The Relationship between Osteoporosis Knowledge, Beliefs and Dietary Calcium Intake among South Asian Women in Auckland

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ABSTRACT

Osteoporosis is a serious public health issue, which is growing in significance because of our aging population. It is estimated that one in three New Zealand women over the age of 50 years will suffer from an osteoporotic-related fracture. The risk of osteoporosis among South Asian women living in New Zealand is unknown. However, this is an important and growing population group.

The purpose of this study was to determine osteoporosis knowledge, health beliefs and dietary calcium intake in a sample of South Asian women living in Auckland, New Zealand. Relationships between these variables and the predictors of dietary calcium intake were examined.

A sample of 102 South Asian women (mean age of 41.6 years) completed an online questionnaire to assess osteoporosis knowledge and health beliefs using the validated Osteoporosis Knowledge Test (OKT) and Osteoporosis Health Belief Scale (OHBS), respectively. A four day food diary was used to assess dietary calcium and energy intake.

In general, these South Asian women were lacking in osteoporosis knowledge, they did not perceive themselves to be susceptible to osteoporosis and did not consider osteoporosis to be a serious disease. They perceived many benefits of consuming a high calcium diet for the prevention of osteoporosis and did not identify many barriers to dietary calcium intake. In addition, these South Asian women were highly health motivated. Perceived barriers to dietary calcium intake ($R=-0.32$; $P<0.01$) and health motivation ($R=0.30$; $P<0.01$) were significantly correlated to dietary calcium intake. Health motivation, perceived barriers to dietary calcium intake and the use of a dietary supplement were significant predictors of dietary calcium intake and together explained 27% of the variance.

These findings suggest that osteoporosis prevention interventions may need to increase awareness, overcome perceived barriers to dietary calcium intake as well as maintain

health motivation among these South Asian women to achieve sufficient dietary calcium intake.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

AI	Adequate Intake
AOS	Asian Osteoporosis Study
BMC	Bone Mineral Content
BMD	Bone Mineral Density
BMI	Body Mass Index
CG	Control Group
DLW	Doubly Labelled Water
DPA	Dual-Photom Absorptiometry
DXA	Dual-Energy X-Ray Absorptiometry
EAR	Estimated Average Requirement
FDR	First-Degree Relative
FFQ	Food Frequency Questionnaire
FOQ	Facts on Osteoporosis Quiz
GH	Growth Hormone
GP	General Practitioner
HBM	Health Belief Model
HRT	Hormone Replacement Therapy
IG	Intervention Group
iPTH	Intact Parathyroid Hormone
IU	International Units
LS	Lumbar Spine
MOH	Ministry Of Health
NNS	National Nutrition Survey
OKT	Osteoporosis Knowledge Test
OHBS	Osteoporosis Health Belief Scale
PBM	Peak Bone Mass
PTH	Parathyroid Hormone
RDA	Recommended Dietary Allowance
RDBPCT	Randomized, Double-Blind, Placebo-Controlled Trial
RDI	Recommended Dietary Intake
SD	Standard Deviation

SP2	Single-Photon Absorptiometry
TEI:BMR	Total Energy Intake to Basal Metabolic Rate Ratio
UK	United Kingdon
UL	Upper Level of Intake
US	United States
YSM	Years Since Menopause

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

Osteoporosis is a serious skeletal disorder characterized by increased skeletal fragility and susceptibility to fracture (Cooper 1999). This is due to micro-architectural deterioration of bone tissue and therefore, a decrease in bone mineral density (BMD) and bone strength (Cooper 1999; New 1999). A number of factors determine bone strength throughout life, including family history, gender, ethnicity, age, menstrual status, dietary habits and the amount of sun exposure and weight-bearing exercise (Bassey 2000; Chumlea et al. 2002; Fairfield & Fletcher 2002; Flynn 2003; Prentice 2004; Wahlqvist & Wattanapenpaiboon 2000).

The prevalence of osteoporotic- related fractures has increased in many countries around the world and this trend is expected to continue as the population ages. Although the majority of osteoporotic fractures currently occur in European countries, by the year 2050 over half of all hip fractures are predicted to occur in Asian countries (Cooper 1999). At least one in three women in New Zealand will suffer from a fracture over the age of 50 (Cornwall & Davey 2004). Hospitalisation due to osteoporotic-related fractures in New Zealand has increased by ~37% from 1980-1996 (Cornwall & Davey 2004). Direct costs of osteoporotic fractures from 1989 to 1992 were NZ$200 million per annum (Randell et al. 1995). As the number of osteoporosis fractures continues to increase, the impact on the health system will become a serious problem.

BMD is often used as an indication of susceptibility to osteoporosis. Bone mass is determined by the peak bone mass (PBM) attained in early life and the rate of decrease in bone mass after the third decade of life (Bonjour et al. 2007; Henry et al. 2004; Ma et al. 2007; Weaver 2008). Dietary calcium intake is the single most important nutrient required for the attainment and maintenance of bone mass throughout life (Nordin 1997). Vitamin D is also essential for bone health as it is involved in the absorption of dietary calcium and bone mineralization (Bonjour et al. 2007; Specker & Vukovich 2007). Although calcium and vitamin D are the most recognized nutrients for bone health, it is important to note that many other nutrients, such as magnesium, zinc, vitamin K and phosphorus are also essential for bone health, particularly during childhood and the adolescent years (Heaney 1993). Other non-nutritional factors involved in maintenance of bone health include regular physical activity (Kelley 1998a and 1998b; Kelley et al. 2001; Specker & Vukovich 2007), menstrual status (Meena et al. 2007; Rizzoli & Bonjour 1999), family history (Brown et al. 2005) and the use of hormone replacement therapy (HRT) (Gambacciani et al. 2002; New & Bonjour 2003). Both nutritional and non-nutritional factors play an important role in osteoporosis prevention. For example, weight-bearing exercise stimulates bone formation and calcium and vitamin D are the required substrates for bone mineralization (Specker & Vukovich 2007). Dietary calcium has recently been shown to affect estrogen metabolism with a higher dietary intake resulting in a higher concentration of estrogen metabolites (Naploi et al. 2005, 2007).

Many interacting factors play a role in the maintenance of bone health and determine susceptibility and prevalence of osteoporosis in women. According to Heaney (1993), the three most important factors for determining bone health are physical acivity, hormonal status and dietary calcium intake. Therefore, although genetic predisposition predicts 60-80% of BMD variation (Bonjour et al. 2007; Prentice 2004), other modifiable lifestyle factors are vital for the prevention of osteoporosis. Moreover, the effects of each of these factors on bone health are largely independent. For example, a high dietary calcium intake can not offset the effect of estrogen deficiency on bone mass during menopause. Similarly, regular physical activity will not compensate for the effect of a low dietary calcium intake or alcohol abuse.

Studies have consistently found inadequate dietary calcium intake in women of all age groups. The 1997 National Nutrition Survey (NNS) (Russell et al. 1999) found all New Zealand women over the age of 15 years to have a dietary calcium intake below recommended amounts. The total mean intake was 735mg/day, with the highest prevalence of inadequate intake in the 15 to 18 year age group (37%), followed by the 65+ age group (30%) (Russell et al. 1999). Similarly, studies in Taiwan (Chang 2006a, 2006b), China (Hu et al. 1993) and India (Shatrugna et al. 2005) have found dietary calcium intakes to be below the recommendations for women. To-date, there have been no studies on dietary calcium intake within the South Asian population in New Zealand.

Knowledge and beliefs play an important role in determining dietary behaviour. Knowledge alone does not always predict behaviour (Terrio & Auld 2002; Wallace

2002) due to the strong influence of internal health beliefs. The Health Belief Model (HBM) proposes that perceived susceptibility and seriousness of a disease as well as perceived barriers and benefits of taking action all interact to influence dietary behaviour (Rosenstock 1960). Therefore, it is important to determine both osteoporosis knowledge and health beliefs in South Asian women, which may influence behaviours such as their dietary calcium intake and hence, their susceptibility to osteoporosis.

The primary aim of this study was to determine the relationship between osteoporosis knowledge and beliefs with dietary calcium intake in a sample of South Asian women living in Auckland, New Zealand. The Asian ethnic group makes up approximately 9% of the total New Zealand population and this is expected to increase exponentially (MOH 2006a; Statistics New Zealand 2006a). The South Asian population makes up 29% of the Asian community (Scragg & Maitra 2005). For the purposes of this study South Asian is defined as either the participant, both parents, or all grandparents being born in India, Pakistan, Bangladesh or Sri Lanka. Average dietary calcium intake in mg/day and in relation to total energy intake will be determined using a four day food diary, which includes one weekend day. Osteoporosis knowledge and beliefs will be determined using the Osteoporosis Knowledge Test (OKT) and the Osteoporosis Health Belief Scale (OHBS), respectively (Kim et al. 1991a, 1991b). Specific subscales regarding general knowledge on osteoporosis, knowledge of food calcium sources and recommended dietary calcium intakes will be used in the OKT. In the OHBS, subscales of interest will be those regarding perceived susceptibility and seriousness to osteoporosis, benefits and barriers to dietary calcium intake and health motivation. The relationship between the subscales of both the OKT and OHBS and the participants' demographic characteristics will be investigated.

CHAPTER 2: LITERATURE REVIEW

2.1 Osteoporosis

Osteoporosis is a systematic skeletal disorder characterized by increased skeletal fragility and susceptibility to fracture due to micro-architectural deterioration of bone tissue (Cooper 1999; New & Bonjour 2003). This is due to decreased BMD and micro-architectural deterioration of bone tissue (Cooper 1999; New 1999); therefore, bone strength is compromised. The high cost of treating osteoporosis patients presents a serious public health problem as prevalence continues to rise.

2.1.1 Health Significance of Osteoporosis

An increase in the prevalence of osteoporosis will negatively impact the health system. Randell et al. (1995) has predicted health costs due to osteoporosis to increase by two fold in all Western countries by the year 2050. Moreover, osteoporosis is a painful and crippling disease and most patients do not return to their previous mobility (Ribeiro et al. 2000; Wynne 2000).

Estimated Health Costs

According to Chang (2006a), worldwide health costs for osteoporosis is >US$13.8 billion. In Australia, Randell et al. (1995) estimated osteoporotic-related fractures to cost AUS$44 million per annum between 1989 and 1992. These costs are expected to double by the year 2011 (Cooper 1999). Lane (1996) estimated an average cost for hip fracture patients in New Zealand to be NZ$33,887.05 for the first year in women aged ≥60 years. This consisted of NZ$17,637.30 for inpatient care for the first 13 weeks, followed by NZ$16,249.75 for the following 39 weeks for residential care and services.

It is important to keep in mind that these are only estimates and are very likely to be under-estimated. Exact costs of osteoporosis are hard to determine for a number of reasons (Wynne 2000):

- Costs vary considerably from region to region;
- Costs are affected by the age of the patient;
- Site and severity of fracture will affect costs;

- Other non-medical costs, such as transportation and supplementation are difficult to account for;
- Cost of outpatient care varies considerably. According to the New Zealand Orthopaedic Association (2003), 25% of those who suffer from a hip fracture require long-term nursing care. Rehabilitation costs makes up the majority of these expenses, as many patients become totally dependent on nursing care (Cornwall & Davey 2004; Randell et al. 1995). The average duration of disability after a hip fracture in women worldwide has been estimated to be 3.60 years and can range from 2.76 to 3.77 years (Johnell & Kanis 2004).

Therefore, the impact of osteoporosis on the health system is probably much more significant than predicted.

Mortality Rates

Mortality and morbidity rates associated with hip fractures can be very high (Wynne 2000). It has been estimated that mortality rate of hip fractures due to complications are 20-25% (Brecher et al. 2002; Chan et al. 2005; Ribeiro et al. 2000; World Health Organization 2003). In India, the estimated number of deaths in 1990 associated with hip fractures in both men and women were 50,951 or 7% of total deaths (Johnell & Kanis 2004). Poon et al.'s (2001) analysis of all primary total hip replacements at Middlemore Hospital showed highest mortality rate in the first three months for femoral neck fractures compared to deaths from hip replacements for other reasons, such as rheumatoid arthritis. Falls causing fractures due to poor bone health in those aged ≥65 years are the second most common cause of unintentional injury deaths in New Zealand (Cornwall & Davey 2004). Moreover, 25-50% of hip fracture patients do not resume their previous mobility, severely affecting their quality of life (Williams et al. 2002).

2.1.2 Prevalence of Osteoporosis

Prevalence studies in Asian countries and in New Zealand are limited. Based on the available evidence, osteoporosis prevalence has increased in countries all around the world and will continue in this direction as the population ages (Johnell & Kanis 2006; Lau 1999; Lau et al. 2002a; Prentice 2004). Therefore, it is important to determine the prevalence of osteoporosis within New Zealand, particularly in the Asian population as this ethnic group is the fastest growing population in New Zealand (Statistics New Zealand 2006a).

Worldwide Estimates

Johnell and Kanis (2006) compiled a large number of studies and data from the World Health Organization (World Health Organization 2004 as cited in Johnell & Kanis 2006) to estimate worldwide prevalence and disability associated with osteoporotic fractures. The estimated number of total fracture sufferers was 56 million people worldwide, including hip, forearm and vertebral fractures. The greatest number of fractures was found in Europe, followed by Western Pacific (Australia, Japan and New Zealand) and South East Asia (Afghanistan, Bangladesh, India, Pakistan, Nepal, Bhutan and the Maldives).

According to Johnell and Kanis (2004), worldwide prevalence of hip fractures has increased by 25% since 1990, with as many as 4.48 million people worldwide suffering from the consequences of a hip fracture in 2000. Seventy percent of hip fractures were in women and occurred most frequently around the peak age of 75-79 years. It is predicted that by the year 2050, there will be at least 6.3 million hip fractures worldwide (Delmas and Fraser 1999). Cooper (1999) estimated 18,550 occurrences of hip fractures in Australia alone by the year 2011.

Prevalence in Asia

According to Delmas and Fraser (1999) and the World Health Organization (2003) although half of all hip fractures worldwide are currently in Europe and North America, the greatest increase in the number of hip fractures worldwide will occur in Asia due to the ageing population. At least half of all hip fractures will occur in Asian countries by the year 2050 (Cooper 1999). The rapid socio-economic changes occurring in Asian countries will cause a rapid increase in the incidence of osteoporotic hip fractures to approximately 3.2 million per year by the year 2050 (Lau 1999). Evidence of this rapid rise is already accumulating. For example, the incidence of hip fractures in Hong Kong has increased by two-fold over the last 30 years (Lau 1999; Lau et al. 2002a).

The Asian Osteoporosis Study (AOS) was an extensive research project aimed at determining the incidence of hip fractures in the Hong Kong SAR region, Singapore, Malaysia and Chiang Mai in Northern Thailand (Lau et al. 2001, 2002a). Hong Kong had the highest incidence rate, followed closely by Singapore; Thailand and Malaysia had much lower rates. The age-adjusted rates in Hong Kong and Singapore were 96% and 80% of white American women rates, respectively. In contrast, Thai and Malaysian women were 50% and 41% respectively of that among white American women (Lau et al. 2001). The high rates of hip fractures in Hong Kong and Singapore may be due to its rapid economic development and highly urbanized cities compared to Thailand and Malaysia (Lau et al. 2001, 2002a). Of particular interest was that rates doubled from age 65 to 74 years and increased exponentially after 75 years of age in all four countries (Lau et al. 2002a). In addition, hip fracture rates among Chinese and Indian women were similar in Malaysia, but were significantly different in Singapore. In Singapore, Chinese women had about double the rate of hip fractures compared to Indians and Malays (Lau et al. 2002a). This indicates that other external factors are likely to affect susceptibility of osteoporotic hip fractures. Other worldwide prevalence studies have also shown large variations within, as well as between countries (Johnell & Kanis 2006). Therefore, differences in environmental and lifestyle factors, such as dietary habits, physical activity and amount of sun exposure, in addition to genetic factors, may play a significant role in the development of osteoporosis (Bonjour et al. 2007; Kochupillai 2000).

<u>Prevalence in South East Asia</u>

Based on the available evidence, prevalence of osteoporosis in South East Asia will become a significant public health problem as the number of fractures begins to rise exponentially (Delmas & Fraser 1999; Johnell & Kanis 2004; Kochupillai 2000; Lau et al. 2002a). According to estimates by Johnell and Kanis (2004), the prevalence of osteoporotic fractures in South East Asia (Afghanistan, Banglades, India, Pakistan, Nepal, Bhutan and the Maldives) is 15% with a total of 8,622,000 fractures in both men and women. Seventeen percent of South East Asian women age ≥50 years suffered from a fracture at the hip, spine, forearm or humerous in the year 2000 (Johnell & Kanis 2004). In a later publication, Johnell and Kanis (2006) predicted a 6% prevalence rate of hip fractures in India, based on a total number of 82,839 hip fractures in 1990.

<u>Prevalence in New Zealand</u>

In New Zealand, one in three women and one in twelve men aged over 50 years will suffer from an osteoporosis-related fracture (Cornwall & Davey 2004). The New Zealand Orthopaedic Association (2003) suggested that 50% of females will experience an osteoporosis-related fracture in their lifetime. The number of estimated hip fractures in New Zealand in 1994 was 3,039 in both men and women, of which 2,276 were in women.

Prevalence of osteoporosis is expected to increase due to the ageing population. Between 2010 and 2035, the largest growing age group will be 65-74 years, which will translate into the ≥85 years age group in 2051 (Figure 1; Ministry of Health (MOH) 2002). Horwath et al. (2001) predicted a rise in the number of hip fractures to at least 4,800 hip fractures over the age of 65 years in 2011 of which 73% will occur in women (Horwath et al. 2001). However, Horwath et al.'s (2001) calculation is likely to be under-estimated as the number of primary hip replacements in 2001 was already 4,911 (New Zealand Orthopaedic Association 2003). According to the New Zealand Orthopaedic Association (2003), the number of hip replacements is expected to increase to 9,718 by the year 2051. Estimated overall increase in osteoporosis incidence from 2001 to 2051 in New Zealand has been reported to be 201% from 380,062 to 764,268 in both men and women (New Zealand Orthopaedic Association 2003). These calculations were based on data from the National Joint Register and Osteoporosis New Zealand (New Zealand Orthopaedic Association 2003).

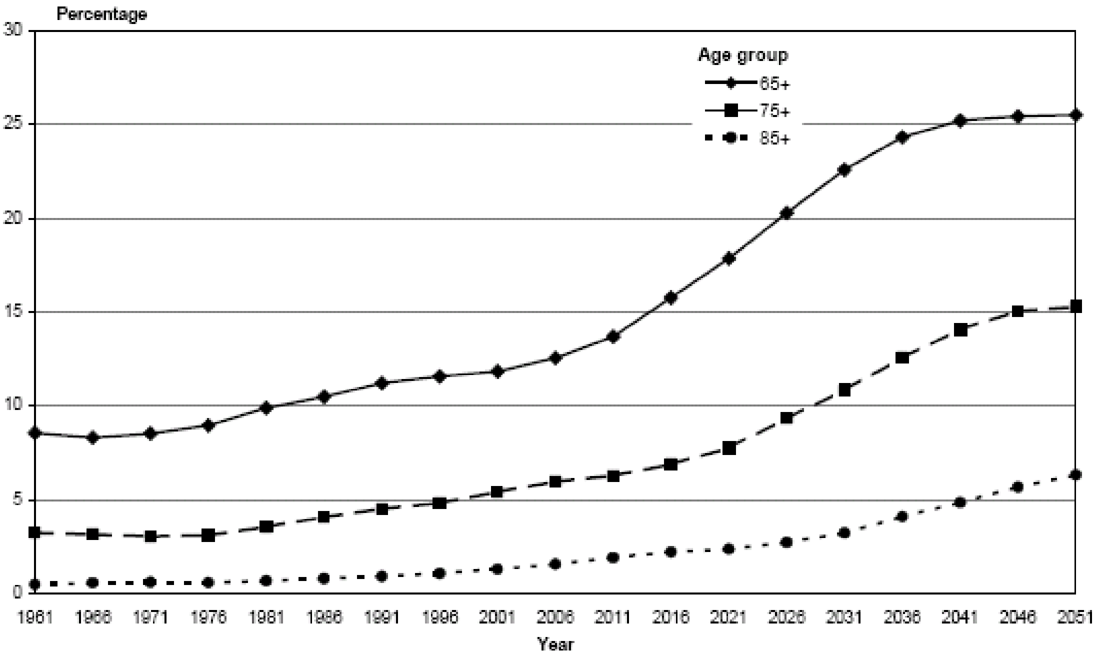

Figure 1: The New Zealand population in three age groups (65+, 75+ and 85+) as a percentage of the whole population from 1961 to 2051 (MOH 2002, p. 19).

Prevalence in the New Zealand Asian Population

As the Asian population in New Zealand continues to grow, it is important to recognize any health problems within this ethnic group. According to the 2006 Census, the Asian ethnic group makes up approximately 9% of the total New Zealand population and is expected to increase to ~12% by the year 2021 (MOH 2006a; Statistics New Zealand 2006a). Chinese people make up the largest proportion of the Asian population (over 40%), followed by Indians (26%), which includes Fijian Indians and Indians not elsewhere classified (MOH 2006a). The Indian population has doubled between 1999 to 2001 (Statistics New Zealand 2002) and is expected to increase from 272,000 in 2001 to 667,000 in 2021 (an increase of 145%) (Statistics New Zealand 2007). The South Asian population (Indian subcontinent, including Sri Lankan) makes up 29% of the Asian community (Scragg & Maitra 2005). Overall, the Indian population makes up 1.7% of the total New Zealand population. In Auckland, the Indian community makes up 27% of the Asian population (MOH 2003a).

