activity*, 14(1), 75. <https://doi.org/10.1186/s12966-017-0525-8>
- Tsai, M. (2008). The relationship between osteoporosis knowledge, beliefs and dietary-calcium intake among South Asian women in Auckland : *A thesis presented in partial fulfillment of the requirements for the degree of Master of Science in Human Nutrition at Massey University, Auckland, New Zealand* [Masters, Massey University]. <http://hdl.handle.net/10179/855>
- Vannucci, L., Fossi, C., Quattrini, S., Guasti, L., Pampaloni, B., Gronchi, G., Giusti, F., Romagnoli, C., Cianferotti, L., Marcucci, G., & Brandi, M. L. (2018). Calcium intake

- in bone health: A focus on calcium-rich mineral waters. *Nutrients*, 10(12), 1930.
<https://www.mdpi.com/2072-6643/10/12/1930>
- von Hurst, P. R., & Wham, C. A. (2007). Attitudes and knowledge about osteoporosis risk prevention: A survey of New Zealand women. *Public Health Nutrition*, 10(7), 747-753. <https://doi.org/10.1017/S1368980007441477>
- Watts, J., Abimanyi-Ochom, J., & Sanders, K. M. (2013). Osteoporosis costing all Australian: A new burden of disease analysis-2012 to 2022.
https://dro.deakin.edu.au/articles/book/Osteoporosis_costing_all_Australian_a_new_burden_of_disease_analysis_-_2012_to_2022/20948722
- Weaver, C. M., Gordon, C. M., Janz, K. F., Kalkwarf, H. J., Lappe, J. M., Lewis, R., O’Karma, M., Wallace, T. C., & Zemel, B. S. (2016). The National Osteoporosis Foundation’s position statement on peak bone mass development and lifestyle factors: A systematic review and implementation recommendations. *Osteoporosis International*, 27(4), 1281-1386. <https://doi.org/10.1007/s00198-015-3440-3>
- Westpac. (2023). *The rise of plant based milks*.
<https://www.westpac.co.nz/rednews/the-rise-of-plant-based-milks/>
- Willett, W., & Lenart, E. (2013). Reproducibility and validity of food frequency questionnaires. *Nutritional Epidemiology*, 3, 96-141.
- Wilson-Barnes, S. L., Lanham-New, S. A., & Lambert, H. (2022). Modifiable risk factors for bone health & fragility fractures. *Best Practice & Research Clinical Rheumatology*, 36(3), 101758.
<https://doi.org/https://doi.org/10.1016/j.berh.2022.101758>
- World Health Organization. (2013). Global action plan for the prevention and control of noncommunicable diseases 2013-2020.
<https://www.who.int/publications/i/item/9789241506236>
- Wu, A.-M., Bisignano, C., James, S. L., Abady, G. G., Abedi, A., Abu-Gharbieh, E., Alhassan, R. K., Alipour, V., Arabloo, J., Asaad, M., Asmare, W. N., Awedew, A. F., Banach, M., Banerjee, S. K., Bijani, A., Birhanu, T. T. M., Bolla, S. R., Cámara, L. A., Chang, J.-C., . . . Vos, T. (2021). Global, regional, and national burden of bone fractures in 204 countries and territories, 1990–2019: A systematic analysis from the Global Burden of Disease Study 2019. *The Lancet Healthy Longevity*, 2(9), e580-e592.
[https://doi.org/https://doi.org/10.1016/S2666-7568\(21\)00172-0](https://doi.org/https://doi.org/10.1016/S2666-7568(21)00172-0)

- Yung, P. S., Lai, Y. M., Tung, P. Y., Tsui, H. T., Wong, C. K., Hung, V. W. Y., & Qin, L. (2005). Effects of weight bearing and non-weight bearing exercises on bone properties using calcaneal quantitative ultrasound. *British Journal of Sports Medicine, 39*(8), 547-551. <https://doi.org/10.1136/bjism.2004.014621>
- Zhang, X., Yu, Z., Yu, M., & Qu, X. (2015). Alcohol consumption and hip fracture risk. *Osteoporosis International, 26*(2), 531-542. <https://doi.org/10.1007/s00198-014-2879-y>
- Zipfel, S., Seibel, M. J., Löwe, B., Beumont, P. J., Kasperk, C., & Herzog, W. (2001). Osteoporosis in eating disorders: A follow-up study of patients with anorexia and bulimia nervosa. *The Journal of Clinical Endocrinology & Metabolism, 86*(11), 5227-5233. <https://doi.org/10.1210/jcem.86.11.8050>

Appendices

Appendix A: Participant Information Sheet



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 Runners and Walkers

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, supported by PhD student Elizabeth Reynolds. 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, DXA bone mineral density scan.

The common sites of osteoporosis fractures are the hip and spine, which can be measured for bone density by DXA; however, the Quantitative Ultrasound measurement is done at the heel bone. We think that runners probably have good heel bone density from running and this might mask the risk of fracture at hip and spine if they only get a Quantitative Ultrasound measurement of their heel. Therefore we want to compare how well this new technology compares to DXA when we compare runners to non-active women.

We will be comparing lifestyle factors and bone health in post-menopausal runners and women who take part in a sport involving running and walking to age-matched low-active women.]

We are recruiting **post-menopausal runners and walkers** for this study. If you would like to participate please contact Elizabeth on 0272791512 or email e.reynolds@massey.ac.nz

Participant Identification and Recruitment

We are inviting women runners and walkers, and women who take part in a sport involving running and walking training of 3 hours per week or more (e.g. running, tennis, competitive walking, tramping) via their registration at the Rotorua full, half-marathon, and 10km and from Manawatu Striders' full, half-marathon, and 10km races. We are also advertising the study in local papers, running and sports groups, workplaces, and social media. We are recruiting 76 post-menopausal runners/walkers 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
- Running or walking at least a total of 3h per week

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, Corteo~~)
- Corticosteroid tablets (e.g. prednisone, cortisone) daily for >3 months previously

What is involved?

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 DXA bone mineral scan instrument.

At the Human Nutrition Laboratory you will have the following measurements taken: Height, weight, DXA 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.

DXA 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 DXA 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 DXA 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 10 years' time, after analysis of your final follow-up results. 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.

Elizabeth Reynolds
Phone: 06 356 9099 ext 83367, or 0272781512
Email: E.Reynolds@massey.ac.nz
School of Food and Nutrition
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.

Appendix B: Participant Eligibility Screening Form.

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	<input type="radio"/>	<input type="radio"/>
Osteogenesis Imperfecta	<input type="radio"/>	<input type="radio"/>
Rheumatoid Arthritis	<input type="radio"/>	<input type="radio"/>
Type I (insulin dependent) diabetes	<input type="radio"/>	<input type="radio"/>
Thyroid Disease <i>which is not under control</i>	<input type="radio"/>	<input type="radio"/>
Inflammatory Bowel Disease (e.g. Crohn's, Ulcerative Colitis, Celiac Disease)	<input type="radio"/>	<input type="radio"/>
Chronic Renal (Kidney) Disease	<input type="radio"/>	<input type="radio"/>
Clinically Significant Liver Disease	<input type="radio"/>	<input type="radio"/>
Eating Disorder (DSM-V)	<input type="radio"/>	<input type="radio"/>

3. Are you currently being treated with the following?

	No	Yes
Biphosphonates (e.g. Fosamax, Arrow-Etidronate, Risedronate-Sandoz, Aclasta)	<input type="radio"/>	<input type="radio"/>
Hormone Replacement Therapy HRT (Evista, Forteo)	<input type="radio"/>	<input type="radio"/>