A review of the 2002/03 New Zealand National Health Survey by Scragg and Maitra (2005) showed an equal prevalence of osteoporosis between the Asian and European population. The age-standardised prevalence of osteoporosis for Asian and European people was both at 2%, whereas the Maori and Pacific Island population had a slightly lower risk at 1% (Scragg & Maitra 2005). Further analysis of the Asian population showed a 1% age-standardised prevalence of osteoporosis within the South Asian population, compared to 1%, 0% and 3% for the Chinese, Korean and South-East Asian (Japan and Indonesian) population, respectively (Scragg & Maitra 2005). Within the Asian population, osteoporosis was not listed as the top five causes of death or in the top ten reasons for discharge from hospitals within the Asian population (MOH 2003a). Nevertheless, it is still highly recommended that health care professionals are aware and knowledgeable about osteoporosis risks as the population begins to age and as the prevalence begins to rise exponentially (Cooper 1999; Delmas & Fraser 1999). It has been predicted by MOH (2002) that the Asian population will expand in the older generation from 2% in 2001 to 4% by the year 2016 (Figure 2).

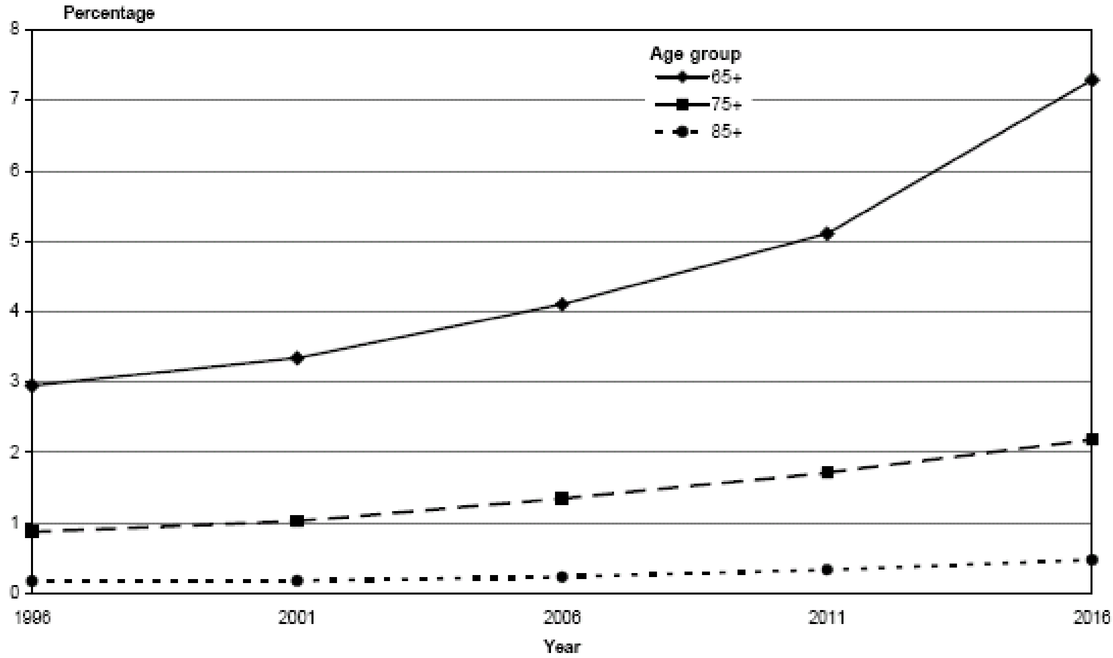

Figure 2: Asian population age growth of three age groups (65+, 75+ and 85+) from 1996 to 2016 (MOH 2002, p. 23).

As the population in New Zealand and around the world begins to age, the prevalence of osteoporosis will gradually increase. Although half of all hip fractures are currently in European countries, it has been predicted that by the year 2050, half of all hip fractures worldwide will occur in Asia (Cooper 1999). Health costs for osteoporosis are expected to double in all countries by the year 2011 (Cooper 1999). In New Zealand, osteoporosis prevalence will increase drastically in the near future as the 65-74 years age group grows rapidly between 2010 and 2035 (MOH 2002).

<u>2.2 Bone Health</u>

To maintain healthy bones throughout life, a diet high in calcium is essential. Bone tissue contains more than 99% of total body calcium; hence, dietary calcium intake is the predominant dietary factor in determining bone strength and maintenance of bone structure (Flynn 2003; Piaseu et al. 2002; Prentice 2004). A diet low in calcium does not impair other cellular and neuromuscular functions it is involved in, such as nerve conduction and muscle contraction. Instead, bone tissue acts as a reservoir to draw calcium from to ensure the cellular and neuromuscular processes are unaffected; therefore, bone strength is adversely compromised (Badenhop-Stevens & Matkovic

2004; Flynn 2003; Kass-Wolff 2004). Calcium reserves in the skeleton are mobilised through an increase in parathyroid function (Meunier 1999). Although the exact mechanism is not completely understood, one negative feedback system has been proposed by Flynn (2003) and Lewis and Modlesky (1998), which is presented in Figure 3.

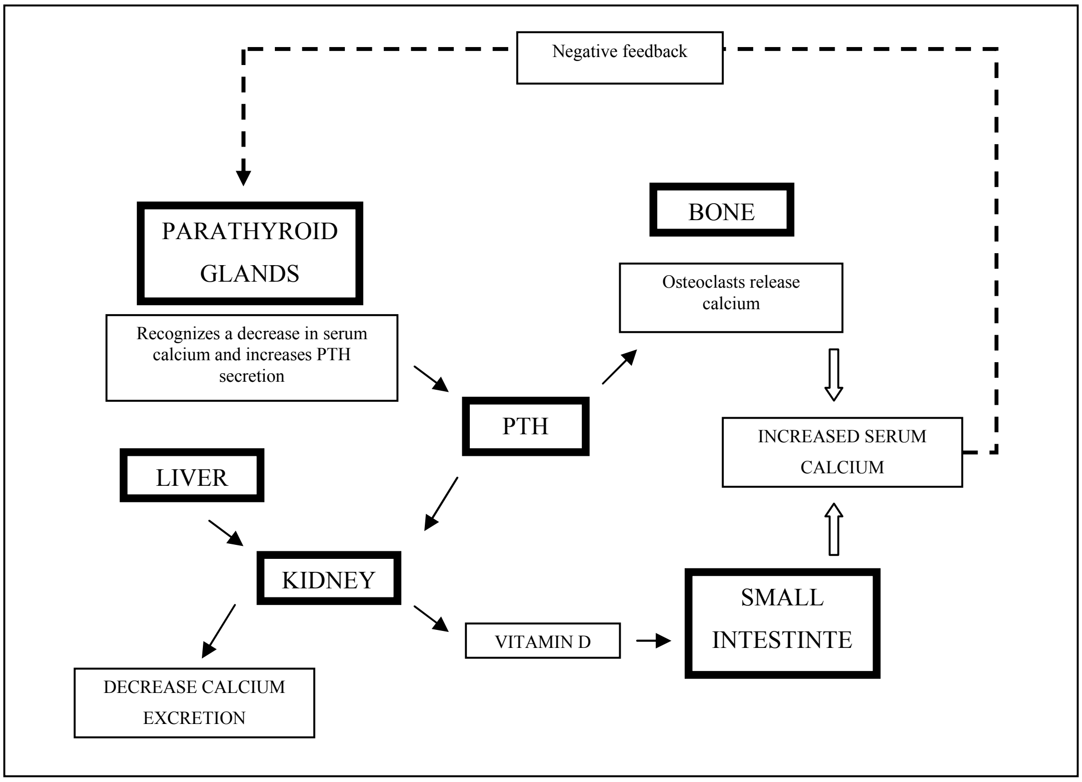

Figure 3: Regulation of serum calcium as proposed by Flynn (2003) and Lewis and Modlesky (1998).

The calcium-sensing receptors located on the parathyroid gland detect a decrease in serum calcium and respond by secreting parathyroid hormone (PTH). PTH acts on the bone to release calcium to increase serum calcium levels (Flynn 2003; Lee & Jiang 2008). In addition, the kidney decreases urinary calcium excretion in response to an increase in PTH levels and vitamin D synthesis is stimulated in the kidney to enhance intestinal calcium absorption (Flynn 2003; Lewis & Modlesky 1998). Once serum calcium has been stabilized to 2.10-2.55mmol/L, a negative feedback system decreases PTH secretion back to baseline levels to maintain serum calcium levels within this range.

2.2.1 The bone remodeling cycle

Bone tissues are constantly being broken down and reformed by a bone resorption and bone formation cyclic process as shown in Figure 4. The cycle involves three main cell types (Delaney 2006; Flynn 2003):

- Osteoblasts – bone-forming cells that regulate crystallization. Derived from mesenchymal lineage of marrow stromal cells and adipocytes (Manolagas & Jilka 1995; Zallone 2006);
- Osteoclasts – bone-resorption cells that repair and remodel bone tissue. Derived from hematopoietic progenitor of the myeloid lineage (Zallone 2006);
- Osteocytes – osteoblasts that are embedded within the bone. These cells sense and translate information about the internal bone environment.

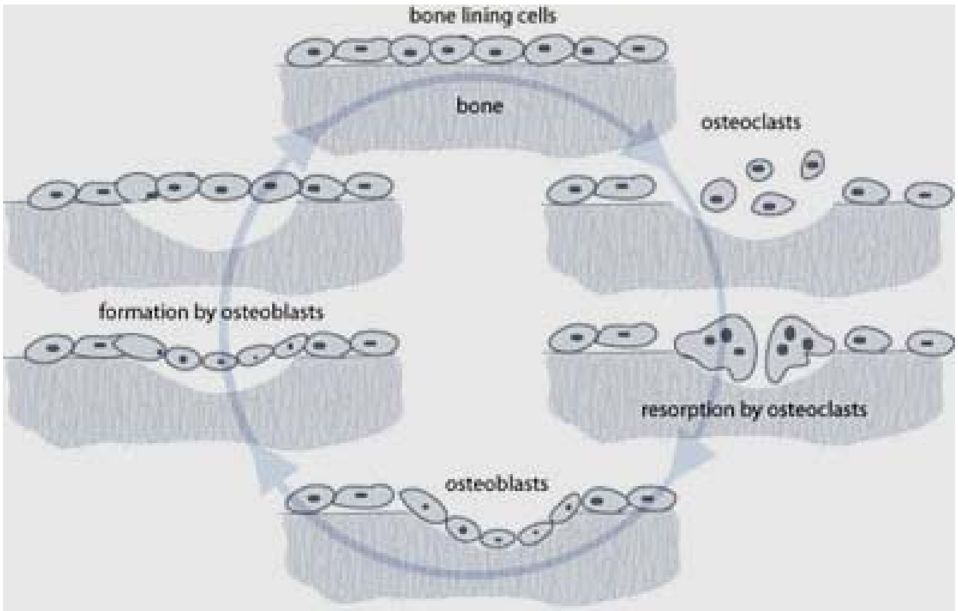

Figure 4: Schematic diagram of the bone remodeling cycle (The constant cycle of bone turnover 2005).

Osteoclasts resorb a volume of bone tissue and is followed by formation of bone tissue in the same region by osteoblasts (Seeman 2003). The balance between these two processes determines BMD. When bone loss is replaced by the same volume of bone formation, there is no net bone loss (Delaney 2006; Seeman 2003). During the growth period in childhood and adolescent years, this cyclic process favours bone formation, resulting in bone accretion (Wynne 2000). Once PBM has been attained around the third decade of life, BMD begins to decline. This occurs due to an increase in bone resorption or a decrease in bone formation, or both. Therefore, it is extremely important for women to maintain an adequate dietary calcium intake throughout life to ensure a high PBM and to slow down the rate of bone loss in later life.

2.2.2 Bone Mineral Density

Bone mineral density is often used as an indication of susceptibility to osteoporosis. Numerous studies have found a significant relationship between a low BMD and osteoporosis-related fractures, most commonly in the hip and spine (Flynn 2003; Henry et al. 2004; van der Klift 2005). According to the MOH and World Health Organization definition, osteoporosis is characterized by a value of 2.5 standard deviations (T-score ≤-2.5) below the mean BMD or bone mineral content (BMC) of young healthy adults (Flynn 2003; National Health Committee 2006; New & Bonjour 2003). Figure 5 below shows the difference between osteoporotic bone tissue and normal bone tissue density using an electron micrograph. For each standard deviation drop in BMD, the risk of a fracture increases by 1.5 to 3-fold (Kanis 2002; Kanis & Glüer 2000; Lewis & Modlesky 1998; New & Bonjour 2003).

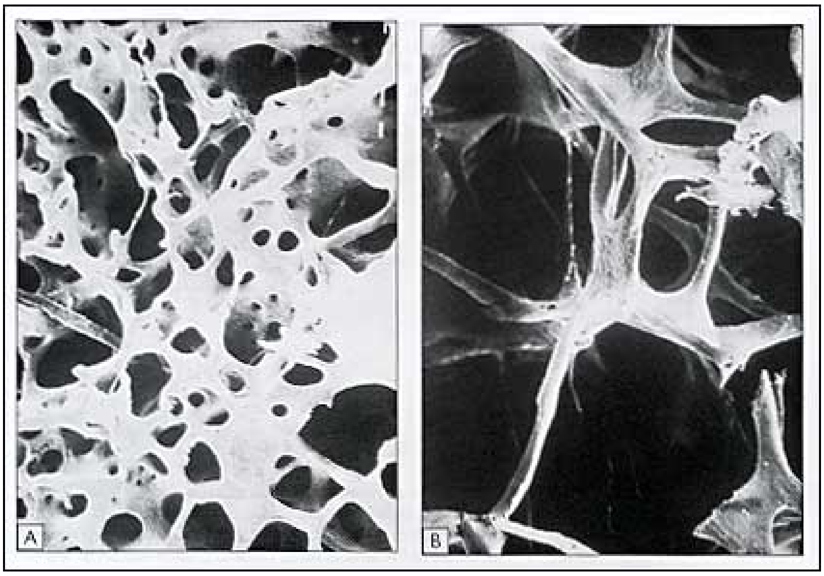

Figure 5: Decrease in bone mineral density and micro-architectural deterioration of bone tissue resulting in osteoporosis (Panel B) compared to normal bone density (Panel A). (Scanning electron micrograph of normal bone density and decreased bone density characteristics of osteoporosis 2007).

BMD throughout life is determined by two main characteristics (Bonjour et al. 2007; French et al. 2000; Prentice 2004):

- PBM attained by the third decade of life. PBM is the amount of bone tissue at the end of skeletal maturation (Bonjour et al. 2007; French et al. 2000). Although genetics plays a major role in determining PBM (Bonjour et al. 2007; Weaver 2008), consuming adequate dietary calcium intake during the prepubertal and adolescent stages is essential in optimizing PBM (Dibba et al. 2000; French et al. 2000; Ma et al. 2007; Wahlqvist & Wattanapenpaiboon 2000; Weaver 2008);
- Rate of decrease in bone mass thereafter. According to Brown et al. (2005), bone mass slowly decreases by approximately 0.3% each year after the third decade and dramatically increases to ~3% during the first three to five years of menopause. There is a large variation in the rate of decrease in BMD between ethnic groups and within countries, indicating both internal and external influences on bone health (Lau et al. 2001; Pothiwala et al. 2006; Prentice 2004).

PBM attained at different sites varies, as well as the rate of decrease in BMD; the femoral neck, spine and wrists are most prone to fractures (Henry et al. 2004; Prentice 2004; Sirola et al. 2003).

Although a low BMD can predict the risk of fracture, it does not necessarily identify those who will have a fracture (Kanis 2002; McClung 2005; van der Klift et al. 2005). A number of factors interact to determine an individual's susceptibility to osteoporosis and can be separated into two broad categories – nutritional and non-nutritional factors. Nutritional factors include dietary calcium intake and vitamin D. Non-nutritional factors include physical activity, genetic predisposition and the effect of menopause. These factors affect bone health during all stages of growth and ageing and therefore need to be considered in risk assessment of osteoporosis.

2.3 Nutritional Risk Factors Affecting Osteoporosis

2.3.1 Role of Dietary Calcium

Dietary calcium intake is the main nutritional factor that determines bone strength and maintenance of BMD throughout life. It is particularly important during the prepubertal

(Bonjour et al. 2007; Dibba et al. 2000; French et al. 2000; Zhu et al. 2008) and adolescent years (Cadogan et al. 1997; Nowson et al. 1997) when bone accretion occurs exponentially. Studies on postmenopausal women have also concluded that a diet high in calcium is beneficial in the prevention of osteoporosis (Dawson-Hughes et al. 1997; Di Daniele et al. 2004; Moschonis & Manios 2006). Based on the evidence, it is clear that adequate dietary calcium intake throughout life is a key factor in the maintenance of bone health and prevention of osteoporosis.

2.3.1.1 Nutritional Reference Values

The MOH released new dietary recommendations for calcium in 2005 (MOH 2006b). The estimated average requirement (EAR) is the "daily nutrient level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group" (MOH 2006b, p. 1). The EAR was calculated by combining 210 studies and determining what the required dietary intake was to obtain a balance between net absorption and excretion (MOH 2006b). Additional losses due to menopause and aging were also accounted for. The recommended dietary intake (RDI) is the "average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97-98 per cent) healthy individuals in a particular life stage and gender group" (MOH 2006b, p. 1). RDI levels were calculated by adding two standard deviations to EAR (EAR + 2SD) (MOH 2006b). Adequate Intake (AI) is the "experimentally determined estimate of nutrient intake by a defined group of healthy people" (Institue of Medicine 1997), p.15). Recommended Dietary Allowance (RDA) is defined as "the levels of intake of energy and dietary components, which on the basis of current scientific knowledge, are considered adequate for the maintenance of health and well-being of nearly all healthy persons in the population" (Barba & Cabrera 2008, p. 406). Table 1 shows the recommended dietary calcium intakes for women of different age groups for different countries (New Zealand, the United States (US), Southeast Asia, Sri Lanka, China and Taiwan).

Table 1: Recommended Dietary Calcium Intakes for Women of Different Age Groups for New Zealand, United States, Southeast Asia, Sri Lanka, China and Taiwan

Age group (years)	**New Zealand** [1]		**United States** [2]	**Southeast Asia** [3, 4]	**Sri Lanka** [5]	**China** [6]	**Taiwan** [5]
	EAR (mg/day)	**RDI (mg/day)**	**AI (mg/day)**	**RDA (mg/day)**	**RDI (mg/day)**	**AI (mg/day)**	**RDI (mg/day)**
19-30	840	1,000	1,000	700	400	800	1,000
31-50	840	1,000	1,000	700	400	800	1,000
51-70	1,100	1,300	1,200	1,000	400	1,000	1,000
>70	1,100	1,300	1,200	1,000	400	1,000	1,000

AI, Adequate Intake; EAR, Estimated Average Requirement; RDA, Recommended Dietary Allowance; RDI, Recommended Dietary Intake

[1] Reference MOH (2006b)

[2] Reference Institue of Medicine (1997)

[3] Reference International Life Sciences Institute – Southeast Asia Region (2005)

[4] Southeast Asia refers to Cambodia, Indonesia, Laos, Malaysia, Mayanmar, Philippines, Singapore, Thailand and Vietnam

[5] Reference Looker (2006)

[6] Reference Chinese Nutrition Society (2007)

2.3.1.2 Food Sources of Calcium

According to the 1997 NNS, the main sources of dietary calcium in the New Zealand diet were milk and cheese (Horwath et al. 2001; MOH 2003b; Russell et al. 1999). Milk provides an excellent source of calcium and some milk products in New Zealand have been fortified with calcium, such as Anchor's 'Calci-Xtra'. 'Anlene' has been fortified with calcium, vitamin D and vitamin K to help with absorption. Anchor 'Mega Milk' has also been fortified with vitamin D and K in addition to calcium to aid in calcium absorption. Other dairy foods, such as yoghurt and cheese are also good sources of dietary calcium.

For those with lactose intolerance, soy products fortified with calcium, canned fish, tofu, legumes and green leafy vegetables are recommended to enhance PBM and maintain BMD throughout life (French et al. 2000; Horwath et al. 2001; MOH 2003b; Weaver 2008). Vegetables high in dietary calcium include broccoli, bok choy, spinach and rhubarb (Kass-Wolff 2004). However, the bioavailability of calcium from these food sources is lower compared to animal sources due to their high fibre and oxalate content, which are known to inhibit dietary calcium absorption (Nordin 1997; Wahlqvist & Wattanapenpaiboon 2000).

Below (Table 2) is a list of common food sources of dietary calcium (mg/100g) according to FoodWorks Professional (Edition version 4.00.1158, Xyris Software, Pty Ltd., Australia) and common Indian dishes (Table 3) based on recipes from Raina et al. (2001) and Thangman (1988) and data from Indian food composition tables (Gopalan et al. 1999).

Table 2: Food Sources of Calcium (FoodWorks Professional Edition version 4.00.1158, Xyris Software, Pty Ltd., Australia).

Food Source	Calcium (mg/100g)
Milk, fluid, standard	116
Milk, fluid, trim	145
Milk, fluid, skim	122
Milk, Calci-Xtra, Anchor	200
Soy drink, So Good	120
Soy drink, So Good Lite	120
Soy drink, Calci plus, Vitasoy	120
Yoghurt, plain, unsweetened	120
Yoghurt, plain, low fat, unsweetened	160
Yoghurt, asst fruits& flavours, sweetened	150
Soy, yoghurt	105
Ice cream, vanilla, standard	121
Ice cream, vanilla, low fat	161
Cheese, edam	770
Cheese, cottage	61
Cheese, feta	360
Cream, sour, reduced fat	130
Cream, standard	55
Cream, reduced fat	76.2
Sardines, drained solids, canned	550
Sardines, fish & oil, canned	460
Mackerel, canned, drained	241

Table 2 continued: Food Sources of Calcium (FoodWorks Professional Edition version 4.00.1158, Xyris Software, Pty Ltd., Australia).