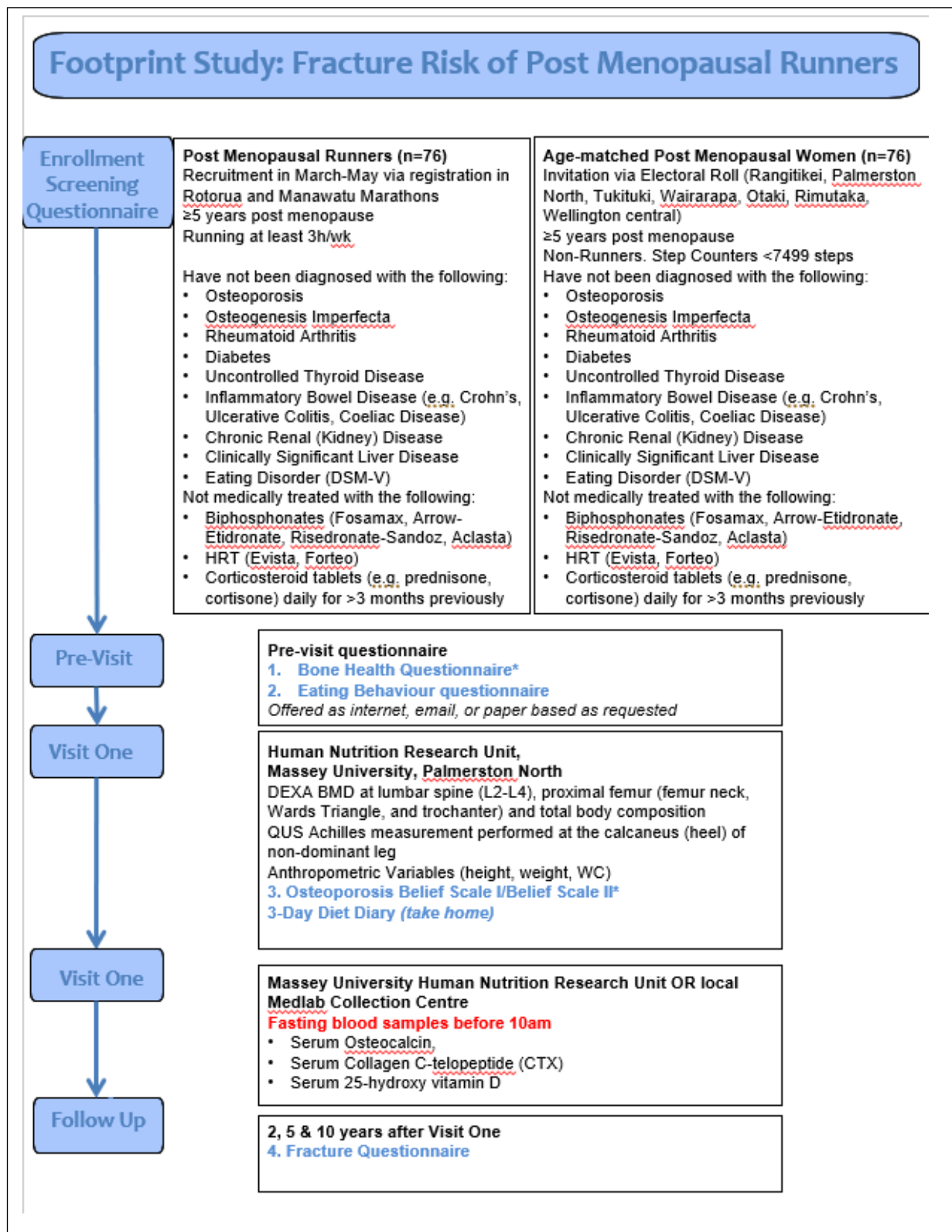
4. Have you previously been treated with the following?

	No	Yes
Corticosteroid tablets (e.g. prednisone, cortisone) daily for >3 months	<input type="radio"/>	<input type="radio"/>

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 C: Flow Chart of Study Inclusion and Exclusion Criteria



Appendix D: Participant Consent Form



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 Women

PARTICIPANT CONSENT FORM - INDIVIDUAL

I have read the Information Sheet and have had the details of the study explained to me. My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I agree to participate in this study under the conditions set out in the Information Sheet.

Signature: **Date:**

Full Name - printed

Appendix H: Ethical Approval



Date: 17 March 2017

Dear Dr Jasmine Thomson

Re: Ethics Notification - SOA 17/07 - Footprint Study: Fracture Risk of Post-Menopausal Runners

Thank you for the above application that was considered by the Massey University Human Ethics Committee: Human Ethics Southern A Committee at their meeting held on Friday, 17 March, 2017.

On behalf of the Committee I am pleased to advise you that the ethics of your application are approved.

Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Brian Finch
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

Appendix F: Bone Health Questionnaire

Questions used for this study including the calcium specific FFQ.

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
	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3. Have you ever been diagnosed with the following?

	Yes	No	Don't Know
Stress Fractures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Osteopenia (lower than normal bone density)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Osteoporosis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

4. Have you had the following medical procedures?

	Yes	No	Don't Know
Hysterectomy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Gastric Surgery (Gastrectomy, Gastric Bypass)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Chemotherapy for breast cancer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Radiation therapy in the previous year	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Aged 14-18 <u>years</u>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Aged 18-25 <u>years</u>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
1 cup instant coffee with milk	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
1 cup of milk	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
1 cup milk drink (latte/flat white, flavoured milk, milk milo, soy drink)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
1 cup milk with cereal/porridge	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
1 slice of bread	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
1 matchbox portion of hard cheese (e.g. cheddar)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
1 matchbox portion of soft cheese (e.g. camembert, brie)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
1 tablespoon of fresh cheese (e.g. cottage cheese, ricotta, sour cream)	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
1 pottle of yoghurt	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

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 work, twice per day (30 minutes) 3 times per week

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 G: Revised Osteoporosis Knowledge Test

Footprint Study Osteoporosis Beliefs II

1. Personal Information

Name

Participant ID

Date

Below is a list of things which may or may not affect a person's chance of getting osteoporosis. After you read each statement, think about if the person is:

MORE LIKELY to get osteoporosis
LESS LIKELY to get osteoporosis
NEUTRAL, it has nothing to do with getting osteoporosis or DON'T KNOW

When you read each statement, select ONE of the 4 choices for your answer:

2. Eating a diet LOW in dairy products

More Likely Less Likely Neutral Don't Know

3. Being post-menopausal; after menopause

More Likely Less Likely Neutral Don't Know

4. Having a parent or grandparent who has osteoporosis

More Likely Less Likely Neutral Don't Know

5. Being a White or Asian woman

More Likely Less Likely Neutral Don't Know

6. Being an elderly man

More Likely Less Likely Neutral Don't Know

7. Having ovaries surgically removed

More Likely Less Likely Neutral Don't Know

8. Taking cortisone (steroids e.g. Prednisone) for a long time

More Likely	Less Likely	Neutral	Don't Know
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9. Having an eating disorder

More Likely	Less Likely	Neutral	Don't Know
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. Consuming more than 2 alcoholic drinks per day

More Likely	Less Likely	Neutral	Don't Know
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

11. Smoking on a daily basis

More Likely	Less Likely	Neutral	Don't Know
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For the next group of questions, select one answer from the 4 choices.

Be sure to select ONLY ONE answer. If you think there is more than one correct answer, choose the BEST answer. If you are not sure, select "Don't know".

12. To strengthen bones, it is recommended that a person exercise at a moderately intense level of 30 minutes a day at least

- 3 days a week
- 4 days a week
- 5 days a week
- Don't Know

13. Exercise makes bones strong, but it must be hard enough to make breathing...

- Just a little faster
- Much faster, but talking is still possible
- So fast that talking is not possible
- Don't Know

14. Which of the following activities is the best way to reduce a person's chance of getting osteoporosis?

- Swimming
- Walking briskly
- Stretching
- Don't Know

15. Which of the following activities is the best way to reduce a person's chance of getting osteoporosis?

- Cycling
- Yoga
- Lifting weights
- Don't know

16. Which of the following activities is the best way to reduce a person's chance of getting osteoporosis?

- Jogging or running
- Golfing using a golf cart
- Gardening
- Don't know

17. Which of the following activities is the best way to reduce a person's chance of getting osteoporosis?

- Bowling
- Doing Laundry
- Aerobic Dancing
- Don't know

18. Which of these is the best source of calcium?

- Apple
- Cheese
- Cucumber
- Don't know

19. Which of these is the best source of calcium?

- Peanut butter
- Lamb
- Canned Sardines
- Don't know

20. Which of these is the best source of calcium?

- Chicken
- Broccoli
- Grapes
- Don't know

21. Which of these is the best source of calcium?

- Yoghurt
- Strawberries
- Cabbage
- Don't know

22. Which of these is the best source of calcium?

- Ice cream
- Grape fruit
- Radishes
- Don't know

23. How much milk must an adult drink to meet the recommended amount of calcium?

- 1 glass daily
- 2 glasses daily
- 3 or more glasses daily
- Don't know

24. Which of the following is the best reason for taking a calcium supplement?

- If a person skips breakfast
- If a person does not get enough calcium from their diet
- If a person is over 45 years old
- Don't know

25. Which vitamin is required for the absorption of calcium?

- Vitamin A
- Vitamin C
- Vitamin D
- Don't know

26. Which is the best source of the vitamin required for the absorption of calcium?

- Carrots
- Oranges
- Sunlight
- Don't know

27. Which is the best source of the vitamin required for the absorption of calcium?

- Spinach
- Cheese
- Salmon
- Don't know

28. When would you achieve peak bone mass?

- Childhood
- Adolescence
- Young adulthood
- Don't know

29. Osteoporosis can be diagnosed by

- Blood test
- DEXA scan
- Symptoms
- Don't know

30. Once you have osteoporosis

- There is nothing you can do about it
- You can take medication to treat it
- You must be careful lifting objects
- Don't know

Thank you for completing the survey.

Please check to be sure you answered all of the questions

Developed by Katherine Kim PhD, Mary Horan PhD, and Phyllis Gendler PhD (1991). Grand Valley State University, with support from the Grand Valley State University Research Grant-in-Aid. Revised by Phyllis Gendler PhD, Cynthia Coviak PhD, Jean Martin PhD, and Katherine Kim PhD (2011, 2012). Question 26 was developed as an addition to the Osteoporosis Knowledge Test by Pamela von Hurst (2006).

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Appendix H: Osteoporosis Health Belief Survey

Footprint Study Osteoporosis Beliefs I

1. Personal Information

Name

Participant ID

Address

Email Address

Date

Osteoporosis is a condition in which the bones become very brittle and weak so that they break easily.

Below are some questions about your beliefs about osteoporosis. There are no right or wrong answers. We all have different experiences which will influence how we feel. After reading each statement, select if you STRONGLY DISAGREE, DISAGREE, are NEUTRAL, AGREE, or STRONGLY AGREE with the statement

It is important that you answer according to your actual beliefs and not according to how you think you should answer. We need the answers that best explain how you feel.

Read each statement. Select ONE best option that explains what you believe:

2. Your chances of getting osteoporosis are high

Strongly Disagree Disagree Neutral Agree Strongly Agree

3. Because of your body build, you are more likely to develop osteoporosis

Strongly Disagree Disagree Neutral Agree Strongly Agree

4. It is extremely likely that you will get osteoporosis

Strongly Disagree Disagree Neutral Agree Strongly Agree

5. There is a good chance that you will get osteoporosis

Strongly Disagree Disagree Neutral Agree Strongly Agree

6. You are more likely than the average person to get osteoporosis

Strongly Disagree Disagree Neutral Agree Strongly Agree

7. Your family history makes it more likely that you will get osteoporosis

Strongly Disagree Disagree Neutral Agree Strongly Agree

8. The thought of having osteoporosis scares you

Strongly Disagree Disagree Neutral Agree Strongly Agree

9. If you had osteoporosis you would be crippled

Strongly Disagree Disagree Neutral Agree Strongly Agree

10. Your feelings about yourself would change if you got osteoporosis

Strongly Disagree Disagree Neutral Agree Strongly Agree

11. It would be very costly if you got osteoporosis

Strongly Disagree Disagree Neutral Agree Strongly Agree

12. When you think about osteoporosis you get depressed

Strongly Disagree Disagree Neutral Agree Strongly Agree

13. It would be very serious if you got osteoporosis

Strongly Disagree Disagree Neutral Agree Strongly Agree

14. Regular exercise prevents problems that would happen from osteoporosis

Strongly Disagree Disagree Neutral Agree Strongly Agree

15. You feel better when you exercise to prevent osteoporosis

Strongly Disagree Disagree Neutral Agree Strongly Agree

16. Regular exercise helps to build strong bones

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

17. Exercising to prevent osteoporosis also improves the way your body looks

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

18. Regular exercise cuts down the chances of broken bones

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

19. You feel good about yourself when you exercise to prevent osteoporosis

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

For the following 6 questions, "taking in enough calcium" means taking enough calcium by eating calcium rich foods and/or taking calcium supplements.

20. Taking in enough calcium prevents problems from osteoporosis

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

21. You have lots to gain from taking in enough calcium to prevent osteoporosis

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

22. Taking in enough calcium prevents painful osteoporosis

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

23. You would not worry as much about osteoporosis if you took in enough calcium

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

24. Taking in enough calcium cuts down on your chances of broken bones

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

25. You feel good about yourself when you take in enough calcium to prevent osteoporosis

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

After reading each statement, select if you STRONGLY DISAGREE, DISAGREE, are NEUTRAL, AGREE, or STRONGLY AGREE with the statement

26. You feel like you are not fit enough to exercise regularly

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

27. You have no place where you can exercise

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

28. Your spouse or family discourages you from exercising

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

29. Exercising regularly would mean starting a new habit which is hard for you to do

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

30. Exercising regularly makes you uncomfortable

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

31. Exercising regularly won't fit in your daily routine

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

After reading each statement, select if you STRONGLY DISAGREE, DISAGREE, are NEUTRAL, AGREE, or STRONGLY AGREE with the statement

32. Calcium rich foods cost too much

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

33. Calcium rich foods do not agree with you

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

34. You do not like calcium rich foods

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

35. Eating calcium rich foods means changing your diet which is hard to do

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

36. In order to eat more calcium rich foods you have to give up other foods that you like

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

37. Calcium rich foods have too much fat

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

38. You eat a well-balanced diet

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

39. You look for new information related to health

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

40. Keeping healthy is very important for you

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

41. You try to discover health problems early

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

42. You have a regular health check-up even when you are not sick

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

43. You follow recommendations to keep healthy

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Thank you for completing the survey.