Food Source	Calcium (mg/100g)
Salmon, red, canned	93
Egg, chicken, boiled	58
Broccoli, florets, boiled, drained	36
Spinach, leaves, boiled, drained	160
Spinach, NZ, leaves & upper stem, raw	65
Rhubarb, raw	103
Tofu	105
Brazil nuts, raw	180
Hazel nuts, raw	179
Almonds, raw	250

Table 3: Calcium Content of Popular Indian Dishes (mg/100g) based on Recipes from Raina et al. (2001) and Thangman (1988) and Data from Indian Food Composition Tables (Gopalan et al. 1999) (FoodWorks Professional Edition version 4.00.1158, Xyris Software, Pty Ltd., Australia).

Food Source	Calcium (mg/100g)
Bean curry	32.7
Beef curry	42.3
Chicken curry	18.2
Pork curry	18.7
Fish curry	76.1
Yoghurt curry	68.5
Mince pea curry	40.9
Mixed vegeTable curry	35.6
Dhal tomato curry	87.8
Butter chicken	33.6
Fish masala	42.8
Home-made curd	149
Curd rice	70.9

2.3.1.3 Factors Affecting Dietary Calcium Absorption and Excretion

Dietary calcium absorption from animal sources are thought to be better compared to plant sources due to the combination of other micronutrients, including magnesium, zinc, vitamin D and vitamin K (Kass-Wolff 2004). Moreover, plant sources of dietary calcium may also be high in phytates, oxalates, fibre and phosphate ions. These are known inhibitors of calcium absorption, therefore, limiting bioavailability (Nordin 1997). Foods high in phytates include legumes, seeds, oats, rye and barley. Foods high in oxalates include chocolate, tea, spinach and rhubarb (Kass-Wolff 2004). Therefore, although spinach and rhubarb are good sources of non-dairy dietary calcium, their high oxalate level limits the bioavailability of calcium.

Caffeine is a weak diuretic and has been thought to affect dietary calcium bioavailability via an increased rate of urinary calcium excretion (O'Brien et al. 1996). A review by Massey & Whiting (1993) concluded that there is no evidence of an effect of caffeine consumption on bone loss or fractures in young women. On the other hand, evidence for older women remains controversial and requires further research. In another extensive review by Heaney (2002), there was inconclusive evidence of a significant effect of caffeine on the calcium economy. Experimental human studies showed a small negative calcium balance with caffeine consumption in those who were consuming inadequate dietary calcium. However, the effect of caffeine on calcium absorption was minimal, which could be counterbalanced with an additional one to two tablespoons of milk per cup of coffee. Metabolic balance studies showed a very weak effect of caffeine on calcium absorption. Five studies measured the effect of caffeine on BMD and only one found a negative effect. However, it should be noted that the effect of caffeine on BMD was only notable for those individuals who had inadequate dietary calcium intakes (<600mg/day). Finally, the majority of observational studies have found no effect of caffeine on calcium and bone economies. Therefore, Heaney (2002) concluded that the effect of caffeine on dietary calcium absorption and BMD is only a very weak effect if any, for those who do not obtain adequate dietary calcium intakes.

It has been well documented that urinary calcium excretion is related to urinary sodium excretion (Heaney 2006; Nordin et al. 1993). However, whether a diet high in sodium would result in an increased risk of osteoporosis and fractures remains unknown (Reid & MacDonald 2001). After extensively reviewing the literature, Teucher and Fairweather-

Tait (2003) concluded that although a high salt diet does result in increased urinary calcium excretion, whether this would result in detrimental effects on BMD and fracture risk in the long run has yet to be established. Further longitudinal, placebo-controlled, randomized, well-controlled trials that utilize accurate methods of measuring bone turnover as well as BMD changes are required. Potassium and protein are other dietary modulators of sodium and calcium excretion and are therefore important factors for future research (Teucher & Fairweather-Tait 2003). The effect of sodium on bone health can not be studied in isolation. Rather, understanding the effect of dietary sodium intake in the context of the whole diet would help to provide practical, realistic recommendations for the prevention of osteoporosis.

2.3.1.4 Dietary Calcium Intake in Women

Dietary Calcium Intake in Asian Women

Only a few studies have determined dietary calcium intake specifically within the Asian population; the results of these studies have consistently found inadequate dietary calcium intakes.

Chang (2006a, 2006b) found inadequate dietary calcium intake among Taiwanese women. A sample of 265 Taiwanese women aged between 25 and 45 years had a mean dietary calcium intake of 454±66mg/day (Chang 2006a). Likewise, mean dietary calcium intakes were between 456±24mg/day (mean age of 46.3years) and 550±10mg/day (mean age of 48.5years) in two other groups of Taiwanese women (Chang 2006b). However, methods used to assess dietary calcium intake in both these studies were not outlined. Therefore, the sources and degree of error of these estimated dietary calcium intakes are relatively unknown. Future research on dietary calcium intake among Taiwanese women is required.

Hu et al. (1993) determined dietary calcium intake in a sample of Chinese women using a three day food diary. The three day weighed food diaries were recorded by researchers in the homes of 764 Chinese women aged between 35 to 75 years. Mean dietary calcium intake across the whole group was 382±176mg/day. Moreover, only one-third of the entire study sample reported a consumption of more than 800mg of calcium each day. A high dietary calcium intake was positively correlated with a higher BMD and

BMC by ~20%. Regression analysis showed consumption of dairy foods to be associated with bone density pre and post menopause, which may indicate a greater bioavailability of dietary calcium from dairy sources, compared to non-dairy sources. When comparing BMD and rate of BMD loss after menopause, the rate of decrease was similar across all participants, despite a higher BMD in the rural group. Therefore, these results suggest the importance of a high PBM in the prevention of osteoporosis.

A low dietary calcium intake in Chinese women was also observed by Lau et al. (2002b). In this study, dietary calcium intake was measured in 90 Chinese women with a seven day food diary repeated every 12 months over a 24 month period. Results found a mean dietary calcium intake of 455±195mg/day, 438±194mg/day and 390±147mg/day at baseline, 12 and 24 months, respectively. As with Hu et al. (1993), these results indicate a high prevalence of inadequate dietary calcium intake in Chinese women.

Based on the few studies on dietary calcium intake in Asian women, inadequate dietary calcium consumption has been demonstrated. A dietary calcium intake that meets the RDI is the predominant nutritional factor in the prevention of osteoporosis. Therefore, Asian women with a low dietary calcium intake are likely to be at risk of developing osteoporosis particularly when they become menopausal. More research is required in this area that utilizes reliable and validated tools of assessment of dietary calcium intake to strengthen these preliminary findings.

Dietary Calcium Intake in Indian Women

The small number of studies on dietary calcium intake within the Indian population has also found mean calcium intakes below RDI. For example, in Shatrugna et al.'s study (2005), mean dietary calcium intake in a sample of 289 Indian women (mean age of 41.0 years) was 270±57mg/day as measured by a food frequency questionnaire (FFQ) and a 24 hour recall. Moreover, the main food sources of dietary calcium came from plant sources, such as cereals and green leafy vegetables, which have a lower bioavailability compared to animal sources. BMD and BMC measurements were significantly associated with dietary calcium intake and were considerably lower compared to other Western countries. The women were recruited from a large urban slum (Addagutta) in Hyderabad, South India. Because these women were generally within the lower socioeconomic group, these results can not be generalized to the whole Indian population. Indian women from the upper socioeconomic group may have considerably different dietary calcium intakes. Therefore, further research in other areas of India is required.

A low dietary calcium intake in Indian women was also reported by Harinarayan et al. (2004). Both dietary calcium intake and serum vitamin D levels were measured in 316 men and women living in rural (n=191; mean age of 44.0 years) and urban (n=125; mean age of 45.5 years) areas of Tirupati, located in the extreme Southeast and Southern part of India. Mean age of participants were 44.0 years and 45.5 years in the rural and urban areas, respectively. Participants were asked to recall their diet of the previous five to seven days, which was recorded by a single observer. One of the authors checked for validity and repeatability of these dietary recalls at random throughout the study. No significant differences were observed between the dietary recall documents and were therefore assumed to be valid and reliable. Analysis of dietary data showed a mean dietary calcium intake ± SEM in rural and urban areas of 264±1.94mg/day and 354±5mg/day, respectively. Intakes were significantly lower in rural areas, which were accompanied by a high consumption of phytates from cereal and rice. Phytates are known to inhibit calcium absorption (Kass-Wolff 2004; New 1999; Nordin 1997) and may therefore enhance the problem of a low dietary calcium intake and increase the risk of osteoporosis. However, the dietary assessment method used is highly susceptible to memory bias. Therefore, the accuracy of these results is questionable.

Another study by Harinarayan et al. (2007) showed similar findings. In this study, a larger cohort was obtained (n=1,148) from the same region of South India. Mean age of the participants in the rural and urban groups were 43.0 years and 46.0 years, respectively. Mean dietary calcium intake ± SEM in rural and urban females were 262±3mg/day and 306±2mg/day, respectively. Once again, dietary calcium intakes were well below the RDI. However, dietary data collection was obtained using the same methodology. Therefore, studies that utilize more accurate methods of dietary calcium assessment within the Indian population are required to confirm these results.

Based on the preliminary evidence, Indian women may not be obtaining adequate dietary calcium. However, the majority of these studies have used unreliable methods of dietary calcium assessment. Future studies within the Indian population that utilize more accurate methods of dietary calcium assessment that have been previously tested for validity and reliability within the Indian ethnic group are required. Moreover, these studies have been based on the recruitment of participants from South India. Therefore, these results can not be generalized to other areas of India. Research on the Northern, Eastern and Western parts of India is required to determine whether dietary calcium intake significantly differs in different areas across India.

Dietary Calcium Intake in Indian Women Immigrants in the United States

As Jonnalagadda and Diwan (2002) discovered, dietary habits are likely to change as people move away from their home country. In this study, all 180 participants were first generation Asian Indian immigrants from Gujarati living in Detroit and Atlanta in the US. The mean time of residency in the US for the entire cohort was 20 years. Dietary assessment was completed with a 24 hour recall. Results showed changes in dietary habits as time of residency in the US increased. For example, carbohydrate and protein intake as a percentage of total energy intake increased with increasing time of residency. On the other hand, percentage of fat from total energy decreased as time of residency increased. More importantly, the mean dietary calcium intake for the entire cohort at the time of the study was below the RDI at 739±391mg/day (males 792±377mg/day; females 739±391mg/day). This was associated with a high phytate and oxalate consumption from rice and cereals as a large number of participants were vegetarians, which is very common in the Indian culture (Goswami et al. 2000; Harinarayan 2005). The bioavailability of dietary calcium is decreased by these inhibitors, which enhances the problem of an inadequate dietary calcium intake.

Shah et al.'s study (2005) also found low dietary calcium intakes in a sample of 25 males and 25 females from India living in the South East area of the US. Participants were between the ages of 18 and 30 and had lived in the US for an average of 14.2 years. Participants completed two 24 hour recalls on non-consecutive days with the assistance of an interviewer. Analysis of dietary data found a mean dietary calcium intake of 751±324mg/day (males 868±376mg/day; females 633±271mg/day). Once again, dietary calcium intake was below the RDI, particularly in the female population.

Dietary Calcium Intake in New Zealand Women

According to the 1997 NNS (Russell et al. 1999), the New Zealand mean ±SEM dietary calcium intake within the female population was 735±12.3mg/day (Table 4).

Table 4: Average calcium intakes (mg/day) in New Zealand women from the 1997 National Nutrition Survey (Russell et al. 1999).

Age group (years)	Mean intake (mg/day)	SEM (mg/day)	NZ Maori mean intake (mg/day)	SEM (mg/day)	NZ European & Others mean intake (mg/day)	SEM (mg/day)	Inadequate intake for whole population (%) [1]
15-18	783	56.6	826	82.5	778	37.7	37
19-24	760	40.7	826	82.5	778	37.7	22
25-44	759	18.1	743	56.2	781	21.1	21
45-64	712	18.9	567	49.3	713	14.3	27
65+	670	22.4	567	49.3	713	14.3	30
Total	735	12.3	732	43.6	749	13.2	25

SEM, Standard Estimate Mean

[1] Inadequate intake was determined by probability analysis. "Probability analysis compares nutrient intakes with the corresponding requirement distribution and calculates the likelihood (probability) that a particular nutrient intake would fail to meet requirement." (Russell et al. 1999, p. 206).

Based on these results, 25% of the female population have an inadequate dietary calcium intake. Further analysis by Horwath et al. (2001) showed that only the 19 to 44 years age group had mean dietary calcium intakes that meet 70% of the RDI. Table 4 shows mean dietary calcium intakes for the New Zealand population by ethnicity and age group. No studies have been done in New Zealand to investigate dietary calcium intake within the South Asian population.

In conclusion, studies that have assessed dietary calcium intake within the Asian and Indian population have consistently reported inadequate intakes. Although the methods of dietary calcium assessment used in these studies are highly susceptible to memory bias, the consistent finding of mean intakes that are well below the RDI give reason to believe that development of osteoporosis is potentially a serious problem within these populations. More research is required with larger, more representative samples with both Asian and Indian women to strengthen these preliminary findings and increase awareness. According to the 1997 NNS, dietary calcium intake in New Zealand women is also inadequate. However, dietary calcium intake in the New Zealand Asian and South Asian population is unknown. Based on overseas studies, dietary calcium intake within this group is likely to be below the RDI. Therefore, this is an area that requires attention and further investigation. This study will be the first to provide an assessment of dietary calcium intake in South Asian women in New Zealand.

2.3.1.5 Dietary Assessment of Calcium

The most common methods of dietary assessment are food diaries, a 24 hour recall and a FFQ. The accuracy of dietary assessment depends on a large range of factors. It is extremely difficult to truthfully measure dietary intake in free-living participants. There is no 'gold standard' for measuring dietary intake as all dietary assessment methods have limitations. Some methods may be more practical than others depending on the aim of the study, budget restraints as well as the number of participants.

A good measure of total energy intake is essential to provide a good estimate of dietary calcium intake. The most accurate method to determine whether energy intake has been accurately reported is to compare it with total energy expenditure. Energy intake and energy expenditure should be equivalent if the individual has maintained their body weight. The use of doubly-labeled water (DLW) is the most accurate method for assessment of energy expenditure in free-living individuals. The principal behind DLW is described by Schoeller (1988). The use of DLW to validate measures of energy intake was first established for humans in 1982 (Schoeller 1988). Since then, studies have used the DLW technique as a 'gold standard' to validate methods of dietary assessment. Due to its high cost, scarcity of isotope and the need for an isotope ration mass spectrometry, the DLW technique may not be feasible in large studies and are generally used only in studies with a small sample size.

Food Diaries

Food diaries can provide a good estimate of total energy intake (Chinnock 2006). This was demonstrated in a DLW study by Koebnick et al. (2005). Thirteen males and 16 females with a mean age of 36.8 years participated in the study. The DLW results were compared against dietary data obtained from a four day self-administered semi-quantitative dietary record. Results showed a significant correlation ($r=0.685$, $p<0.001$) between total energy intake from the food diary and energy expenditure.

A review of DLW studies by Black et al. (1993) showed good agreement between energy expenditure and estimated energy intakes obtained from weighed food diaries. Four out of the five studies showed good agreement between total energy intake and energy expenditure. These studies included apparently healthy participants who were within the healthy weight range, i.e. body mass index (BMI) between 18kg/m^2 and 25kg/m^2. On the other hand, studies that recruited participants who were overweight and obese, both currently and previously found significant under-reporting of total energy intake by 36% and 26%, respectively. Therefore, a four day food diary may only provide a good measure of total energy intake for those who are within the healthy weight range.

A food diary requires participants to write down all food and liquids consumed at the time of consumption; hence, it is the most labour intensive of all dietary assessment methods. However, recording food and fluid consumption at the time has many benefits, such as limiting the influence of perception and memory (Black et al. 1993). In addition, food diaries are low in cost and require less time to administer compared to interview based methods, such as the 24 hour recall. Therefore, in a large study such as the present one, a food diary is the most practicable and feasible method of dietary assessment.

Providing clear instructions to participants on how to complete a food diary can produce accurate and reliable estimates of dietary calcium intake. In the present study, participants were clearly instructed to write down all meals, snacks, drinks and condiments added to foods at the time of consumption. They were asked to provide as much information as possible, such as brand names, method of cooking and recipes. In addition, participants were asked to accurately record quantities consumed using household measures or weight measurements. The importance of eating as normally as possible was also emphasized.

Little is known about the dietary habits of South Asian women in New Zealand. Winichagoon (2008) and Margetts and Nelson (1997) suggested using a food diary when detailed food and nutrient intake is required, particularly when little is know about patterns of food intake within the population of interest. Moreover, the Asian diet typically consists of complex dishes containing several traditional ingrediets that would be difficult to capture using other dietary assessment methods (Winichagoon 2008). Therefore, the use of a food diary appears the most appropriate best method to measure dietary calcium intake for the present study.

Extending the number of days to seven days of dietary record may not necessarily provide a more accurate and detailed description of dietary patterns. Some studies have suggested that as the number of days increase, accuracy and reliability actually begins to drop as participants lose motivation (Black et al. 1993; Trabulsi & Schoeller 2001). Bonifacj et al. (1997) found no significant differences in nutrient intakes between a four day weighed food diary and a seven day estimated food record with checklists and photos for portion sizes. Food diaries were collected four times over one year. A total of 98 men and women (mean age of 41.9 years) completed the study. All nutrients had a correlation of >0.82 between the four day and the seven day food diary. Mean dietary calcium intake based on the four day and seven day dairy was 886±247mg/day and 875±259mg/day, respectively and was not significantly different.

Likewise, Bingham et al. (1994) found no significant differences in dietary calcium intake between a four day weighed food diary collected four times over one year and a seven day structured food diary. The seven day structured food diary asked participants to select foods that they had eaten from a checklist and to indicate whether it was a small or large portion size. Space was also allocated to note any foods not on the list. A total of 160 women aged between 50 and 65 years whom were randomly selected from a general practitioner's list in Cambridge, United Kingdom (UK) completed the study. Mean dietary calcium intake based on the four day and seven day diaries were 952±245mg/day and 981±322mg/day, respectively and were not significantly different. Therefore, four days of dietary record is sufficient to capture habitual dietary calcium intake and will also decrease participant burden compared to a seven day food diary.

Limitations of Food Diaries

Because estimation of dietary calcium intake relies on the accuracy of reported total energy intake, under-reporting is a significant limitation. Under-reporting is a common phenomenon in all dietary assessment methods, particularly in women (Jakes et al. 2004; Marks et al. 2006; McNaughton et al. 2005; Trabulsi & Schoeller 2001). Both systematic and random under-reporting can occur. Some possible reasons for under-reporting have been proposed. However, the exact reason for under-reporting is unknown and it varies between individuals.

Some studies have found participants to under-report because they have changed their normal dietary habits and are under-eating during the recording period (Heitmann & Lissner 1995; Lührmann et al. 1999; Trabulsi & Schoeller 2001). For example, in Chinnock's study (2006), 60 men and women were asked to complete a four day estimated food diary. Although the participants were instructed to eat as normally as possible, a large number of participants lost weight during the study period. The proposed reason for this weight lost by Chinnock (2006) was a conscious or unconscious effort to consume less food to induce weight loss, or simply due to the inconvenience of recording the food.

Similarly, Martin et al. (1996) found 29 women (mean age of 48.7 years) to under-eat while completing a seven day food diary, which resulted in a mean weight loss of 0.23±0.05kg. Energy expenditure was measured using the DLW technique for 13 days. The DLW results showed that participants consumed an average of 80±18% of total energy expenditure.

Rennie et al. (2007) found a large number of both men and women to under-report total energy intake based on a seven day weighed food diary. Sixty men and women aged between 19 and 64 years from Great Britain completed a seven day food diary as well as a ten day DLW trial to determine total energy expenditure. Using the Goldberg cut-off of <1.54, Rennie et al. (2007) found 88% of women and 80% of men to under-report food intake. In addition, women were more likely to under-report as well as overweight and obese individuals compared to those of healthy weight. Under-reporting was 39% and 57% higher in obese men and women, respectively.

Under-reporting of total food intake will affect assessment of dietary calcium intake. This was demonstrated by Johansson et al. (1998). Four day weighed food diaries were completed by a sample of 74 women aged between 20 to 50 years. Results showed an under-estimated dietary calcium intake by ~15% due to under-estimation of total energy intake by 10-20%. Therefore, estimates of dietary calcium intake using a food record are likely to be under-estimated due to under-reporting of total energy intake.

Observation bias is a common phenomenon in all methods of dietary assessment (Brunner et al. 2001; Kelemen 2007). This refers to changes in dietary habits during the recording period to become socially desirable. This includes changes in the types of foods eaten as well as portion sizes. For example, females may alter their eating habits to consume more 'healthy' foods, such as fruits, vegetables and fish, and less of the 'unhealthy' foods, such as cakes and confectionary (Bedard et al. 2004; Heerstrass et al. 1998; Kelemen 2007; Trabulsi & Schoeller 2001). Other indirect personal effects of reported food intake include ideals about body images and size as well as perceived norms of meal size (Bedard et al. 2004; Rozin 1996). Therefore, females may under-report serving sizes to become socially desirable. Moreover, according to Rozin (1996), the feminine ideal of food intake includes a grazing pattern and may also be a source of under-reporting food intake.

<u>The 24 Hour Recall Method</u>

The 24 hour recall is a retrospective dietary assessment method where the individual recalls their food and fluid intake in the previous 24 hours or previous day. A 24 hour recall is not a reliable method for estimating individual total energy intake or dietary calcium intake. The large day-to-day variation of food intake can not be captured with a single 24 hour dietary assessment (Kelemen 2007; Margetts & Nelson 1997; McNaughton et al. 2005) and would therefore, affect estimates of habitual dietary calcium intake. In addition, many people find it difficult to accurately describe and recall portion sizes (Kaaks 1997; Margetts & Nelson 1997). Therefore, the accuracy of total energy intake and dietary calcium intake is likely to be significantly over or under-estimated (Heerstrass et al. 1998; Maclntyre et al. 2000; Margetts & Nelson 1997; McNaughton et al. 2005).