Please check to be sure you answered all of the questions

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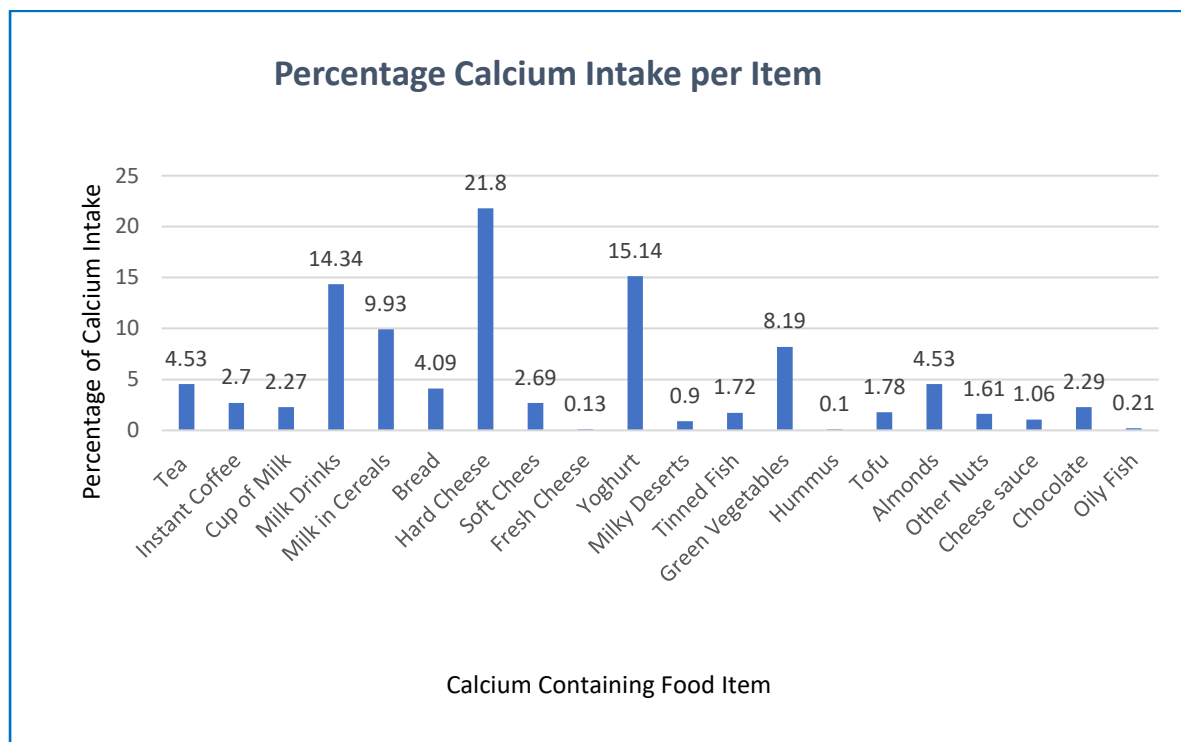
Appendix I: Average calcium amounts per FFQ item.

Food Group	Food item (taken from food Works 10 software)	Calcium
1 cup of tea with milk	Tea black regular with milk=33.50mg	34mg
1 cup of instant coffee with milk	with water & milk standard 3.3% fat=43.10mg with water & milk trim 0.5% fat=49.08mg	46mg
1 cup of milk	Milk standard 3.3% fat fluid =306.14mg Milk lite 1.5% fat fluid=338mg Milk trim 0.5% fat fluid=338mg Milk trim 0.3% fat fluid=364mg Milk whole 4% fat fluid=300.30	329mg
1cup of milk drink e.g. latte, flavored milk, soy milk	Flat white full cream milk=214.84mg Flat white reduced milk=254.48 Latte full cream =214.84mg Latte reduced milk=254.48mg Soy milk regular=290.70 Soy milk essential =330.20 Chocolate milk=262.49 Almond milk=177.40	250mg
1 Cup of milk with cereal /porridge	Porridge with standard milk 3.3% fat= 300 Porridge with trim milk 0.5% fat=330	315mg
½ cup of dairy-based pudding e.g. ice cream	vanilla, premium=71.96 vanilla, standard=86.21mg assorted berry flavour standard=69.60mg chocolate standard=66.34	74mg
50g chocolate	Milk chocolate, dairy milk=135mg	135mg
1 matchbox hard cheese (33g)	Cheddar, mainland= 267.30mg Cheddar tasty anchor=293.70mg Edam anchor=326.70 mg Edam mainland= 283.20 mg Colby =267.30mg	288mg
1 matchbox soft cheese (33g)	Camembert=180.51mg Brie = 151.80mg	166mg

1 handful of other nuts	Walnut= 23.40 Brazil nut=54mg Hazel nut=41.10mg	40mg
Slice of bread		32mg

1 tablespoon fresh cheese	Cheese cottage=10.01mg Cottage light, 1%fat=13.99 Sour cream=12.61mg Cheese cream=14.20mg	13mg
1 cup cheese sauce-based dish	Macaroni cheese=200.55mg	201mg
1 pottle yoghurt (125g)	Fresh n fruity regular fat fortified=236.25 Plain low fat unsweetened=200mg Greek style low fat, cyclops=231.25mg Greek style Dewinkle=250mg	229mg
1 tablespoon hummus	Original, 6.5% fat= 4.48mg Roasted capsicum, 7.5% fat=4.40mg Sundried tomato, 7.5% fat= 4.84mg	5mg
Canned fish with bones (57g)	Sockeye, canned drained=136.23mg Pink or red flesh, canned in spring water, drained=153.90 mg Salmon chum, canned drained=136.23mg	144mg
1 fillet oily fish	King, fillet, skin & bones removed, baked=14.34mg King, fillet, skin & bones removed, pan-fried=12.57mg Tuna, blue fin, flesh, raw=14.96mg	14mg
¾ cup bean curd/tofu (6oz)	Regular, firm raw=357.20mg Regular, firm stir fired=438.65mg Regular, firm simmered or pouched=324.63	373mg
½ cup green vegetables	Broccoli boiled, drained= 26.40mg Broccoli, microwaved=31.35mg Spinach English boiled=66mg Bok choy poached=62.65mg	47mg
1 handful almonds	Dried & blanched=74.10mg Dry roasted, salted added= 79.80mg Dried raw, unsalted=81mg	78mg