In addition to observation bias described above, interviewer bias is another source of error with the 24 hour recall. Interviewer bias can occur even with a well-trained interviewer. Even slight modifications in the wording of questions can alter participants' response. The detail and quality of data collected can also be significantly affected by the interviewer and interviewee state of mind, referred to as observer and subject bias, respectively (Black et al. 1993; Margetts & Nelson 1997). In addition, with a large study such as the present one, interview-based dietary assessment is unpractical and time-consuming.

Food Frequency Questionnaires (FFQs)

FFQs are designed to capture eating patterns based on frequency of consumption of certain groups of food over a long period of time; most often over the last 12 months. One major disadvantage with the use of a FFQ for the present study is the lack of knowledge regarding dietary habits of South Asian women in New Zealand. It is preferable to develop a FFQ for each study based on the population of interest to ensure it includes appropriate cultural foods and popular dishes (Kelemen 2007; Margetts & Nelson 1997; Winichagoon 2008). Moreover, portion sizes used in the questionnaire should reflect the average portion size consumed by the population of interest (Margetts & Nelson 1997). Most FFQ validation studies have been conducted using Caucasian populations and no FFQs have been developed specifically for the South Asian ethnic group. Therefore, it would be inappropriate to use a FFQ for the present study.

Some researchers have found the FFQ to be an inaccurate dietary assessment method for estimating dietary calcium intake. Bingham et al. (1994) and Bingham and Day (1997) found two types of FFQs to predict significantly different amounts of daily dietary calcium intake. The two types of FFQs used were the Cambridge and Oxford Questionnaires. The Cambridge FFQ was developed based on a previous study on dietary patterns of a Cambridge population (Bingham et al. 1981). The Oxford FFQ was a modified version of the Nurses Health Study FFQ (Willet et al. 1985 quoted in Bingham et al. 1994). Both questionnaires measured average intake of foods over the last year and utilized the same frequency categories. However, the Cambridge FFQ had a higher percentage of vegetable food items (27% of total food items) compared to the Oxford FFQ (18% of total food items). The number of food groups as well as the number of items in each food group was also different between the two questionnaires.

Moreover, the order of food categories listed was also different. In both studies, participants were randomly chosen from two general practitioners' lists in Cambridge. A total of 156 women aged between 50 and 65 years completed the entire study over the 12 month period. Results showed significantly different estimates of dietary calcium intake depending on which FFQ was administered. Average dietary calcium intake according to the Oxford and Cambridge FFQs were 1,308mg/day and 763mg/day, respectively. When compared to a four day weighed record, the Oxford FFQ significantly over-estimated, while the Cambridge FFQ under-estimated dietary calcium intake (Bingham & Day 1997). According to Bingham et al. (1994), this is likely due to an inaccuracy in frequency reports as well as the format of the FFQ (Bingham & Day 1997).

A number of other studies have reported an over-estimation of dietary calcium intake with the FFQ. Riboli et al. (1997) found a 250-item and a 130-item FFQ to significantly over-estimate total energy, protein, carbohydrate and dietary calcium intakes compared to a three day weighed food diary. All three types of dietary assessment methods were collected every two months over 12 months from 206 men and women (mean age of 61.5 years) randomly selected from a list of residents in Malmö, Sweden. The three day weighed food record was checked thoroughly and followed up by trained interviewers with quality checks throughout the study. All interviewers were trained together to avoid interviewer bias. Both types of FFQ significantly over-estimated total energy intake as well as dietary calcium intake, mainly due to an over-estimation of frequency of vegetable and dairy product consumption.

Ambrosini et al. (2003) also found the FFQ to over-estimate dietary calcium intakes compared to a seven day food diary using household measuring units. Subjects were recruited from another intervention trial in Western Australia (Musk et al. 1998 quoted in Ambrosini et al. 2003). Eighty three men and women completed the food record and 72 men and women completed the FFQ. Any missing information was followed up and clarified by the participant. Results showed significant differences in estimated dietary calcium intake between the two methods. Mean dietary calcium intakes according to the seven day food diary and FFQ were 757±222mg/day and 888±331mg/day, respectively. The proportion of dietary calcium intake below the RDI was 58% from the FFQ, compared to 96% when using the seven day food diary. Therefore, these authors suggested that FFQs may over-estimate dietary calcium intake.

In summary, although food diaries are likely to give under-estimations of total energy and dietary calcium intake, the magnitude and direction of error is better understood compared to the 24 hour recall and FFQ. Food diaries have also been found to provide a better estimate of dietary calcium intake compared to the 24 hour recall and FFQ. In addition, due to the large study sample size in the present study and limited knowledge regarding dietary habits of South Asian women in New Zealand, a food diary is much more practical and reliable. A four day food diary has been shown to be as reliable as a seven day food diary. Moreover, studies have found that as the number of days increase, participant motivation and accuracy decreases. Therefore, a four day food diary is the best dietary assessment method for both total energy and dietary calcium intake for the current study.

2.3.1.6 Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

During the prepubertal and adolescent years, linear growth occurs at an exponential rate. Adequate dietary calcium intake is crucial during these years to ensure calcium balance and maximal skeletal mineralization. A positive calcium balance will help ensure that an optimal PBM is reached by the third decade of life (Bonjour et al. 2007; French et al. 2000; Ma et al. 2007; Weaver 2008). Many clinical trials have demonstrated a positive effect on BMD with a high dietary calcium intake in young girls. Increases in bone acquisition during these early years have also been shown to persist into later life (Bonjour et al. 2007; Nowson et al. 1997; Wahlqvist & Wattanapenpaiboon 2000) and therefore, aid in the prevention of osteoporosis. In addition, a diet rich in calcium can help prevent the rate of bone degeneration in later life (Moschonis & Manios 2006; Lau et al. 2002b). A summary of clinical trials showing efficacy of calcium-rich foods or calcium supplementation is shown in Table 5. Some of these studies will be discussed in the following sections.

Studies on Prepubertal and Adolescent Girls with Calcium-Rich Foods

A diet rich in calcium during the prepubertal years has been found to enhance BMD by 1-6% (Bonjour et al. 2007; French et al. 2000; Zhu et al. 2008). Although linear growth in females generally comes to a halt around 16 to 18 years, bone mineral accretion continues up to the age of 30 (Wahlqvist & Wattanapenpaiboon 2000). As sumarised in Table 5, a number of studies have found a diet rich in calcium to significantly increase BMD and BMC in adolescent girls after 12 (Bonjour et al. 1997; Dibba et al. 2000;), 18 months (Cadogan et al. 1997) and 24 months (Zhu et al. 2008). A number of reviews have reported on the importance of adequate dietary calcium intake during the childhood and adolescent years (French et al. 2000; Wahlqvist & Wattanapenpaiboon 2000). Therefore, it can be concluded with confidence that a diet rich in dairy foods that provide a high dietary calcium intake enhances BMD and attainment of a high PBM.

Studies on Prepubertal and Adolescent Girls with Calcium Supplementation

Clinical trials with calcium supplementation have also found a positive effect on bone density (Table 5). Twin studies provide strong evidence due to similarities in genetic composition. Both Nowson et al. (1997) and Johnston et al. (1992) showed a significant increase in BMD at various sites in the intervention group. Although the exact mechanism could not be concluded based on these studies, it may be due to a decrease in the bone turnover rate (Dibba et al. 2000; Johnston et al. 1992). Nowson and colleagues (1997) suggested future twin studies with larger sample sizes and longer follow-up periods to determine whether calcium supplementation can aid in attainment of a high PBM to decrease susceptibility of fractures.

In summary, the results of clinical trials with prepubertal and adolescent girls provide compelling evidence that a diet high in calcium can increase BMD by 1-6% compared to those with intakes below recommended levels (Bonjour et al. 1997; Cadogan et al. 1997; Dibba et al. 2000; Dodiuk-Gad et al. 2005; French et al. 2000; Lloyd et al. 1993; Nowson et al. 1997; Rozen et al. 2003; Stear et al. 2003; Zhu et al. 2008). A diet rich in calcium should be encouraged from an early age before PBM is obtained. This may help to prevent the onset of osteoporosis in later life.

Studies on Postmenopausal Women with Calcium-Rich Foods

During the early adult years up to the third decade, adequate dietary calcium ensures that a high PBM is reached and attained. As BMD begins to decrease thereafter, a diet high in calcium can help retard the rate of BMD loss and therefore, prevent the onset of osteoporosis (Lau et al. 2002b; Moschonis & Manios 2006; Reid et al. 1995).

A number of studies have demonstrated the benefit of a diet high in calcium-rich foods in slowing down the rate of BMD decline and are summarized in Table 5. For example, both Lau et al. (2002b) and Moschonis & Manios (2006) found a high intake of milk or dairy products in the intervention group to significantly decrease the rate of BMD loss compared to the control group. Future studies with larger sample sizes as well as measures of physical activity and serum vitamin D levels are recommended.

Studies on Postmenopausal Women with Calcium Supplementation

Other studies with postmenopausal women have utilized calcium supplements rather than calcium-rich foods. Results have consistently found a decrease in the rate of BMD loss in the supplementation group compared to the control group (Fardellone et al. 1998; Reid et al. 1993). Storm et al. (1998) showed greatest benefits with calcium supplementation followed by milk supplementation over two years. Both groups had a significantly lower rate of BMD loss compared to the control group. A high dietary calcium intake may help prevent fractures in the long term as demonstrated by Reid et al. (1995). Hence, Storm et al. (1998) recommended calcium supplementation for postmenopausal women to help prevent the decrease in BMD, particularly if dietary calcium intake from food sources is insufficient and during the winter when serum vitamin D levels may be low.

Based on the literature, it is clear that both calcium-rich foods and calcium supplementation are effective in decreasing the rate of bone loss that occurs rapidly during later life. A number of reviews and meta-analysis reports have concluded that calcium supplementation is beneficial for postmenopausal women in the prevention of osteoporosis (Lewis & Modlesky 1998; Meunier 1999; Nordin 1997; Shea et al. 2002). The main mechanism is via a decrease in the rate of bone loss that occurs during the early years of menopause as a result of estrogen depletion. Moreover, some studies have shown calcium supplements to be readily absorbed and may be as effective for the prevention of osteoporosis as milk (Heaney et al. 2001; Mortensen & Charles 1996). Therefore, calcium supplementation is highly recommended for those women who are not obtaining sufficient dietary calcium levels through food sources.

Table 5: A Summary of Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
Clinical Trials with Prepubertal and Adolescent Girls					
Bonjour et al. (1997)	• Randomized, controlled trial with calcium fortified foods • 12 months	• 108 prepubertal girls • Mean age of 8.0 years	• 55 girls were supplied with calcium fortified foods for 48 weeks • 53 girls also received same foods that had not been fortified • BMD measurements were made at 6 sites using DXA	• Significant mean BMD gains at all 6 sites in the IG compared to CG by 3.5-5.0% • Gains were significantly correlated with total dietary calcium intake	
Cadogan et al. (1997)	• Randomized, controlled trial with milk supplementation • 18 months	• 80 girls • Mean age of 12.2 years	• 44 girls received 568ml of milk each day • 36 girls were asked to continue with their normal dietary habits • BMD and BMC measurements were taken every 6 months with DXA	• Milk provided on average 115-120mg calcium per 100g, which significantly ↑ dietary calcium intake to 1,125mg/day in the IG compared to the CG (703mg/day) • Protein, phosphorus, magnesium, zinc, riboflavin and thiamine intakes also significantly ↑ in the IG • There was a significant ↑ in total body BMD (9.6% vs.. 8.5%) and BMC (27% vs.. 24%) in the IG compared to CG	

Table 5 continued: A Summary of Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
Dibba et al. (2000)	• RDBPCT with calcium supplementation • 12 months	• 80 boys and 80 girls • Mean age of 10.3 years	• Participants were stratified by sex and 80 in the IG received 1,000mg calcium/day • Measurments made at baseline and 12 months included BMD and BMC at the distal and midshaft radius using Lunar SP2, dietary intake using a direct-weighing method over 2 days and plasma osteocalcin	• Mean dietary calcim intake increased in IG group from 342mg/day to 1,056mg/day • Significant ↑ in BMD of 4.5% at the midshaft radius and 7.0% at the distal radius in the IG, even after adjusting for weight, height, sex, age, dietary calcium intake and pubertal status • IG experienced a greater ↓ in plasma osteocalcin, which suggests an effect on the bone remodeling rate	
Dodiuk-Gad et al. (2005)	• Phase 1 – RDBPCT with calcium supplementation • 12 months • Phase 2 – follow-up for 3.5 years	• Phase 1 – 96 postmenarche girls • Mean age of 14.9 years • Phase 2 – 45 girls were successfully followed-up; 17	• 49 girls received 1,000mg/day of calcium • 47 girls received a placebo • Measurements made included a semiquantitative FFQ, physical activity and lifestyle questionnaires and BMD and BMC measurements	• At 12 months, IG had significantly higher total body BMD gains compared to the CG (3.8±0.3% vs. 3.1±2.9%) • LS BMD gains were significantly higher in the IG compared to placebo (3.66±0.35% vs. 2.93±0.45%)	The small sample size during phase 2 may account for the inability to detect any significant differences

Table 5 continued: A Summary of Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
		from the calcium group and 28 girls from the CG	with DXA	• Phase 2 – LS and total body were insignificantly higher in the IG	
Johnston et al. (1992)	• RDBPCT with calcium supplementation • 3 years	• 42 monozygotic twin pairs • Mean age of 9.5 years	• One twin in each pair received 1,000mg/day of calcium • The other twin received a placebo • Measurements taken included urine samples, physical activity questionnaire, one-day food records and BMD measurements with a Lunar SP-2 absorptiometer	• Over the 3 years, mean dietary calcium intake for the IG and CG were 1,612mg/day and 908mg/day, respectively • Significantly greater ↑ in BMD at all sites in the IG by 1.4% • Those who were prepubertal reported the greatest gains • Could be due to a ↓ bone turnover rate	Use of twins provides good control of other possible confounding factors, such as genetic factors, different dietary habits and physical activity
Lloyd et al. (1993)	• RDBPCT with calcium supplementation • 18 months	• 94 adolescent girls • Mean age of 11.9 years	• 46 girls received 500mg/day of calcium • 48 girls received a placebo Participants were stratified according to their BMI and baseline LS BMD measurements	• Supplementation significantly ↑ dietary calcium intake At 18 months, LS BMD and total body BMD in the IG ↑ by 18.7±5.8% and 9.6±3.5%, respectively, compared to	

Table 5 continued: A Summary of Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
			• Measurements made at baseline and every 6 months included Tanner stages, 24 hour urine samples, three day dietary records and LS and total body BMD	15.8%±7.0% and 8.3%±2.9%, respectively, in the CG • ↑ in BMC were also significantly higher in the IG	
Nowson et al. (1997)	• RDBPCT with calcium supplementation • 18 months	• 37 adolescent twin pairs, both monogyzotic and dizygotic completed trial at 12 months • At 18 months, 28 twin pairs completed the trial • Mean age of 14.0 years	• One twin in each pair received 1,000mg/day of calcium • The other twin receive a placebo • BMD measurements were taken at hip and spine every 6 months with DXA	• Supplementation significantly ↑ dietary calcium intake to ~1,600mg/day • After 6 months, the IG had significant ↑ in spine and total hip BMD compared to CG • At 18 months, the only difference between groups was a significantly higher spine BMD in IG	Use of twins provides good control of other possible confounding factors, e.g. genetic factors, different dietary habits and exercise levels. Further studies required with larger sample sizes to determine whether these ↑ in BMD would persist into later life and therefore, prevent

Table 5 continued: A Summary of Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
					osteoporosis
Rozen et al. (2003)	• RDBPCT with calcium supplementation • 12 months	• 100 adolescent girls who had been postmenarche for at least 1 year • Mean age of 14.0 years	• 49 girls received 1,000mg/day of calcium • 51 girls received a placebo • BMD measurements were made at 12 months with DXA • Serum measures of bone markers were also taken	• Total body BMD gains in the IG was 3.8±0.3% compared to 3.07±0.29% in the CG • LS BMD gains were 3.66±0.35% in the IG compared to 3.00±0.43% in the CG • Bone biomarkers indicated a lower bone turnover rate in the IG compared to the CG	
Stear et al. (2003)	• Randomized trial with calcium supplementation and exercise intervention • 15.5 months	• 130 adolescent girls • Mean age of 17.3 years	• Four groups – calcium supplementation (n=28); calcium and exercise (n=37); exercise and placebo (n=38); placebo (n=28) • Calcium groups received 1,000mg/day supplementation • Exercise intervention involved 3 times 45 minute aerobic classes each week over 24 weeks	• Calcium groups ↑ their daily dietary calcium intakes by ~700mg/day • Compliance to exercise intervention was low with only 27% of participants who attended > 50% of classes • No interaction between calcium supplementation and exercise at any skeletal sites	The lack of attendance to aerobic classes limited the ability to detect any other significant differences. Moreover, small sample sizes resulted in insufficient statistical power

Table 5 continued: A Summary of Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
			• Measurements made at baseline and at 15.5 months included weight, height, physical activity questionnaire, FFQ and BMC and bone area measurements with DXA	• Participants in the calcium groups experienced a significant ↑ in bone mineral acquisition at all skeletal sites measured, including spine, hip and total body • Those who attended > 50% of aerobic classes showed a significantly higher BMC measurement at the hip compared to the placebo. However, results were only modest compared to the calcium group	
Zhu et al. (2008)	• Randomized trial with either calcium fortified milk, calcium and vitamin D fortified milk or control (no milk supplementary)	• 345 Chinese girls from nine schools in Beijing • Mean age of 10.1 years	• 110 received 330ml milk fortified with 560mg of calcium/day • 112 received 330ml milk fortified with 560mg of calcium and 5-8μg of vitamin D/day • Control group received no milk supplementary	• Significant ↑ in calcium intake for both supplementation groups compared to CG • Significant ↑ in vitamin D intake for vitamin D group compared to all other groups	Furture trials with larger sample sizes and a wider geographical representation

Table 5 continued: A Summary of Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
	• 24 months		• Measurements made at baseline and 24 months included total body BMD and BMC with DXA, pubertal stage, weight, height and dietary intakes (24 hour recall for seven days at baseline and 3-day food record at 24 months)	• At 24 months, both supplemented groups had significant greater gains in total body, leg and arm size-correlated BMD compared to CG	
Clinical Trials with Postmenopausal Women					
Lau et al. (2002b)	• Randomized trial with milk powder supplementation • 24 months	• 185 postmenopausal Chinese women • 6-7 years postmenopausal • Mean age of 57.0 years	• 95 women received 50g of milk powder each day to provide 800mg of calcium and 240IU of vitamin D • No placebo given to the remaining 90 women and asked to record their daily milk intake • BMD measurements made every 6 months with DXA • Dietary calcium intake was measured with a seven day food diary every 12 months	• At 24 months, mean dietary calcium intakes were 390mg/day and 1046mg/day in the CG and IG, respectively • IG had a significantly lower rate of BMD ↓ by 50% compared to the CG • Differences in BMD between groups remained significant even after adjusting for changes in body weight and baseline dietary calcium intakes	Future studies can include measures of bone markers to determine whether this is due to a decrease in bone turnover rate, as well as a placebo CG

Table 5 continued: A Summary of Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
Moschonis & Manios (2006)	• Randomized, controlled trial with calcium supplementation (CaG), calcium fortified dairy foods (DG) and CG • 12 months	• 101 postmenopausal women • Mean age of 60.5 years	• 39 women in the DG received three portions of low-fat dairy products fortified with 400mg calcium/portion and 2-5µg of vitamin D • 26 women in the received CaG received the fortified diary products as well as 600mg/day calcium supplementation • CG resumed their normal dietary habits • Measurements made at baseline, five months and 12 months included three 24 hour recalls and a three day activity questionnaire • BMD measurements made with DXA at baseline and 12 months	• Significant ↑ in calcium intake in CaG and DG compared to CG • At 12 months, DG had higher levels of BMD at pelvis, total spine and total body compared to all other groups • Within groups, only the DG experienced significant ↑ in LS, pelvis, total spine and total body BMD, whereas the CG experienced a ↓ in total spine and total body BMD	Future studies extended over a longer period is required to determine whether these gains in BMD persists and results in ↓ rate of bone fractures
Reid et al. (1995)	• RDBPCT with calcium supplementation	• 78 postmenopausal women • Women were	• 38 women received 1,000mg/day of calcium • 40 women received a placebo	• IG had a significantly lower rate of bone loss at LS and femoral neck compared to the CG	Small sample size and small number of fractures reported

Table 5 continued: A Summary of Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
	• 4 years	menopausal for at least 3 years • Mean age of 58.5 years	• BMD measurements were made every 6 months with DXA	• IG reported significantly fewer fractures • 2 fractures were reported in 2 participants in the IG • 9 fractures were reported in 7 participants in the CG	limits ability to generalize results. Future studies required
Storm et al. (1998)	• RDBPCT with milk and calcium supplementation • 2 years	• 53 postmenopausal women • Mean age of 71.3 years	• 17 women received 1,000mg/day of calcium supplementation • 19 women were advised to consume 4 x 8 ounce glasses of milk each day • 17 women received a placebo • Dietary calcium intake was measured every 6 months with a four day food diary and a FFQ • BMD was measured at the LS and femur neck every 6 months	• Dietary calcium intake ↑ significantly in both the milk (1052±118mg/day) and supplementation group (1678±57mg/day) • Significant ↓ in the rate of BMD loss in the supplementation group, followed by the milk group compared to the CG • ↑ in LS BMD as dietary calcium intake ↑, even after adjusting for BMI, smoking status, exercise and baseline BMD	Compliance to milk consumption was low with most participants consuming 2-3 glasses a day. This may have affected results

Table 5 continued: A Summary of Clinical Trials showing Efficacy of Calcium-Rich Foods or Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
				• Those in the supplementation group with the highest dietary calcium intake experienced the greatest ↑ in LS BMD group compared to the CG • Only the supplementation group showed a significant ↑ in femoral neck BMD compared to all other groups	

↓ decrease; ↑ increase; BMC, Bone Mineral Content; BMD, Bone Mineral Density; BMI, Body Mass Index; CG, Control Group; DPA, Dual-Photon Absorptiometry; DXA, dual-energy x-ray absorptiometry; FFQ, Food Frequency Questionnaire; IG, Intervention Group; LS, Lumbar Spine; RDBPCT, Randomized, Double-Blind, Placebo-Controlled Trial; SP2, single-photon absorptiometry

2.3.2 Role of Vitamin D

Vitamin D is essential for strong healthy bones and plays an important role in the prevention of osteoporosis. Vitamin D is involved in the metabolism and regulation of dietary calcium and is therefore, related to bone mineral status (New & Bonjour 2003). A low serum vitamin D level triggers the parathyroid glands to increase secretion of PTH. In response, the kidney enhances vitamin D synthesis as described earlier. The rate of the bone remodeling cycle depends largely on serum PTH levels. An increase in serum PTH results in an increase in the bone turnover rate (Greenspan et al. 2005; Lee & Jiang 2008). Moreover, as PTH levels increase, bone resorption begins to outweigh bone formation and consequently, bone loss is accelerated (Lee & Jiang 2008; Specker & Vukovich 2007). Therefore, vitamin D deficiency results in enhanced bone resorption as well as an increase in the bone remodeling rate (Mosekilde 2005; Pasco et al. 2004). Studies have found an increase in the prevalence of serum vitamin D deficiency and insufficiency in countries all around the world (Lee & Jiang 2008), including New Zealand (Lips 1996; Scragg et al. 1995).

Intestinal Calcium Absorption

It is well known that vitamin D is required for the absorption of dietary calcium and an inadequate level of vitamin D can inhibit calcium absorption (Nordin 1997; Prentice 2004). As a result, vitamin D deficiency increases the risk of developing osteoporosis. This type of absorption is commonly referred to as vitamin D_3-dependent absorption or cholecalciferol ($1,25(OH)_2D_3$)- dependent absorption. Ingestion of calcium stimulates the vitamin D_3-dependent calcium transport system (Kass-Wolff 2004). This type of calcium absorption decreases with age, particularly as estrogen levels begin to decline during menopause (Gambacciani et al. 2002; Kass-Wolff 2004). Therefore, older people are at greater risk of inadequate dietary calcium absorption and hence, development of osteoporosis.

Bone Maturation

Vitamin D is a crucial component in the prevention of osteoporosis because it is involved in bone maturation and matrix formation (Garrow et al. 2003; Wahlqvist & Wattanapenpaiboon 2000; Wynee 2000). Vitamin D is known to increase osteoblast activity and therefore, enhanced bone formation (Garrow et al. 2003). Moreover, sufficient serum vitamin D provides adequate dietary calcium absorption to allow for calcification and bone mineralization (Garrow et al. 2003). The predominant role of vitamin D during growth and adolescence is to obtain a high PBM (Grant & Holick 2005). Vitamin D deficiency (serum level <25nmol/L) in children can cause rickets and reduced linear growth (Garrow et al. 2003). During adulthood, vitamin D is required for the maintenance of bone mass and an insufficient serum level has been found to be related to an increased risk of fractures (Feskanich et al. 2003).

Ultraviolet Synthesis of Vitamin D

Adequate vitamin D levels can be obtained from exposure to ultraviolet (UV) rays in sunlight. Vitamin D_3 is formed when UV rays transform 7-dehydrocholesterol into previtamin D_3 in the skin (Garrow et al. 2003). Temperature-dependent isomerization transports previtamin D_3 to the liver, where the enzyme 25-hydroxylase acts on it to produce 25-hydroxy-vitamin D ($25OHD_3$) (New 1999; Nordin 1997). This is then transported to the kidneys, where it is transformed into the active form of vitamin D ($1,25(OH)_2D_3$). Synthesis of vitamin D in the skin is determined by a number of factors (New & Bonjour 2003):

- Amount of unprotected skin exposed to UV light;
- Amount of melanin pigmentation in the skin;
- Amount of precursor in the skin.

A significant negative association between age and serum vitamin D level has been a consistent finding (Greenspan et al. 2005; Malavolta et al. 2005; Prentice 2004) and is related to a decrease in the efficiency of vitamin D synthesis from UV light (Grant & Holick 2005). Therefore, elderly people are at greater risk of developing vitamin D deficiency, particularly those who are house-bound (Australian and New Zealand Bone and Mineral Society 2005; Greenspan et al. 2005; Kass-Wolff 2004; Lucas et al. 2005; Malavolta et al. 2005;).

Prevention of Fractures

Insufficient serum vitamin D levels have been consistently linked to compromised bone density and increased risk of fractures (Fairfield & Fletcher 2002; Feskanich et al. 2003; Lips 2001; Mosekilde 2005). For example, Pasco et al. (2004) found a significant association between a low serum vitamin D level and risk of fractures in a sample of 297 predominantly Caucasian postmenopausal women (mean age of 72.8 years) in South

East Australia. Even a slight vitamin D insufficiency (serum level 25-50nmol/L) can have deleterious effects on BMD (Lee & Jiang 2008; Meunier 1999; New & Bonjour 2003). It has been estimated that 30% of hip fractures are related to vitamin D deficiency (Chan et al. 2005).

In New Zealand, elderly adults who have experienced a hip fracture show a serum vitamin D level that is on average 18mmol/L lower compared to other elderly adults (Weatherall 2000). The New Zealand population, particularly elderly people, should be encouraged to be active outdoors, especially during the winter, to avoid vitamin D insufficiency and deficiency (Sinclair 2006). Although the efficiency of UV synthesis of vitamin D decreases with age, older people still have substantial ability to synthesize subcutaneous vitamin D. Regular sun exposure of the face, hands and arms has been recommended to decrease the risk of osteoporosis (Australian and New Zealand Bone and Mineral Society 2005; Lucas et al. 2005; Sinclair 2006).

2.3.2.1 Nutritional Reference Values

Some vitamin D can be obtained through dietary consumption. The MOH has recently published recommended dietary guidelines for vitamin D (MOH 2006b). The recommended dietary intakes for adult women in New Zealand, the US, China and Southeast Asian countries are presented in Table 6 below.

Table 6: Nutrient Reference Values for Vitamin D for Adult Women for New Zealand, United States, China.and Southeast Asia

Age (years)	New Zealand [1]		United States [3]	China [4]		Southeast Asia [5, 6]
	AI (µg/day) [2]	UL (µg/day) [2]	AI (µg/day)	RNI (µg/day)	UL (µg/day)	RDA (µg/day)
19-30	5	80	5	5	20	5
31-50	5	80	5	5	20	5
51-70	10	80	10	10	20	10
>70	15	80	15	10	20	15

AI, Adequate Intake; RDA, Recommended Dietary Allowance; RNI, Recommended Nutrient Intake; UL, Upper Level of Intake

[1] Reference MOH (2006b)

[2] Multiply by 40 to convert µg to IU

[3] Reference Institue of Medicine (1997)

[4] Reference Chinese Nutrition Society (2007)

[5] Reference International Life Sciences Institute – Southeast Asia Region (2005)

[6] Southeast Asia refers to Cambodia, Indonesia, Laos, Malaysia, Mayanmar, Philippines, Singapore, Thailand and Vietnam

2.3.2.2 Food Sources of Vitamin D

Although there are some food sources of vitamin D, obtaining adequate levels through food consumption alone is very unlikely. Therefore, vitamin D supplementation or synthesis of vitamin D in the skin from UV light is necessary. Oily fish, such as salmon and mackerel are rich sources of vitamin D (Lips 1996). Dairy products and eggs also contain moderate levels of vitamin D. Some milk products in New Zealand are now fortified with vitamin D, such as Anchor 'Mega Milk' and 'Anlene'. Below is a list of food sources (Table 7) of vitamin D per 100g of food, according to FoodWorks Professional Edition (version 4.00.1158, Xyris Software, Pty Ltd., Australia).

Table 7: Food Sources of Vitamin D (IU/100g) (FoodWorks Professional Edition version 4.00.1158, Xyris Software, Pty Ltd., Australia).

Food Source	Vitamin D (IU/100g) [1]
Salmon, baked	200
Salmon, red, canned	160
Salmon, steamed	176
Mackerel, blue, flesh, raw	160
Mackerel, canned, drained	224
Egg, chicken, boiled	70.8
Milk, fluid, standard	1.2
Cheese, edam	8.0
Cream, standard	0.15

[1] Divide by 40 to convert IU to µg

In summary, it is evident that vitamin D plays a key role in the prevention of osteoporosis due to its role in calcium absorption, metabolism and regulation as well as bone maturation and matrix formation. Vitamin D insufficiency is linked to a low BMD and an increased risk of fracture. Although there are some food sources of vitamin D, such as oily fish and dairy products, obtaining sufficient levels through food consumption alone is unlikely. Sunlight is the best source of vitamin D and adequate levels can be obtained from a minimum of ten to fifteen minutes of unprotected exposure.

2.3.2.3 Serum Vitamin D levels in Women

Serum Vitamin D levels in Indian Women

Only a few studies have been published that have determined serum vitamin D levels in South Asian women. For example, in Harinarayan et al.'s study (2004) mentioned previously, dietary calcium as well as serum vitamin D levels were analyzed in men and women from rural and urban areas of Tirupati, South India. Analysis of fasting blood results showed only 31% of the study group had sufficient vitamin D levels (>70nmol/L). Fifty percent were regarded as having insufficient levels (50-70nmol/L), 15% were deficient (<50nmol/L) and three participants were severely deficient.

Another study by Harinarayan et al. (2007) with 943 and 205 men and women from the urban and rural areas of Tirupati (mean age of 44.5 years) showed 70% of rural female participants to have deficient vitamin D serum levels (<50nmol/L), while 29% were insufficient (50-70nmol/L) and only 1% were sufficient (>70nmol/L). In the urban female population, 75% were deficient, 26% were insufficient and only 6% had sufficient levels.

Roy et al. (2007) also found a high prevalence of vitamin D insufficiency in a sample of 78 South Asian women (mean age of 29.2 years) living in the Greater Manchester area, UK. Participants completed a lifestyle questionnaire, BMD measurements with dual-energy x-ray absorptiometry (DXA) at the wrist, hip and lumbar spine. Blood samples were also taken, including measurements of serum vitamin D and PTH. Results showed 94% of women to have serum vitamin D levels ≤37.5nmol/L and 26% had serum vitamin D levels ≤12.5nmol/L. There was a significant negative correlation between serum vitamin D and PTH levels as well as a positive association between serum vitamin D and BMD, particularly at the hip and wrist. However, it should be noted that the response rate of this study was low and may therefore not be representative of the South Asian population in the UK. Nevertheless, these extremely high rates of vitamin D insufficiency and deficiency raise some serious issues for the prevention of osteoporosis within this population.

The Indian culture believes that women who wear revealing clothing are unacceptable and is highly discouraged (Roy et al. 2007; Sachan et al. 2005). Considering their cultural values, it is not surprising that inadequate vitamin D levels are highly prevalent in Indian women. Based on the evidence from India, it is very likely that South Asian women in New Zealand are also vitamin D insufficient. This assumption needs to be confirmed with future research.

<u>Serum Vitamin D levels in New Zealand Women</u>

Lips' review (2001) was the first global study to determine serum vitamin D levels across 25 countries and five continents. According to this study, 24% of older New Zealand women (mean age of 76 years) were at risk of vitamin D deficiency (<40nmol/L) and this was highest during the winter (69% of participants were vitamin D deficient). In general, there was a consistent seasonal variation with a greater prevalence of vitamin D deficiency during the winter-spring than the summer-autumn season. This yearly circular trend has also been reported by other researchers (Lee & Jiang 2008; Malavolta et al. 2005).

Studies to determine serum vitamin D levels in New Zealand women have consistently reported a high prevalence of vitamin D insufficiency and deficiency. For example, Lucas et al. (2005) found 28% and 74% postmenopausal women to have vitamin D insufficiency (<50nmol/L) during summer and winter, respectively. Zero to 3% were vitamin D deficient (<25nmol/L) during the summer and 6-16% were vitamin D deficient during the winter. The sample consisted of 1,606 healthy postmenopausal women (≥ five years postmenopausal) with a mean age of 73.7 years, living independently in Auckland, New Zealand. As Lips (2001) found, there was a marked seasonal variation in serum vitamin D levels. There was a significant positive correlation between serum vitamin D levels, physical activity and time spent outside gardening. Therefore, women who are not active outdoors have a greater chance of being vitamin D deficient or insufficient; hence, a greater risk of the development of osteoporosis.

A high prevalence of vitamin D insufficiency was also found in a small sample of older women living independently in Dunedin (n=38; age >70 years old) (McAuley et al. 1997). During the summer, 26% had serum vitamin D levels <40nmol/L. Of the 32 postmenopausal women that participated during the winter, 69% had a vitamin D level <40nmol/L. Because the sample size was small and participants were recruited from one city in New Zealand, more research is required with larger, more representative samples to strengthen these preliminary findings.

In summary, it is evident that vitamin D plays a crucial role in the maintenance of strong and healthy bones throughout life. Sunlight is the best source of vitamin D; however, elderly people may not be obtaining ten to fifteen minutes of sunlight everyday, particularly if they are house-bound. Moreover, the efficiency of UV synthesis of vitamin D as well as vitamin D_3-dependent calcium absorption in the gut decreases with age. Based on the available evidence, vitamin D insufficiency and deficiency is common in women living independently in New Zealand. This is a serious public health concern as vitamin D is essential for bone mineralization, calcium metabolism and a sufficient serum level is crucial for the prevention of osteoporosis. Vitamin D supplementation is highly recommended for vitamin D deficient individuals to prevent bone mineral deterioration and osteoporosis.

2.3.2.4 Clinical Trials showing Efficacy of Supplementary Vitamin D

As discussed earlier, vitamin D has an important role in the maintenance of BMD and in the prevention of osteoporosis. Vitamin D deficiency can be restored with 1,000IU vitamin D supplementation each day (Australian and New Zealand Bone and Mineral Society 2005). Insufficient levels (<50nmol/L) can be restored with 400-800IU per day (Greenspan et al. 2005).

A number of clinical trials and reviews have reported moderate benefits of vitamin D supplementation for bone health in women (Di Daniele et al. 2004; McAuley et al. 1997; Nordin 1997) and are summarized in Table 8. Collectively, vitamin D supplementation may result in a slight increase in BMD (Ooms et al. 1995) via a decreased rate of BMD loss (Peacock et al. 2000). However, results with vitamin D supplementation alone are only modest and authors have recommended combining vitamin D supplementation with calcium supplementation to achieve maximal gains in BMD for women (Patel et al. 2001; Peacock et al. 2000).

A meta-analysis by Papadimitropoulos et al. (2002) found vitamin D supplementation of >400IU/day for at least six months to significantly effect the incidence of vertebral fractures in postmenopausal women. This conclusion was based on a pooled analysis of 25 randomized controlled trials giving a total number of 4,017 women in the supplementation group and 4,107 women in the control group. The follow-up period ranged from one to five years. However, some studies combined treatment with calcium supplementation. Therefore, it is difficult to determine whether vitamin D supplementation alone or in combination with calcium would be beneficial for the prevention of osteoporosis.

More recently, Boonen et al. (2007) also completed a meta-analysis of randomized, controlled vitamin D supplementation trials, with or without calcium supplementation. All trials assessed relative risk of hip fracture and had to report risk of hip fracture as a separate outcome. Participants were postmenopausal women and/or men over the age of

50 years. A total of nine trials were analyzed, giving a total number of 53,260 participants. Six trials used 700-800IU/day of vitamin D supplementation, while the remaining three trials administered 400IU/day. Moreover, six trials also included 500-1,200mg/day of calcium supplementation. The results of the meta-analysis showed no reduction in risk of hip fracture with vitamin D supplementation alone. Only those who took calcium and vitamin D supplementation reported a significant reduction in risk of hip fracture by 18% compared to the control group. However, compliance in some studies were low and ranged from 18% to 67%. Moreover, the method of analysis assumes that all trials had a similar design and quality as well as a consistent magnitude of effect. In addition, risk of hip fracture was the outcome; therefore, these results can not be generalized to other skeletal sites. In conclusion, Boonen et al. (1997) recommends a daily intake of 1,000-1,200mg of calcium and 700-800IU of vitamin D for postmenopausal women, who may be at risk of developing osteoporosis.

Vitamin D and Calcium Supplementation

Cholecalciferol supplementation trials have been mostly conducted in conjunction with calcium supplementation (Table 8). The majority of these trials have reported supplementation to increase BMD at various sites (Chapuy et al. 1994; Di Daniele et al. 2004; Dawson-Hughes et al. 1997; Grados et al. 2003). More importantly, this may result in a significant reduction in the incidence of fractures, as demonstrated by Dawson-Hughes and colleagues (1997). Only 6% of women in the intervention group reported an incidence of a first fracture at three years compared to 13% in the placebo group. The main mechanism based on analysis of serum PTH and osteocalcium levels may be via a decreased rate in bone remodeling (Dawson-Hughes et al. 1997; Baeksgaard et al. 1998).

In conclusion, vitamin D supplementation taken alone produces moderate benefits on BMD. When taken in conjunction with calcium supplementation, the effect on bone density is enhanced as it significantly reduces the rate of bone loss. Therefore, calcium and vitamin D supplementation may help to prevent osteoporosis in both peri- and postmenopausal women.

Table 8: Summary of Clinical Trials showing Efficacy of Vitamin D Supplementation With or Without Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
Clinical Trials with Vitamin D Supplementation Without Calcium Supplementation					
Baeksgaard et al. (1998)	• RDBPCT • 2 years	• 197 postmenopausal women • Menopausal for at least 6 months • Mean age of 62.5 years	• Three groups –calcium and vitamin D supplementation (n=65); calcium, vitamin D and multivitamin supplementation (n=70); placebo (n=68) • Supplementation was 1,000mg/day of calcium and 500IU/day of vitamin D • BMD measurements were taken at baseline and every year with DXA • Dietary analysis was completed with a 7 day food diary at baseline and at 2 years • Serum measures of PTH were also taken	• Results did not differ significantly between the two supplementation groups and were therefore combined • Significant ↑ in LS BMD during the first year followed by a small ↓ in the IG • CG showed no significant changes in LS BMD • An insignificant ↑ in femoral neck BMD by 1.6% in the IG compared to the CG • Slight significant ↓ in PTH levels by 26.5% in the IG during the first year, which was statistically different from the CG	Differences in PTH levels indicate a ↓ in the bone turnover rate. Future studies are required to any clinically significant effects in reducing fracture rates with calcium and vitamin D supplementation

Table 8 continued: Summary of Clinical Trials showing Efficacy of Vitamin D Supplementation With or Without Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
Cooper et al. (2003)	• RDBPCT • 2 years	• 153 early postmenopausal women • Mean age of 56.3 years	• 73 women received 1,000mg/day of calcium and 10,000IU/day of vitamin D • 80 women received 1,000mg/day of calcium plus a placebo • BMD measurements were made at 6 sites every 6 months with DXA • Other measurements made included dietary analysis with a FFQ, physical activity and medical and social history	• No significant differences in BMD at all sites between groups • Overall, there were significant ↑ in BMD at the Ward's triangle and trochanter in both groups • No significant changes in LS and femoral neck BMD	Vitamin D supplementation may not provide any additional benefits than calcium supplementation alone
Ooms et al. (1995)	• RDBPCT • 2 years	• 348 elderly women • Mean age of 80.4 years	• 177 women were given 400IU/day of vitamin D • Remaining 171 women were given a placebo • BMD at the femoral neck and trochanter were made at baseline	• Slight ↑ in femoral neck BMD, particularly during the first year in the IG • Associated with a significant ↑ in serum vitamin D levels and a slight insignificant ↓ in PTH levels	The serum blood results indicate a ↓ in bone turnover. However, no bone biomarkers were taken. Future studies

Table 8 continued: Summary of Clinical Trials showing Efficacy of Vitamin D Supplementation With or Without Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
			and end of each year with DXA • Serum vitamin D and PTH levels were measured		are required to determine the exact mechanism
Patel et al. (2001)	• RDBPCT • Cross-over trial • 2 years	• 70 women • Mean age of 47.2 years	• 35 women received 800IU/day of vitamin D • 35 women received a placebo • At the end of year 1, groups were crossed-over to receive the other treatment • BMD measurements were made with DXA at baseline and every 3 months • Serum measures of vitamin D and PTH	• Marked change in serum vitamin D levels in the IG as well as a highly significant seasonal variation between summer and winter • The only significant change in BMD was at the trochanter in the IG	The use of a cross-over trial provides good control for other confounding variables. Vitamin D supplementation alone may be insufficient for the prevention of osteoporosis at other skeletal sites
Peacock et al. (2000)	• RDBPCT • 4 years	• 236 elderly men and women • Men had a mean age of 75.6 years	• Three groups – calcium supplementation (n=124); vitamin D supplementation (n=124); placebo group (n=129)	• At 4 years, the CG lost significantly more BMD at the hip compared to the calcium group • Rate of BMD loss was ~0.5% per	

Table 8 continued: Summary of Clinical Trials showing Efficacy of Vitamin D Supplementation With or Without Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
		• Women had a mean age of 73.4 years	• Calcium group received 750mg/day of calcium • Vitamin D group received 600IU/day of vitamin D3 • BMD measurements were made at hip every 6 months with DXA	year in the CG and was associated with an ↑ in bone turnover and PTH level • The vitamin D group had BMD measurements intermediate between the CG and calcium group • Bone density in the vitamin D group was not significantly different from the CG	
Clinical Trials With Calcium Supplementation					
Chapuy et al. (1994)	• RDBPCT • 3 years	• 3,270 elderly mobile women • Mean age of 84.0 years	• 872 women received 1.2g/day of calcium and 800IU/day of vitamin D supplementation • 893 women received a double placebo • Reports of fractures recorded every 6 months • BMD measurements were	• Significantly ↓ in probability of hip and non-vertebral fractures in the IG compared to the CG • CG showed a significant ↑ in PTH levels compared to baseline levels, which was associated with a low serum vitamin D • Significant negative correlation	