Appendix J: Percentage Contribution of FFQ Item to Calcium Intake



Appendix K: Percentage of Correct Answers for Each OKT-r Question

Domain/ Item	Correct (%)	Incorrect (%)
Below is a list of things which may or may not affect a person's chance of getting osteoporosis. After reading the stamen select one of four choices for your answer ¹		
Risk Knowledge Domain		
Eating a diet low in dairy products <u>More likely</u> ; less likely; Neutral; Don't know	62.1	37.9
Being post-menopausal: after menopause <u>More likely</u> ; less likely; Neutral; Don't know	87.9	12.1
Having a parent or grandparent with osteoporosis <u>More likely</u> ; less likely; Neutral; Don't know	89.4	10.6
Being a white or Asian woman <u>More likely</u> ; less likely; Neutral; Don't know	48.5	51.5
Being an elderly man <u>More likely</u> ; less likely; Neutral; Don't know	21.2	78.8
Having ovaries surgically removed <u>More likely</u> ; less likely; Neutral; Don't know	45.5	54.5
Taking cortisone for a long time <u>More likely</u> ; less likely; Neutral; Don't know	72.7	27.3
Having an eating disorder <u>More likely</u> ; less likely; Neutral; Don't know	84.8	15.2
Consuming more than 2 alcoholic drinks per day <u>More likely</u> ; less likely; Neutral; Don't know	47	53
Smoking on a daily basis <u>More likely</u> ; less likely; Neutral; Don't know.	55.5	45.5
Exercise knowledge Domain (Multiple choice²)		
To strengthen bones, it is recommended that a person exercises at moderate intensity for 30 minutes at least. <u>5 days/week</u> ; 4days/week; 3 days/week; DK ³	33.3	66.7
Exercise makes the bones strong, but it must be hard enough to make breathing: <u>Much faster but still possible to talk</u> ; Just a little faster; So fast that talking is not possible; DK	65.2	34.8
Best activities to reduce a person's chances of getting osteoporosis: <u>Brisk walking</u> ; swimming; stretching; DK	66.7	33.3
Best activities to reduce a person's chances of getting osteoporosis: <u>Lifting weights</u> ; cycling; yoga; DNK	62.1	37.9
Best activities to reduce a person's chances of getting osteoporosis. <u>Jogging/ running</u> ; golfing ; gardening; DK	63.6	36.4
Best activities to reduce a person's chances of getting osteoporosis. <u>Aerobic dancing</u> ; bowling; doing laundry; DK	62.1	37.9

¹ Answers underlined.

² Answers underlined.

³ DK = Don't know

Domain/ Item	Correct (%)	Incorrect (%)
Nutrition knowledge Domain (multiple choice²)		
Which is the best source of calcium? <u>Cheese</u> ; apple; cucumber; DNK	97	3
Which is the best source of calcium? <u>Canned sardines</u> ; Lamb; peanut butter; DNK	66.7	33.3
Which is the best source of calcium? <u>Broccoli</u> ; chicken; grapes; DNK	45.5	54.5
Which is the best source of calcium? <u>Yoghurt</u> ; strawberries; cabbage; DNK	97	3
Which is the best source of calcium? <u>Ice cream</u> ; grapefruit; radishes; DNK	83.3	16.7
How much milk must an adult drink to meet the recommended amount of Calcium? <u>3 or more glasses/day</u> ; 2glasses/day; 1 glass/day; DNK.	10.6	89.4
Best reason for taking a calcium supplement. <u>Person doesn't get enough calcium in their diet</u> ; person skips breakfast; person is over 45 years old; DNK	83.3	16.7
Which vitamin is required for the absorption of calcium? <u>Vitamin D</u> ; Vitamin A; Vitamin C; DNK.	56.1	43.9
Which is the best source for the vitamin required for the absorption of calcium? <u>Sunlight</u> ; carrots; oranges; DNK	62.1	37.9
Which is the best source for the vitamin required for the absorption of calcium? <u>Salmon</u> ; spinach; cheese; DNK	24.2	75.8
General Knowledge Domain (multiple choice²)		
When would you achieve peak bone mass? <u>young adulthood</u> ; adolescence; childhood; DNK	72.3	27.3
Osteoporosis can be diagnosed by: <u>DEXA scan</u> ; blood test; symptoms; DNK	78.8	21.2
Once you have osteoporosis: <u>You can take medications to treat it</u> ; nothing you can do about it; must be careful lifting objects; DNK	66.7	33.3
Mean Total OKT score	62.5	
2 Answers Underlined		