Table 8 continued: Summary of Clinical Trials showing Efficacy of Vitamin D Supplementation With or Without Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
			completed for 128 women • Biochemical variables measured in a subgroup of 52 women	between serum PTH and BMD, which remained significant even after controlling for age	
Dawson-Hughes et al. (1997)	• RDBPCT • 3 years	• All were living independently • Mean age of 71.0 years • 176 men and 213 women	• 86 men and 101 women received 500mg of calcium plus 700IU of vitamin D per day • 90 men and 122 women received a placebo • BMD measurements were made very 6 months with DXA • Any falls or fractures were reported at each visit • Serum blood samples were taken	• Significant positive effect of supplementation on femoral neck, LS and total body BMD • Women in IG experienced significantly less total body bone loss • Results were most significant during the first year • Osteocalcin levels indicate a ↓ rate of bone turnover	
Di Daniele et al. (2004)	• RDBPCT • 2.5 years	• 60 perimenopausal and 60 postmenopausal women	• 60 women received 500mg/day of calcium and 200IU/day of vitamin D • 60 women received a placebo • Whole body, lumbar spine, femur,	• At the 15 and 30 month follow-up, BMD was significantly higher in the IG compared to the CG • The CG had lost a total of ~0.4% BMD each year whereas the	

Table 8 continued: Summary of Clinical Trials showing Efficacy of Vitamin D Supplementation With or Without Calcium Supplementation

Reference	Study Design and Duration	Participant Characteristics	Methodology	Main Results	Notes
			forearm and hand BMD measurements were made at baseline, 15 and 30 months	supplementation group experienced an ↑ in BMD	
Grados et al. (2003)	• RDBPCT • 12 months	• 192 postmenopausal women • Mean age of 74.6 years	• 95 women received 1,000mg/day of calcium and 800IU/day of vitamin D • 97 women received a placebo • BMD measurements were made with DXA made at baseline and 12 months • Serum vitamin D and PTH levels were also measured	• Significant ↑ in BMD in the IG at all sites, except the trochanter • The IG experienced an average ↑ of 3.1% at the LS compared to no significant changes in the CG • IG showed an ↑ in BMD at the femoral neck by 1.4% vs. 0.59% ↓ in CG • Associated with an ↑ serum vitamin D levels and a ↓ in PTH levels in the IG	Serum blood results indicate a ↓ rate in bone turnover, which is likely to be the mechanism in preventing BMD loss in this sample of women

↓ decrease; ↑ increase; CG, Control Group; DXA, Dual-Photon Absorptiometry; IG, Intervention Group; LS, Lumbar Spine; PTH, Parathyroid Hormone; RDBPCT, Randomized, Double-Blind, Placebo-Controlled Trial

2.4 Non-Nutritional Risk Factors Affecting Osteoporosis

In addition to dietary calcium intake and serum vitamin D levels, other non-nutritional factors are also important in the prevention of osteoporosis. These include regular weight-bearing exercise, a genetic predisposition and menopausal status. Both nutritional and non-nutritional factors interact closely to determine an individual's susceptibility to osteoporosis. For example, in addition to a gene-environment interaction, weight-bearing exercise stimulates bone formation, which requires adequate dietary calcium and serum vitamin D levels for bone mineralization (Bonjour et al. 2007; Specker & Vukovich 2007). The effects of non-nutritional factors on bone health have been studied extensively and will now be reviewed.

2.4.1 Physical Activity

Physical activity plays a role in attainment and maintenance of BMD through mechanical and metabolic stimulation of bone matrix formation. Although the exact physiological mechanism is still unclear, it is thought to be related to the stimulation of prostaglandin E2 and growth hormone (GH) from the pituitary gland. This in turn enhances bone formation through the stimulation of osteoblast production and activity (Murphy & Carroll 2003; Turner & Robling 2003). According to Lewis and Modlesky (1998), repetitive loads of more than 1.5 times body weight is adequate to stimulate bone formation. In addition, short bouts of intense activity has been found to be more beneficial than longer periods of exercise as skeletal tissue becomes desensitized to mechanical loading after 20 to 36 consecutive cycles (Murphy & Carroll 2003; Turner & Robling 2003). In the absence of mechanically-induced strain, bone remodeling shifts in favor of bone resorption, which leads to bone loss. Therefore, individuals who are sedentary are more likely to develop osteoporosis later in life compared to those who are active and participate in weight-bearing exercise, such as team sports and aerobic dancing.

Peak Bone Mass

Regular weight-bearing exercise during childhood and adolescence can help attain a high PBM by inducing bone formation and reducing the rate of bone modeling (Delaney 2006; Dibba et al. 2000; French et al. 2000; Turner & Robling 2003; Vainionpää et al. 2005; Wahlqvist & Wattanapenpaiboon 2000). The benefit of physical activity on BMD is long-term as formation of skeletal tissue has been shown to persist into adulthood

(Bassey 2000; Murphy & Carroll 2003). In Pesonen et al.'s study (2005), 1,551 women (mean age of 53.0 years) were randomly selected from the Kuopio Osteoporosis Risk-Factor and Prevention Study and followed up over five years. Of these women, 168 were in the highest quantile for BMD and were classified as the high BMD group. The remaining 1,383 women were used as controls. Results found a significant difference between the two groups in participation in competitive sports during adolescence – those in the highest quantile had a significantly higher participation rate compared to the control group. These women also had significantly fewer fractures over the next five to ten years. Therefore, this study demonstrates how physical activity throughout life can help attain a high PBM and therefore, prevent the onset of osteoporosis and related fractures in later life.

Bone Mineral Density

Once PBM has been achieved, continual regular exercise can help prevent the decline in BMD that is observed from the third decade of life (Lewis & Modlesky 1998; Specker & Vukovich 2007). The benefit of exercise for maintenance of BMD during adult life has been demonstrated in a number of exercise intervention trials, including Vainionpää et al.'s study (2005). In this study, 39 out of 80 premenopausal women were randomly assigned to the exercise group (mean age of 38.1 years) while the remaining served as the control group (mean age of 38.5 years). The exercise group participated in a 60 minute supervised exercise program three times a week for one year. Bone density measurements were made using DXA at a number of sites, including the lumbar spine and femoral neck. Dietary calcium intake was determined using a questionnaire formulated by these authors for the study. Results found a mean dietary calcium intake of 1,099mg/day for the whole study group, which did not differ between the exercise and control group. Comparison of BMD between the two groups before and after intervention showed a significantly greater bone mineral acquisition at the femoral neck and L1 of the lumbar spine in the intervention group compared to the control group. However, changes in BMD were not significant in other non-weight bearing sites, such as the forearm. Therefore, mechanical loading and stimulation from regular weight-bearing exercise can help maintain BMD during adulthood and therefore prevent the onset of osteoporosis in women.

Regular physical activity during the postmenopausal years can also help maintain BMD (Bassey 2000; Lewis & Modlesky 1998). This was demonstrated in Nelson et al.'s (1991) intervention over a 12 month period. Thirty six postmenopausal women who were at least two years menopausal but less than 70 years old participated in the study. Participants were split into four groups – exercise with moderate dietary calcium (EXMOD); exercise with high dietary calcium (EXHI); sedentary with high dietary calcium (SEDHI); and sedentary with moderate dietary calcium (SEDMOD). Dietary calcium groups were randomly assigned; however, exercise groups were selected based on participant's preference to increase compliance. The exercise groups participated in 50 minute walks four times a week, while the sedentary groups were advised they could do some exercise but not on a weekly basis. The high calcium groups were given a calcium drink containing 831mg of calcium, whereas the low calcium groups were provided with a drink containing 41mg of calcium. After 12 months, BMD at the spine had decreased by 7% in the sedentary groups but increased by 0.5% in the exercise groups. There was no significant effect of dietary calcium on spine BMD. On the other hand, femoral neck BMD had decreased by 1.1% in the moderate calcium groups, but increased by 2% in the high calcium groups. However, the effect of exercise on femoral neck BMD was not significant, which may be due to a small sample size. Further research with a larger sample size is required to determine whether exercise would have an effect on femoral neck BMD.

Several meta-analysis reviews have concluded a positive effect of aerobic activity and resistance training on bone health. Kelley (1998a) completed a meta-analysis of six randomized and nonrandomized controlled trials with a total of 230 postmenopausal women. Inclusion criteria for studies were controlled trials with a control group, aerobic exercise intervention and reports of changes in hip BMD and loading sites. Study period ranged from 32 to 104 weeks and sessions ranged from 25 to 90 minutes. Analysis of these six trials found moderate benefits of aerobic exercise on hip BMD compared to the control group. Hip BMD changes were 2.1% and -0.3% in the exercise group and control group, respectively. Hence, Kelley (1998a) concluded that aerobic exercise can help prevent osteoporosis in postmenopausal women due to a decrease in the rate of BMD deterioration.

In another meta-analysis by the same author, Kelley (1998b) analyzed nine studies to give a total number of 719 participants. The inclusion criteria were randomized trials with exercise as the primary intervention; postmenopausal women; inclusion of a control group; and changes in regional bone mass had to be reported. Six studies used aerobic type training while the remaining five studies used strength type training. The mean length of trials was 15.1 months with participants receiving training on average three days a week. The mean duration of each training session was 36 minutes. Mean age for the exercise groups and control groups combined ranged from 43-79 years and 46-76 years, respectively. Mean years since menopause were 3-16 years and 4-16 years in the exercise groups and control groups, respectively. There were no significant differences between groups in mean age, years since menopause, initial body weight, initial BMI, compliance or total number of participants. Results showed both aerobic and resistance training to increase regional BMD compared to baseline values by an average of 1.6% and 0.7%, respectively. Although there were small decreases in the rate of regional bone loss, it is not yet known whether these changes would result in a reduction in fracture rates. Of note is that the benefits of exercise on regional BMD diminished when data was stratified for calcium supplementation or HRT use. This indicates that calcium supplementation and HRT treatment plays a greater role in the prevention of osteoporosis than exercise. As the number of studies included in this meta-analysis was small, further investigation is required before any set recommendations for aerobic or resistance training to prevent osteoporosis can be made.

More recently, Kelley et al. (2001) published a meta-analysis report that included only resistance training as the intervention. Other inclusion criteria were the inclusion of a control group, adult females as participants, a minimum of 16 weeks of training and BMD measurements reported at the femur, lumbar spine or radius. A total number of 29 studies were included for analysis with 572 and 551 participants in the intervention and control groups, respectively. Results showed a small but insignificant effect of resistance training on femur BMD of 0.33% increase compared to a 0.05% decrease in the control group. At the lumbar spine, there was a small significant effect on BMD as the exercise group experienced a 0.19% decrease, compared to a 1.45% decrease in the control group. Similarly, at the radius, the exercise group reported a 1.22% increase in BMD compared to a 0.95% decrease in the control group. Moreover, when calcium supplementation, previous exercise habits and type of BMD assessment used were taken into account, results remained the same. Therefore, Kelley et al. (2001) concluded that resistance training can be beneficial for all women in the maintenance of BMD. In addition, when the data of pre- and postmenopausal women were analysed separately, benefits of resistance training were more profound for postmenopausal women. However, as stated previously, whether these effects in BMD would have a clinical impact in rate of osteoporosis-related fractures is unknown. Nevertheless, women should still be encouraged to participate in regular physical activity as exercise has many other health benefits (Kelley 1998b; Kelley et al. 2001).

In summary, both aerobic and strength training exercise can help attain a high PBM and maintain BMD throughout life. Weight-bearing exercise mechanically and metabolically stimulates bone matrix formation by enhancing osteoblast production and activity. The benefit of exercise on bone mass during childhood and adolescence is long-term as an increase in bone density persists into adulthood. Regular weight-bearing physical activity, such as aerobics and running during the premenopausal and postmenopausal years can help slow down the rate of BMD loss observed after the third decade of life. Resistance training has also been found to have modest effects in maintaining BMD for women. Whether these small effects in BMD would have a clinical impact in reducing the rate of osteoporosis-related fractures is not yet known. However, regular physical activity is still highly recommended for all women as it has many other health benefits, such as positive changes in body composition and muscle strengthening.

2.4.2 Genetic Predisposition

A number of genetic factors affect BMD and is linked to the development of osteoporosis (New & Bonjour 2003). Results from Brown et al.'s (2005) twin study showed 60-80% variation in bone mass due to genetic factors. Therefore, a family history of osteoporosis will significantly increase an individual's susceptibility to osteoporosis. This was evident in Pouillès et al.'s study (2006) as participants with osteoporosis reported up to 3-fold more parental history of fragility fractures compared to age- and menstrual status matched controls.

Bone geometry and size is determined genetically and has been linked to the development of osteoporosis (Ailinger et al. 2005; Chumlea et al. 2002). Differences in bone geometry and size may be the reason why although Asian women have a lower BMD compared to Caucasian women, the rate of incidence and prevalence of osteoporosis within the Asian population is currently lower (Chumlea et al. 2002; Cooper 1999; Kanis & Glüer 2000). Some studies have found adjusting for a small body size or skeletal frame in Asian women to correct for the low BMD measurements (Babbar et al. 2006; Flynn 2003; Pulkkinen et al. 2004). According to Alekel et al. (1999), adjustment for a shorter hip axis length in Indian and Pakistan women compared to Caucasian women would eliminate the difference in BMD measurements and therefore, the associated risk of a hip fracture. It has also been suggested that Asian women require a higher threshold point for fractures to occur due to differences in frame size (Chumlea et al. 2002; Lau 1999).

Genetics has some contribution to body composition and body weight, which has been consistently correlated with BMD (Chapurlat et al. 2000; Chumlea et al. 2002; Di Daniele et al. 2004; Makovey et al. 2005; Sirola et al. 2003; Wallace & Ballard 2002; Weaver 2008;). In Shatrugna et al.'s study (2005), whole body and femoral neck BMC and BMD were significantly higher with increasing BMI. However, hip, spine and forearm BMD was only significantly higher in those with a BMI above 23kg/m². Ilich et al. (2003) also found whole body, lumbar spine and femur BMC and BMD to be significantly positively associated with BMI and body composition. Although the exact mechanism is unclear, most authors have hypothesized greater mechanical loading and strain with greater body weight to act as a protective factor against osteoporosis (Alekel et al. 1999; Chumlea et al. 2002;).

Certain receptor genes have been hypothesized to be associated with osteoporosis. For example, a vitamin D receptor gene has recently been found to be related to an individual's bone mass (Lau 1999). Vitamin D is involved in calcium metabolism and homeostasis; therefore, the interaction of vitamin D with its receptor will affect bone mineral status (New & Bonjour 2003). Morrison et al. (1994) demonstrated a relationship between vitamin D receptor gene polymorphism and reduced BMD as well as an increased bone turnover rate in a sample of postmenopausal women. However, the relationship between vitamin D receptor and the incidence of osteoporotic-fractures has been conflicting (New & Bonjour 2003). In addition, the molecular mechanism of the relationship between vitamin D receptor and bone mineral status still remains unclear (Becherini et al. 2000). More extensive molecular and genetic research is required.

The estrogen receptor has also been hypothesized to be an osteoporotic-related gene (Becherini et al. 2000; Pouillès et al. 2006). Estrogen plays a significant role in the maintenance of BMD. An individual's response to estrogen is determined by the interaction between estrogen and its receptor (Lim et al. 1997). Estrogen receptors have been identified on osteoblast and osteoclast cells in a number of ethnic groups and may therefore play a crucial role in the bone remodeling cycle (Becherini et al. 2000; Pouillès et al. 2006). Mizunuma et al. (1997) found a certain estrogen receptor genotype to significantly affect bone mineral status before the onset of menopause in a sample of 173 Japanese women. However, the relationship was no longer evident around the age of 50 during the menstrual transition stage. Chen et al. (2001) found the estrogen receptor α gene polymorphism to be a genetic marker for osteoporosis in a sample of 174 Chinese postmenopausal women in Taiwan. Similarly, Becherini et al. (2000) found a significant association between estrogen receptor α repeat polymorphism and lumbar spine BMD in a cohort of 620 Italian women. Therefore, genetic determinants of estrogen receptors as well as other osteoporosis-related genes are likely to significantly contribute to an individual's susceptibility to osteoporosis.

In summary, twin studies have shown that genetic predisposition contributes to 60-80% variance in bone mass and therefore, plays a significant role in determining an individual's susceptibility to osteoporosis. Bone geometry and size has been found to be related to susceptibility of osteoporosis. A small frame may act as a protective factor against osteoporosis, which may account for the lower prevalence of osteoporosis within Asian women compared to Caucasian women. A number of osteoporosis-related gene receptors have been recognized, including the vitamin D receptor and estrogen receptor. Differences in gene polymorphism and genotypes may also explain the different prevalence rates of osteoporosis between ethnic groups.

2.4.3 Hormonal Effect

Estrogen undoubtedly plays an important role in the acquisition and maintenance of bone mass. Age of menarche has been consistently shown to affect PBM and hence, BMD in later life due to exposure to estrogen (Chevalley et al. 2005; Lloyd et al. 1992;

Ribot et al. 1992; Tuppurainen et al. 1995). In addition, nutrition and possibly dietary calcium intake specifically, may be associated with age of menarche (Chevalley et al. 2005; Cole 2000; Okasha et al. 2001). Osteoporotic-fractures are most common in postmenopausal women due to a rapid decline in estrogen. According to Cornwall and Davey (2004), one in three women in New Zealand over the age of 50 will suffer from an osteoporotic-related fracture in their lifetime. Estrogen deficiency has been postulated to affect the bone remodeling cycle and therefore, significantly increase the rate of bone loss (Gambacciani et al. 2002; Khan & Syed 2004; Meena et al. 2007). Therefore, those who have had a hysterectomy or an ovarian surgery are also at risk of developing osteoporosis. Moreover, a high level of dietary calcium intake has been shown to increase the production of active estrogen metabolites and estrogen hydroxylation (Napoli et al. 2005, 2007). This may result in greater bone mineralization and therefore increase BMD and aid in the prevention of osteoporosis.

Estrogen plays a vital role in controlling the remodeling cycle (Gambacciani et al. 2002; Khan & Syed 2004;). A decline in estrogen during menopause results in increased bone turnover up to 2-fold (Rizzoli & Bonjour 1999). Although the exact mechanism is still under debate, estrogen deficiency is thought to enhance bone resorption due to an increase in the lifespan of osteoclast cells (Meena et al. 2007; Mizunuma et al. 1997; Seeman 2003). In addition, the number and activity of mature osteoblast cells may also decrease with age due to impaired proliferation, recruitment and differentiation (Manolagas & Jilka 1995; Seeman 2003). As a result, bone loss is accelerated during menopause (Gambacciani et al. 2002;; Meena et al. 2007; Suresh & Naidu Dhananjaya 2006).

The rate of bone loss that occurs with estrogen deficiency is most dramatic within the first five years of menopause (Shatrugna et al. 2005; Sirola et al. 2003). Subsequently, bone loss slows down slightly from ~3% to ~1% each year for up to seven years or until the age of 70 years (Lewis & Modlesky 1998). Thereafter, bone loss increases once again (Brown et al. 2005; Chang 2006a). The decline in bone mass can be as high as 15% per decade after menopause (World Health Organization 2003).

A number of studies have used bone markers to demonstrate the effect of estrogen deficiency on the remodeling cycle and bone density (Khan & Syed 2004; Meena et al.

2007; Sirola et al. 2003). For example, Suresh and Naidu Dhananjaya (2006) showed women who were less than ten years menopausal to experience the highest rate of bone resorption compared to those who had been menopausal for more than ten years. This study recruited 304 women from the outpatient department of the Endocrinology and Metabolism of Sri Venkateswara Institute of Medical Sciences, Tirupati, South India. Women were divided into five groups – premenopausal or control (n=47); one to five years since menopause (1-5YSM; n=58); six to ten years since menopause (6-10 YSM; n=77); 11 to 15 years since menopause (11-15 YSM; n=58) and more than 15 years since menopause (>15 YSM; n=40). Blood samples were taken to measure intact parathyroid hormone (iPTH) levels, which is known to be a good biomarker of the rate of the bone remodeling cycle. Results showed women who were menopausal had a higher rate of bone turnover compared to the control group. More specifically, those in the 1-5 YSM and 6-10 YSM groups had a higher rate of bone resorption than bone formation, whereas those in the 11-15 YSM and >15YSM groups had relatively equal rates of bone formation and resorption. Estrogen deficiency was the main reason for the increased rate of bone loss in the early postmenopausal groups; hence, Suresh and Naidu Dhananjaya (2006) highly recommended estrogen replacement therapy for women who are in their first ten years of menopause to prevent osteoporosis.

Shatrugna et al.'s study (2005) described previously in the 'Dietary Calcium Intake in Indian Women' section found a significant relationship between menopausal status and BMD at the hip. In this study, 41% of the 289 Indian women were postmenopausal. Fasting blood samples and lumbar spine, hip and femoral neck BMD and BMC measurements were taken. Results showed that the effect of menopause remained significantly correlated to femoral neck and lumbar spine BMD, even after adjusting for weight and age. The mean age that these women became menopausal was 40.8 years. BMD and BMC measurements notably decreased after the age of 45 years in these women. Therefore, these results are consistent with Suresh and Naidu Dhananjaya's (2006) with women experiencing a rapid rate of bone loss within the first ten years of menopause.

Similarly, Chapurlat et al. (2000) found estrogen deficiency to be the predominant factor in predicting rate of bone loss. A sample of 196 premenopausal women (mean age of 38.6 years) and 76 perimenopausal women (mean age of 46.8 years) were recruited from the region of Lyon, France and followed up over three years. BMD measurements were made using DXA every year at the hip and lumbar spine. Blood and urine samples were also collected for analysis. Results showed a significant rate of BMD loss at the femur neck in the perimenopausal group, whereas the premenopausal group exhibited no significant bone loss during the three years. Blood and urine analysis revealed estrogen deficiency to be the main cause of bone loss during these early years of menopause.

In summary, the evidence shows that estrogen deficiency during menopause significantly accelerates the rate of bone mineral loss, particularly during the first ten years. In addition to a diet rich in calcium, sufficient serum vitamin D levels from sun exposure and regular weight-bearing activity, HRT can also help prevent the onset of osteoporosis in postmenopausal women. Therefore, it is recommended that postmenopausal women seek professional advice regarding possible treatments for the prevention of osteoporosis, particularly if they have a family history of osteoporosis.

2.5 Osteoporosis Prevention

Osteoporosis prevalence has increased in many countries including New Zealand and will continue to rise as the population ages. Prevention of osteoporosis from an early age is crucial as the effects of osteoporosis are irreversible. Making the right food choices in an environment where food is available in abundance is a key part to the prevention of osteoporosis. For example, the rising consumption of soft drinks has largely over-ridden the consumption of fresh milk (New & Bonjour 2003), which not only contributes to the rising obesity epidemic, but also to a low dietary calcium intake (Russell et al. 1999). What people chose to eat is largely influenced by culture, economics, knowledge and beliefs (Chan et al. 2007; Schmiege et al. 2007). Therefore, in theory, an individual's dietary behaviour can be altered by increasing knowledge and changing internal beliefs. This has been the protocol of a number of osteoporosis prevention trials. These education interventions have shown both positive and no effect on health behaviour, such as dietary calcium intake and physical activity. The inconsistent results indicate that both knowledge and beliefs interact in a complex way alongside other cultural and economic factors, which ultimately determines an individual's behaviour.

2.5.1 Role of Knowledge and Beliefs

Some studies have demonstrated a greater level of osteoporosis knowledge to predict a higher dietary calcium intake. For example, Blalock et al. (1996) found those women who had never seriously thought about increasing their dietary calcium intake to be significantly less knowledgeable about osteoporosis and the problems associated with the disease. In other words, the level of osteoporosis knowledge according to the Precaution Adoption Process Model (Weinstein 1988) significantly predicted dietary calcium intake. Those in stage one had considerably less knowledge about osteoporosis compared to all other stages. The Precaution Adoption Process Model proposes seven stages of change in behaviour as shown in Figure 6 on the following page.

In contrast, other studies have not found a direct positive relationship between osteoporosis knowledge and dietary calcium intake. Terrio and Auld (2002) and Wallace (2002) both found no association between osteoporosis knowledge and dietary calcium intake. Chang (2006a) found an inverse relationship between level of osteoporosis knowledge and dietary calcium intake. A multivariate analysis by Hernandez-Rauda and Martinez-Garcia (2004) also did not find osteoporosis knowledge to be a significant predictor of dietary calcium intake or physical activity. Therefore, these studies reveal that factors other than knowledge interact to determine behaviour.

One reason why increased knowledge does not always bring about a change in behaviour is the strong influence of internal health beliefs. A health belief can be described as perception of susceptibility and seriousness of the illness, benefits and barriers of taking action to prevent onset of illness, and health motivations (Carlsson & Johnson 2004; Piaseu et al. 2002). Therefore, a greater level of osteoporosis knowledge may not always predict a high dietary calcium intake due to different belief systems and perceptions.

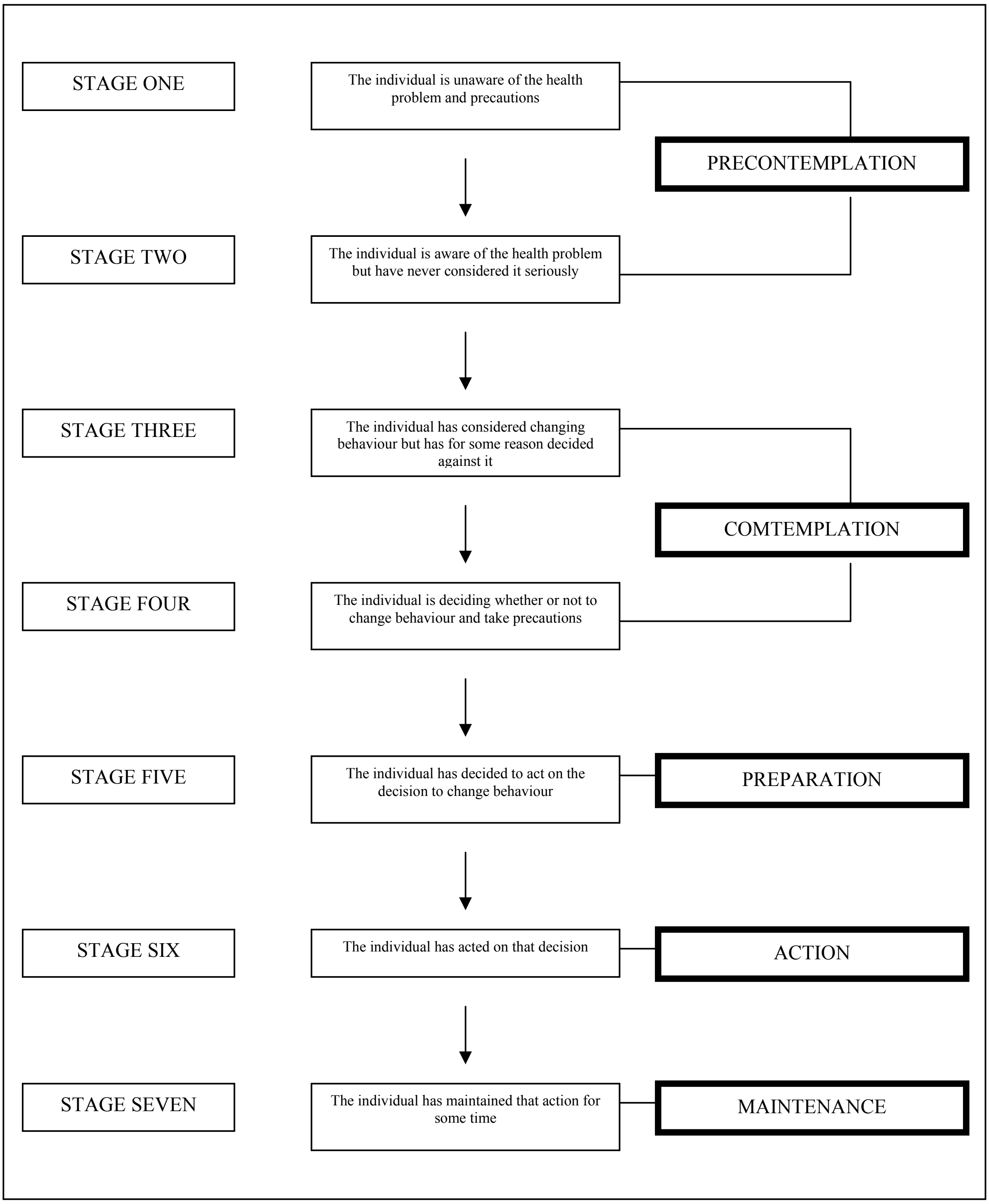

Figure 6: The Precaution Adoption Process Model (Weinstein 1988).

2.5.2 Health Belief Model (HBM)

A number of health belief models have been formulated to explain why some individuals are highly motivated to change health behaviours while others are not. The HBM was first developed in the 1950s primarily to treat patients with psychological conditions and addictions (Rosenstock 1960). Over the years, the use of the model has expanded to other health condition, including osteoporosis. The HBM proposes that an individual's health behaviour is strongly influenced by internal beliefs and perceptions of and is illustrated in Figure 7. The theoretical approach of the present study is based on the HBM.

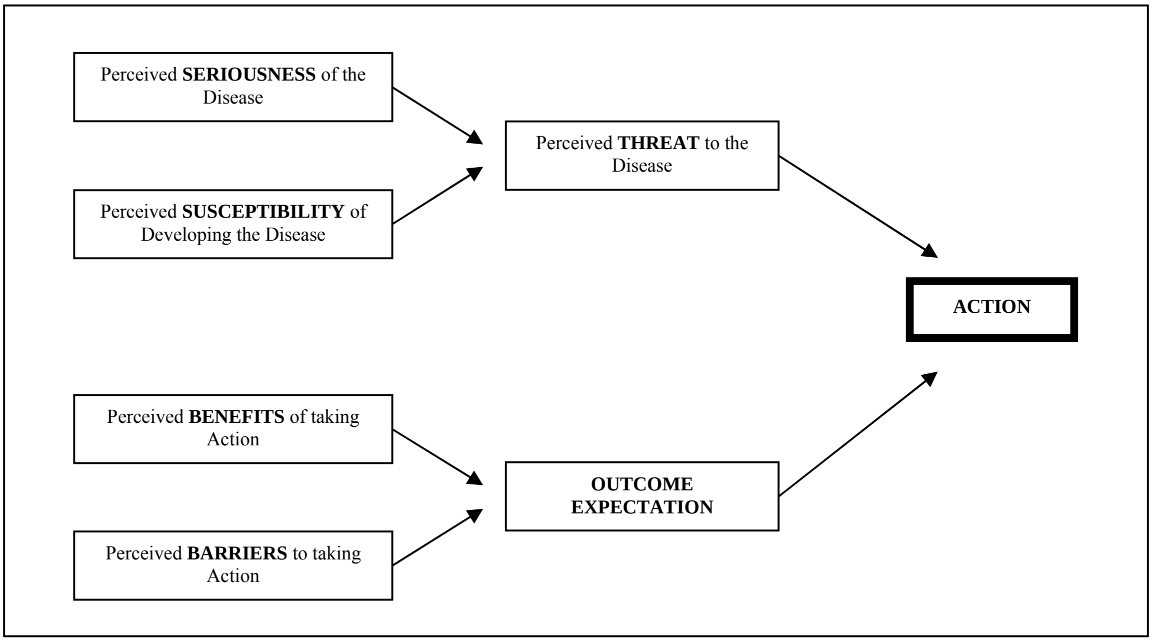

Figure 7: The Health Belief Model (Rosenstock 1960).

Self-efficacy has been widely recognized to have a large impact on health behaviour (Ali & Twibell 1995; Aree-Ue et al. 2005; Baheiraei et al. 2006; Conn et al. 2003; Schmiege et al. 2007). It is the amount of conviction or self-confidence an individual has to carry out a particular behaviour (Bandura 1977). The stronger the self-efficacy, the more likely an individual will put forth an active effort to change behaviour for a longer period of time. Self-efficacy was first incorporated into the HBM by Rosenstock et al. (1988). Indeed, a number of studies have found self-efficacy to predict dietary calcium intake (Baheiraei et al. 2006; Conn et al. 2003; Schmiege et al. 2007). For example, Piaseu et al. (2002) discovered that knowledge had a greater influence on dietary calcium intake when mediated by a greater level of confidence in changing behaviour, i.e. self-efficacy. Self-efficacy alone predicted 30% of the variance in dietary calcium intake.

Although the HBM provides a good model for predicting behaviour, there are some limitations. One limitation of the HBM is that it does not include social, cultural and economic influences (Poss 2001; Quah 1985). Social and cultural norms and pressures are known to strongly affect behaviour (Schouten & Meeuwesen 2006; Schmiege et al. 2007; Theroux & Taylor 2003). For example, cultural values and religious beliefs can affect perceived susceptibility and seriousness of disease, as well as preventive practices (Quah 1985). Economic factors are also known to influence health behaviours (Rozin 1996), such as cost of foods and perception of value for money. An individual's demographic characteristics are also likely to influence behaviour, which is not included in the HBM (Poss 2001). Nevertheless, the HBM has been used successfully to change and explain behaviour in a number of studies (Quah 1985).

2.5.3 The Influence of Health Beliefs on Dietary Calcium Intake in Women

The influence of internal health beliefs on behaviour is complex and may possibly never be completely understood. Some studies have used the HBM as a framework (Figure 7) to determine whether it can be used to predict dietary calcium intake. Results of these studies have been inconsistent and are summarized in Table 9.

The HBM proposes that if a person perceives a high chance of getting that disease, they are more likely to take action to prevent it. A high perception of susceptibility may also be related to greater knowledge (Saw et al. 2003). Indeed, Wallace (2002) found perceived susceptibility to be the strongest predictor of dietary calcium intake. On the other hand, other authors (Chang 2006b; Schmiege et al. 2007; Werner et al. 2003) have not reported this correlation. According to Gerend et al. (2006), although people with a family history of osteoporosis believe that they are highly susceptible to osteoporosis, they also believe that it is beyond their control. Therefore, they believe that a diet high in calcium will not be effective in preventing osteoporosis. Other factors must also come into play to determine behaviour and action towards prevention of osteoporosis.

According to the HBM, those who perceive the disease to result in serious consequences are more likely to take prevention measures. Hence, those who perceive osteoporosis to be crippling, painful, costly and significantly affect quality of life, are more likely to have a diet rich in calcium. A study by Chang (2006a) illustrated this relationship in a sample of Taiwanese women. However, not all studies have supported this direct relationship (Wallace 2002). Therefore, as with perceived susceptibility, a high perception of disease seriousness does not always predict a high dietary calcium intake.

Perceived barriers of consuming calcium-rich foods have been found to predict actual dietary calcium intake (Schmiege et al. 2007). Barriers may be things such as taste, inconvenience (Blalock et al. 1996), lactose intolerance, a misconceptrion regarding the nutritional content of milk and milk products, such as a high cholesterol (Gulliver & Horwath 2001a; Von Hurst & Wham 2007; Wham & Worsley 2003), energy and fat content (Gulliver & Horwath 2001a; Wham & Worsley 2003), as well as cost (Wham & Worsley 2003). Therefore, overcoming these barriers to dietary calcim intake may be an important part in the prevention of osteoporosis.

Perceived benefits of dietary calcium intake have been found to interact closely with perceived barriers to predict dietary calcium intake (Ali & Twibell 1995; Blalock et al. 1996; Gulliver & Horwath 2001b). Gulliver and Horwath (2001a) found those women who liked the "image of women who look after themselves by eating or drinking plenty of milk products" were significantly more likely to be in the contemplation stage than the precontemplation stage (Figure 6). Moreover, those in the precomtemplation/contemplation stage of change perceived significantly more barriers than benefits to milk consumption, whereas those in the action/maintenance stage perceived greater benefits than barriers. Therefore, both perceived benefits and barriers of milk consumption significantly predicted the stage of change and dietary calcium intake in this sample of New Zealand women.

In summary, knowledge alone does not predict behaviour due to the strong influence of personal beliefs and perceptions. The HBM proposes that behaviour is determined by perception of susceptibility and seriousness of the disease, combined with perceived benefits and barriers to taking action to prevent the disease. Studies have produced conflicting results, which demonstrates the complexity of knowledge, belief and behaviour. Collectively, increasing self-efficacy and perceived benefits of dietary calcium as well as overcoming perceived barriers to dietary calcium intake may be a key step in the prevention of osteoporosis. The present study will investigate whether osteoporosis knowledge and health beliefs are related to dietary calcium intake in a sample of South Asian women living in Auckland, New Zealand.

Table 9: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
Ali & Twibell (1995)	• 100 postmenopausal women, mostly Caucasian • Mean age of 66.7 years	• Dietary calcium intake was measured with a 24 hour recall • Frequency of exercise was determined (min/week) • Tools used were the Calcium, HRT and Exercise Benefits/Barriers Scale, Self-Efficacy Scale and the Control of Health Scale	• Mean dietary calcium intake was 1,244mg/day from milk and other diary products and dietary supplements • Dietary calcium intake from milk was significantly and moderately correlated with perceived benefits & less barriers to calcium intake • Those who had a high dietary calcium intake perceived more self-efficacy, believed health was internally controlled and perceived better health status	Small sample size of postmenopausal women who were predominantly Caucasian limits generalization of results
Babbar et al. (2006)	• 300 Chinese and Hong Kong women living in New York • Mean age of 63.0 years	Osteoporosis knowledge was measured with a 30-item knowledge questionnaire in Chinese based on the HBM concepts. This had been previously pilot tested on 10 Chinese women • Dietary calcium intake was measured with a modified	• Mean duration of residency in New York was 17.8 years • 50% of participants had a dietary calcium intake <644mg/day and only 25% had a dietary calcium intake of >972mg/day • 50% and 3% of participants used calcium and vitamin D supplementation, respectively • 4% of participants used hormone therapy • Mean knowledge score was 53% • Good knowledge about the importance of dietary calcium and exercise for prevention of osteoporosis, whereas knowledge on	

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
		quantitative FFQ with additional Chinese calcium-rich foods, such as soy, seaweed and bok choy • BMD measurements were made at the hip and spine with DXA	genetic risk factors were lacking • Only 62% could name 2 food sources of calcium • Only 7% had BMD measurements within the normal range • >50% had osteoporosis at the LS or hip • 1/3 of participants reported speaking to their GPs about osteoporosis • Multivariate linear regression model showed age, BMI and height to significantly predict BMD	
Berarducci (2004)	• 95 senior nursing students at the nursing college in South West Florida from 2002 to 2003 • Mean age of 25.9 years	• Students completed the Osteoporosis Knowledge Questionnaire that had been previously tested for reliability and validity	• Mean knowledge score was 66% or 14.6 out of a maximum score of 22 • 39% recognized that BMD begins to ↓ around the age of 30 • 20% and 60% could correctly identify RDI of dietary calcium intake for women aged 40-49 years and vitamin D, respectively • Only 35% correctly answered prevalence of osteoporosis in women >50 years	Sample was based on a convenience sample of nursing students from one college; therefore, results can not be generalized to other nursing students

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
Blalock et al. (1996)	• 452 premenopausal women from North Carolina, US • Mean age of 39.7 years	• Questionnaires were mailed out to participants • Dietary calcium intake was assessed with a 24-item FFQ • Osteoporosis beliefs was measured with the OHBS • Osteoporosis knowledge was determined with a osteoporosis knowledge questionnaire • Women were grouped into stages of change based on the Precaution Adoption Process model	• Those at stage (S) 1 had significantly lower level of knowledge about calcium than S2 • Those in the never engaged stages (S1 and S2) had significantly less knowledge and were less concerned than all other stages • White women more likely to be in acting stage (S6-7) • Those who were currently thinking about or planning to ↑ calcium intakes had greater health motivation, perceived more benefits and control and believed that calcium could ↓ the risk of osteoporosis • Those in S4 to S7 reported less barriers to dietary calcium intake • Those who were in the currently engaged stages (S4-5) reported more perceived benefits • Inconvenience was the most significant predictor of osteoporosis, explaining 30.4% of variance of stage of change, followed by knowledge and perceived benefits, explaining 6% of variance	
Carlsson & Johnson (2004)	• 48 Korean immigrants living in Nova Scotia, Canada	• Measures taken included level of acculturation, health perceptions and practices • Osteoporosis knowledge was	• Participants had a high level of education and had resided in Canada for an average of 14 years • Mean osteoporosis knowledge score was 50% • Lifestyle risk factors were better understood than genetic risk	Small sample size

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
	• 8 males and 18 females • Mean age of 48.0 years	determine using a questionnaire developed by these authors, including risk factors, consequences, prevention and treatment • Osteoporosis beliefs was measured with the OHBS • Dietary calcium intake was measured with a 24 hour recall and a Korean FFQ	factors • Knoweldge regarding treatment was poorly understood • 88% recognized the importance of dietary calcium for bone health • 58% perceived their eating habits to be excellent or good and 62% felt their intakes met nutritional needs • 19% reported an ↑ dairy consumption due to acculturation • General low perception of susceptibility, whereas perceived seriousness of osteoporosis was higher • Health motivation was high	
Chang (2006a)	• 265 Taiwanese women • Mean age of 42.5 years	• Osteoporosis knowledge was determine with an osteoporosis knowledge questionnaire • Osteoporosis health beliefs were determined with the OHBS	• Mean dietary calcium intake was 454mg/day • Mean knowledge score was 80.6% • Those who perceived osteoporosis to be a serious disease had higher levels of dietary calcium intake • Those who were unaware of the seriousness of the disease did not think it would be beneficial to have a diet high in calcium • Significant negative correlation between dietary calcium intake and osteoporosis knowledge	

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
			• Dietary calcium intake was positively associated with perceived susceptibility and seriousness of osteoporosis • Regression model showed significant factors influencing calcium intake in following order: knowledge; number of children; health score; BMI; education; history of bone examination. Accounted for 31.8% of variance	
Chang (2006b)	• 304 women from a public health centre in Northern Taiwan • Mean age of 47.4 years	• Osteoporosis knowledge and beliefs and preventive behaviours were measured with a tool that had been previously validated in another sample of Taiwanese women	• 97 women had a mother who had been diagnosed with osteoporosis (FDR group) while 207 were assigned as the non-FDR group • Mean dietary calcium intakes were 456mg/day and 550mg/day in the FDR and non-FDR groups, respectively • Osteoporosis knowledge was poor in both groups, scoring a mean of 5.6 and 5.0 out of a possible maximum of 15 in the FDR and non-FDR groups, respectively • Knowledge scores were not significantly different between the two groups • FDR group perceived greater susceptibility • Only difference between groups in preventive behaviours was more bone examination in the FDR group	

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
Chen et al. (2005)	• 539 Taiwan public health nurses • Mean age of 37.3 years	• Osteoporosis knowledge was determined with the Scale of Osteoporosis Knowledge with 50 items and 6 categories. The questionnaire was tested for reliability and validity • Possible score ranges from -50 to 50	• Mean osteoporosis knowledge score was 34.2 • Overall knowledge was related to age, education and previous studies at school • Categories with highest scores were preventive measures followed by incidence and pathophysiology • Lowest scoring sections were signs and symptoms, diagnosis and risk factors	
Gerend et al. (2006)	• 358 postmenopausal women from women's community groups in Pheonex, US • Mean age of 62.0 years	• Perceived susceptibility to osteoporosis was measured with the Direct Comparative Risk Item and was followed up by further questions by two independent raters	• Limited knowledge regarding lifestyle risk factors, including importance of dietary calcium intake, physical activity, smoking and caffeine consumption • Only half recognized a high calcium intake acts as a protective factor against osteoporosis • Those who perceived a low risk of susceptibility attributed it to their behaviours • Those who perceived a high susceptibility attributed it to family history and believed that it was out of their control	