Appendix L: OHBS Percentage of Agreement/ Disagreement to Each Question

Construct	Level of agreement				
	SA	A	N	D	SD
<i>Susceptibility (n=66)</i>					
Your chances of getting osteoporosis are high	9.1	21.2	25.8	36.4	7.6
Because of your body build, you are more likely to develop osteoporosis	1.5	24.2	31.8	33.3	9.1
It is extremely likely that you will get osteoporosis	4.5	16.7	24.2	39.4	15.2
There is a good chance that you will get osteoporosis	4.5	24.2	28.8	36.4	6.1
You are more likely than the average person to get osteoporosis	3.0	16.7	27.3	42.4	10.6
Your family history makes it more likely that you will get osteoporosis	7.6	22.7	18.2	36.4	15.2
<i>Severity (n=66)</i>					
The thought of having osteoporosis scares you	6.1	45.5	33.2	12.1	3.0
If you had osteoporosis, you would be crippled	0.0	19.7	13.6	56.1	10.6
Your feelings about yourself would change if you got osteoporosis	0.0	33.3	22.7	36.4	7.6
It would be very costly if you got osteoporosis	0.0	22.7	40.9	31.8	4.5
When you think about osteoporosis you get depressed	0.0	6.1	25.8	45.5	22.7
It would be very serious if you got osteoporosis	1.5	34.8	37.9	25.8	0.0
<i>Benefits of exercise (n=66)</i>					
Regular exercise prevents problems that would happen from osteoporosis	18.2	72.7	7.6	1.5	0.0
You feel better when you exercise to prevent osteoporosis	21.2	59.1	15.2	4.5	0.0
Regular exercise helps to build strong bones	37.9	51.5	7.6	3.0	0.0
Exercising to prevent osteoporosis also improves the way your body looks	22.7	63.6	9.1	3.0	1.5
Regular exercise cuts down the chances of broken bones	24.2	48.5	22.7	4.5	0.0
You feel good about yourself when you exercise to prevent osteoporosis	21.2	56.2	12.1	1.5	0.0
<i>Benefits of calcium (n=65)</i>					
Taking in enough calcium prevents problems from osteoporosis	6.2	73.8	13.8	6.2	0.0
You have lots to gain from taking in enough calcium to prevent osteoporosis	9.2	73.8	12.3	3.1	1.5
Taking in enough calcium prevents painful osteoporosis	1.5	49.2	35.2	12.3	1.5
You would not worry as much about osteoporosis if you took in enough calcium	1.5	40.0	36.9	21.5	0.0
Taking in enough calcium cuts down on your chances of broken bones	6.2	70.8	10.8	12.3	0.0
You feel good about yourself when you take in enough calcium to prevent osteoporosis	1.5	52.3	38.5	6.2	1.5

Level of agreement

Construct	Sample (%)				
	SA	A	N	D	SD
<i>Barriers to exercise (n=65)</i>					
You feel like you are not fit enough to exercise regularly	3.1	9.2	4.6	49.2	33.8
You have no place where you can exercise	0.0	1.5	1.5	38.5	58.5
Your spouse or family discourages you from exercising	0.0	3.1	4.6	33.8	58.5
Exercising regularly would mean starting a new habit which is hard for you to do	0.0	16.9	6.2	35.2	41.5
Exercising regularly makes you uncomfortable	1.5	9.2	9.2	36.9	43.1
Exercising regularly won't fit in your daily routine	3.1	10.8	4.6	44.6	36.9
<i>Barriers to calcium n=65</i>					
Calcium rich foods cost too much	1.5	6.2	16.9	58.5	16.9
Calcium rich foods do not agree with you	3.1	6.2	9.2	53.8	27.7
You do not like calcium rich foods	3.1	1.5	10.8	52.3	32.3
Eating calcium rich foods means changing your diet which is hard to do	0.0	3.1	13.8	53.8	29.2
In order to eat more calcium rich foods, you have to give up other foods that you like	0.0	3.1	10.8	60.0	26.2
Calcium rich foods have too much fat	0.0	4.6	12.3	63.1	20.0
<i>Health motivation (n= 65)</i>					
You eat a well-balanced diet	23.1	56.9	15.4	3.1	1.5
You look for new information related to health	9.2	66.2	20.0	3.1	1.5
Keeping healthy is very important for you	41.5	53.8	3.1	1.5	0.0
You try to discover health problems early	21.5	58.5	12.3	7.7	0.0
You have a regular health check-up even when you are not sick	12.3	26.2	27.7	27.7	0.0
You follow recommendations to keep healthy	16.9	60.0	16.9	6.2	0.0