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
Gulliver & Horwath (2001a & 2001b)	• 965 women randomly selected from the New Zealand electoral roll from Dunedin and Christchurch • Mean age of 45.0 years	• Mail out survey to determine dietary calcium intake with a FFQ and a brief diet history • Women were categorized into stages of change based on the Precaution Adoption Process Model based on their current consumption of dairy products and intentions to ↑ consumption	• There was a general lack of awareness of importance of milk products for bone health • Of those consuming less than 2 servings of dairy products a day, 73% had no intention to ↑ consumption • No different in employment status, living situation and education between stages of change • Perceived benefits relating to future health issues was positively correlated with milk consumption • Most significant barriers were body weight and perception of a high cholesterol content in milk • Stage of change was most significantly predicted by perceived benefits rather than barriers	
Matthews et al. (2006)	• 437 elderly women from four Southwestern Washington and Northwestern	• Participants completed a questionnaire that was formulated specifically for the study based on a literature review	• General low perception of susceptibility • 42% rated their knowledge as good or excellent but only 18% could identify RDI for both calcium and vitamin D • Only 49% and 19% knew calcium and vitamin D RDIs, respectively	Sample was based on a convenience sample in Washington and Oregon counties and can therefore not be generalized to other

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
	Oregon counties in US • Mean age of 63.0 years			populations
Pèrez-Edo et al. (2004)	• 850 GPs throughout Spain between 15 and 45 years • Data was collected from the 1995 South Australian Health Omnibus Survey	• Mail-out questionnaire included questions on a description of everyday conditions, such as preventive practices, follow-ups, treatment and diagnosis • Osteoporosis knowledge was determined based on 25 multi-choice items • One interview for each household with at least one person over the age of 15 years	• Mean knowledge score was 63% • Knowledge was significantly associated with age, years of practice and speciality • Those who were younger with less experience and who specialized in general medicine had the lowest level of osteoporosis knowledge compared to those who specialized in family and community medicine • There was a general lack of knowledge regarding individual risk factors, such as age, menstrual status and family history	

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
Ribeiro et al. (2000)	• 178 women recruited from 8 local churches in Canada • Aged between 25 and 84 years • 44% were between 55 and 84 years	• All participants completed a questionnaire that was designed specifically for the study to determine osteoporosis knowledge and preventive behaviours	• Only 24% consumed more than 2 servings of calcium-rich foods each day and may be related to a lack of osteoporosis knowledge • Limited knowledge regarding risk factors of osteoporosis – 27% gave vague or incorrect answers and an additional 33% were able to recognize only one risk factor • Only 29% recognized the benefits of HRT for the prevention of osteoporosis	Results were based on a convenience sample in Canada; therefore, results can not be generalized to other populations
Saw et al. (2003)	• 1,376 women in Western Singapore • Mean age of 57.1 years	• Osteoporosis knowledge and beliefs were determined with a semi-structured, home-based interview that had been previously tested and validated and translated into Chinese	• Those who had heard of osteoporosis were younger, more educated, exercised regularly and were not married • Knowledge was fair to very good but was low in middle-aged & elderly women • 85.7% knew that dietary calcium was an important factor for prevention of osteoporosis • 43.7% knew that regular exercise was an important risk factor • 30.5% knew that a family history of osteoporosis was a risk factor • Perceived susceptibility ↑ with ↑ knowledge and was higher among	

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
			younger and well-educated women	
Schmiege et al. (2007)	• 411 women at baseline and 285 at follow-up from psychology class at Arizona State University • Mean age of 18.7 years	• Participants completed mailed questionnaires at baseline and 6 months, including the OHBS, measures of injunctive and descriptive norms, and intention to consume dietary calcium and exercise over a 4 week period • Dietary calcium intake was measured using FFQ • Frequency of weight-bearing exercise per week was measured using 11 categories	• Only perceived barriers to calcium intake and execise predicted behaviour • Descriptive norms (supportive social environment) negatively predicted barriers and positively predicted self-efficacy and intention to consume dietary calcium and to exercise	Convenience sample used can not be generalized to other populations
Terrio & Auld (2002)	• 75 women from a convenience sample within a church in Colorado, US	• Women were categorized into three age groups – 25-35; 36-46 and >50 years • Semi-structured interview was conducted to determine knowledge	• Mean osteoporosis knowledge scores were 18%, 20% and 25% for the 25-35 years, 36-46 years and >50 years age groups, respectively • Older women had greater knowledge • General lack of knowledge regarding HRT • Knowledge was not significantly associated with dietary calcium	Sampling was based on a convenience sample; therefore, results can not be generalized to other populations

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
		on osteoporosis risk factors, consequences, preventive measures, perceived susceptibility,diagnosis and treatment	intake or physical activity	
Ungan & Tümer (2001)	• 270 women from Middle East Technical University Medical Centre in Ankara, Turkey • Mean age of 44.9 years	• Interview-based questionnaire was conducted with 26 questions to determine osteoporosis knowledge, including benefits of a high dietary calcium intake and regular exercise, genetic risk factors and other lifestyle risk factors	• Mean osteoporosis knowledge score was 63.1% • >65% knew that a hip fracture would be disabling but >90% did not recognize that hip fractures had a high mortality rate • >40% did not recognize the following risk factors – age, gender, race, smoking, heredity, having a diet rich in calcium and exercise • 80% considered dietary calcium to be protective factor but only 36% could identify all food sources • 75% had never discussed osteoporosis with their physician • Significant positive correlation between osteoporosis knowledge and education	
Von Hurst & Wham (2007)	• 622 women living in Auckland, New	• Self-administered, internet based questionnaires of OKT and OHBS to measure osteoporosis	• Mean knowledge score was 63% • Younger women had less knowledge • Perception of susceptibility was low and was not associated with	Use of an internet-based questionnaire may bias results as not everyone

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
	Zealand in 2005 • Mean age of 32.6 years • Women were predominantly Caucasian	knowledge and beliefs, respectively	age • >2/3 considered themselves to be not susceptible • No significant effect of age on perceived seriousness • 64% agreed it would be a serious disease but only 22.5% thought it would be crippling • Perceived barriers to dietary calcium intake was not affected by age • Belief that milk contained high cholesterol content was the main barrier to dietary calcium intake, especially in older women • High perception of benefits of both dietary calcium intake and exercise and was not effected by age	has access to the internet. Results can not be generalized to the whole of New Zealand because sample was collected in Auckland
Wallace (2002)	• 273 university students • Mean age of 28.3 years	• Dietary calcium intake was assessed with a rapid dietary assessment • Osteoporosis knowledge was assessed with the FOQ • Osteoporosis health beliefs was assessed with the OHBS • Self-efficacy was also measured	• Mean dietary calcium intake was 922mg/day • Mean osteoporosis knowledge score of 65% • There was no significant relationship between knowledge and dietary calcium intake • Perceived susceptibility was the strongest predictor of dietary calcium intake	Results can not be generalized based on the sample of students from one university who were predominantly Caucasian and from a higher socioeconomic group

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
Werner et al. (2003)	• 174 women from an outpatient medical screening program in Israel • Mean age of 55.1 years	• Telephone interviews by a trained interviewer • Questions were formulated to determine perceived susceptibility to osteoporosis and concern about osteoporosis using a 5-point likert scale • Osteoporosis knowledge was measured with the FOQ • Preventive behaviours such as physical activity and use of dietary supplements or osteoporosis medication were determined	• Women in the FDR group perceived higher susceptibility compared to the non-FDR group • There were no differences in preventive behaviour between groups • 48 women had a mother who had been diagnosed with osteoporosis and was assigned as the FDR group. The remaining 126 women were assigned as the non-FDR group • Mean osteoporosis knowledge scores were 12.3 and 12.5 out of a possible maximum of 23 in the FDR and non-FDR groups, respectively	
Wham & Worsley (2003)	• 713 men and women living in Auckland, New Zealand	• Telephone surveys were conducted based on a 27-item attitude questionnaire that covered topics such as sensory, cost, usage, health and nutrition knowledge and	• Although 90% knew that milk was a good source of dietary calcium, over 1/3 consumed less than one glass of milk per day • 9.4% of 16-30 year olds consumed no milk at all, this was highest among young women (15%) Strongest predictor of milk consumption was “milk is expensive	

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
		beliefs	compared to fizzy drinks" • Those who perceived cost to be a barrier also tended to believe that milk was for old people • "Milk is good value for money" was the most significant predictor of dietary calcium intake for those who agreed with the statement • 1/3 thought that fruit juice was better for you than milk • 1/3 of women thought that all milk was high in fat • >27% thought that milk was high in cholesterol	
Williams et al. (2002)	• 163 women from local primary schools in Convetry, UK • Mean age of 40.0 years	• Osteoporosis knowledge was measured with a modified version of the Osteoporosis Patient Knowledge Questionnaire	• Mean osteoporosis knowledge score was 20.2 out of a possible maximum of 47 • Osteoporosis knowledge was significantly associated with age • Overall low perception of susceptibility to osteoporosis • Most knew that women and elderly people are at greater risk of osteoporosis • 73% knew that dairy foods were a good source of dietary calcium but <50% knew the importance of vitamin D and sunlight • Low knowledge about benefits of HRT and family history as a risk factor	Sample was based on a convenience sample of women from local primary schools in the UK and can therefore not be generalized to other populations

Table 9 continued: Summary of Cross-Sectional Studies on the Influence of Osteoporosis Knowledge and Health Beliefs on Dietary Calcium Intake

Reference	Participant Characteristics	Methodology	Main Results	Notes
			• Low level of knowledge regarding the type of exercise to prevent osteoporosis. Only 32% knew that walking was better than swimming	
Wizenberg et al. (2003)	• 467 women randomly selected from 2000 electoral roll in Southern Tasmania, Australia • Mean age of 37.8 years	• Osteoporosis knowledge was measured with the Osteoporosis Knowledge Assessment Tool formulated based on information from the Osteoporosis Prevention and Self-management courses utilized by Osteoporosis Australia • This tool was tested to ensure validity and reliability • Sample was thought to be representative of the Tasmanian women population aged 25-44 years	• Mean knowledge score was 44% • Lack of knowledge is of concern as women approach menopause	

↓ decrease; ↑ increase; BMD, Bone Mineral Density; BMI, Body Mass Index; DXA, dual-energy x-ray absorptiometry; FDR, First-Degree Relative; FFQ, Food Frequency Questionnaire; FOQ, Facts on Osteoporosis Quiz; GP, General Practitioner; HBM, Health Belief Model; HRT, Hormone Replacement Therapy; LS, Lumbar Spine; OHBS, Osteoporosis Health Belief Scale; OKT, Osteoporosis Knowledge Test; RDI, Recommended Dietary Intake; US, United State

2.5.4 Osteoporosis Knowledge in Women

Although a greater understanding of osteoporosis does not necessarily result in higher dietary calcium intake, it is still important to identify the level of osteoporosis knowledge and common misconceptions in women. A lack of knowledge is likely to result in misconceptions such as a high cholesterol and fat content in all milk products as reported by von Hurst and Wham (2007), Wham and Worsley (2003) and Gulliver and Horwath (2001a). Studies that have looked at osteoporosis knowledge in women have consistently found a lack of knowledge in women of all ages (Ailinger et al. 2005; Chan et al. 2007; Curry et al. 2002; Gerend et al. 2006; Matthews et al. 2006; Terrio & Auld 2002; Wallace 2002) with mean scores ranging from 35% to 63% (Carlsson & Johnson 2004; Chang 2004; Chang 2006b; Ungan & Tümer 2001; Williams et al. 2002). These studies are summarized in Table 9 above. The results from some of these studies will now be reviewed.

A lack of knowledge regarding smoking and caffeine consumption as a risk factor for osteoporosis has been identified by a number of authors (Gerend et al. 2006; Spencer 2007; Ungan & Tümer 2001). Moreover, studies have found women to be unaware of the benefits of HRT for the prevention of osteoporosis (Ribeiro et al. 2000; Terrio & Auld 2002).

The ability to identify food sources rich in dietary calcium is important for the prevention of osteoporosis. A lack of understanding regarding dietary sources of calcium was reported in Ungan and Tümer's study (2001). Although most participants understood that a diet rich in calcium is a protective factor against osteoporosis, only 36% could identify all of the calcium-rich foods listed, such as milk, cheese and yoghurt.

There also seems to be a lack of knowledge regarding the benefits of physical activity in promoting bone health (Larkey et al. 2003; Spencer 2007; Williams et al. 2002). For example, in Ribeiro et al.'s study (2000), participants showed low levels of knowledge about preventive behaviours, including physical activity. However, sample selection was based on a convenience sample and can therefore, not be generalized to the population.

Osteoporosis knowledge studies on Asian women have generally found a lack of knowledge on osteoporosis (Babbar et al. 2006; Carlsson & Johnson 2004; Chang 2006b; Saw et al. 2003). Asian women tend to have a higher understanding about lifestyle risk factors than genetic risk factors (Carlsson & Johnson 2004).
For example, Babbar et al. (2006) found 85% of participants understood that calcium helps build strong bones and 77% recognized that calcium can reduce the risk of osteoporosis. Moreover, 84% recognized that regular exercise helps build strong bones and 75% knew that regular exercise can help prevent osteoporosis. In contrast, only 16% knew that a family history was a significant risk factor.

A couple of osteoporosis knowledge studies have been completed with New Zealand women (Gulliver & Horwath 2001b; Von Hurst & Wham 2007) and have also reported a lack of osteoporosis knowledge.

Based on the evidence available, Werner's systematic review (2005) of osteoporosis knowledge studies concluded that although the general public had a sound understanding that dietary calcium and regular physical activity are important for bone health, knowledge in other risk factors and preventative measures are lacking. The studies under review were based 20 studies published between 1998 and 2004. The majority of these studies were focused on peri- and postmenopausal women with only three studies based on pre-pubertal girls and four studies included men. The use of different tools of osteoporosis knowledge assessment makes it difficult to do direct comparisons between studies. Moreover, most of these studies were based on convenience sampling and therefore, can not be generalized to the whole population. Nonetheless, Werner's review (2005) found evidence to indicate that although most of the population are aware of the disease, knowledge in the areas of consequences, treatment and prevention of osteoporosis is lacking.

The evidence clearly shows a lack of osteoporosis knowledge in women of all ages. Although most women are aware of the importance of dietary calcium for building strong and healthy bones, knowledge on food sources of dietary calcium may be less than desirable. Moreover, knowledge on other risk factors, such as smoking, a high caffeine consumption and regular weight-bearing exercise seems to be lacking. Studies with Asian women have generally found a good level of knowledge regarding the benefits of dietary calcium and regular exercise for the prevention of osteoporosis. On the other hand, genetic risk factors are less well understood. In addition, studies have found treatment of osteoporosis such as the use of HRT to be poorly understood by all women.

2.5.5 Osteoporosis Knowledge in Health Professionals

Health professionals provide an important source of sound advice and information about osteoporosis to the public. However, very little attention has been paid to the level of knowledge in health professionals (Werner 2005). Although osteoporosis knowledge among health professionals will not be determined in the present study, it is important to recognize that a lack of knowledge within this population group may be highly prevalent. Indeed, a low level of osteoporosis knowledge in health professionals has been reported in a few studies (Pèrez-Edo et al. 2004), which are summarized in Table 9.

Nursing students have also been a target population for osteoporosis knowledge studies. Nurses provide an important source of accurate health information to the general public as well as identification of high risk groups. Hence, assessment of osteoporosis knowledge in nurses is important for the prevention of osteoporosis. However, results from Berarducci's (2004) and Chen et al.'s (2005) studies did not show adequate levels of osteoporosis knowledge. Only 35% of participants in Chen et al.'s study (2005) reported osteoporosis being taught at the nursing college. Therefore, health educator providers may need to incorporate osteoporosis into the curriculum to increase the level of knowledge about osteoporosis in health professionals.

A systematic review of nine knowledge studies in health professionals from 1998-2004 by Werner (2005) concluded that although physicians could accurately define osteoporosis and understood the risk factors of osteoporosis, areas that required attention were prevalence, dietary information on calcium and dietary calcium content of foods. In addition, most general practitioners expressed interest in receiving information about prevention and treatment of osteoporosis. Werner (2005) suggested more research to develop an intervention program that could be facilitated by health professionals and therefore, aid in the prevention of osteoporosis.

Studies that have looked at osteoporosis knowledge in health professionals have reported a lack of understanding in many areas of osteoporosis, including RDI of calcium and vitamin D and the calcium content of foods. This lack of knowledge is a serious issue as health professionals may not feel confident enough to discuss osteoporosis with their patients. Women should feel confident in seeking sound advice from primary health professionals. Therefore, further research and effective implementation strategies to enhance osteoporosis knowledge in health professionals are areas that require more attention.

2.5.6 Education Intervention Trials

One approach towards osteoporosis prevention is the use of education interventions to increase osteoporosis knowledge and awareness. If an individual does not know that a diet high in calcium is important for the prevention of osteoporosis, they are likely to perceive more barriers than benefits of dairy product consumption (Gulliver & Horwath 2001b). Therefore, according to the HBM, the individual is less likely to take preventive measures, such as a high dietary calcium intake or regular physical activity. A number of education intervention trials have been formulated using the HBM as the main framework to increase dietary calcium intake and are summarized in Table 10; results have been inconsistent.

A number of osteoporosis education intervention trials have produced positive results measured as an increase in dietary calcium intake (Sedlak et al. 2007). For example, Manios et al. (2007) found an intervention program based on the HBM and the Social Cognitive Theory to significantly increase dietary calcium intake. The Social Cognitive Theory was first developed by Bandura et al. (1977) and is illustrated in Figure 8 on the following page.

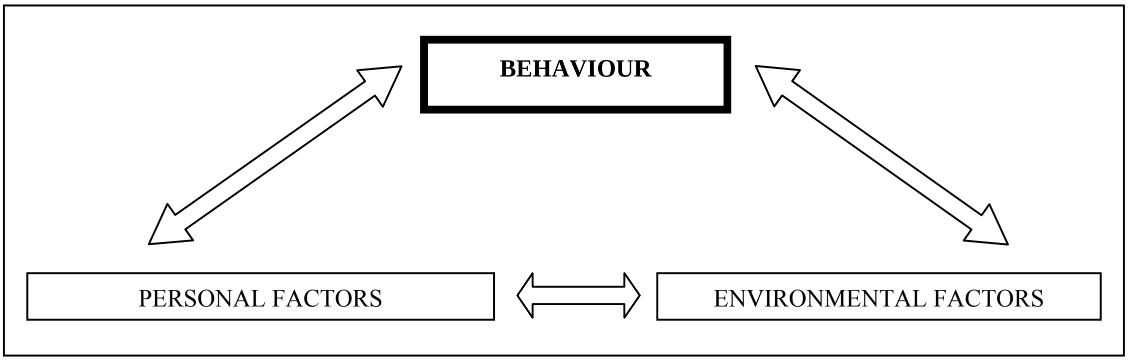

Figure 8: The Social Cognitive Theory (Bandura et al. 1977).

Personal factors include knowledge, skills, expected outcomes, goal setting, problems solving skills and stress management. Environmental factors include the social environment, such as family and friends, as well as the physical environment, such as availability of food. According to the Social Cognitive Theory, self-efficacy and outcome expectations can be enhanced by recognizing past failed attempts and implementing other successful techniques to create a behavioural change (Elder et al. 1999).

Tussing and Chapman-Novakofski (2005) designed an education intervention program using the HBM as well as the Theory of Reasoned Action Model (Fishbein & Ajzen 1986) as illustrated in Figure 9. The intervention resulted in a significant increase in dietary calcium intake, primarily due to an increase in perceived benefits of calcium intake, susceptibility to osteoporosis as well as increased calcium self-efficacy.

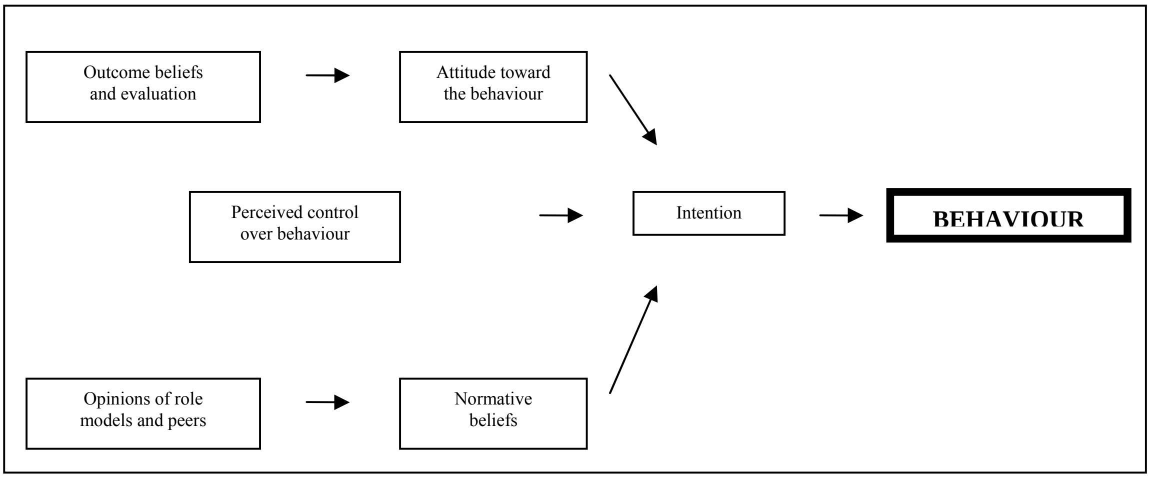

Figure 9: The Theory of Reasoned Action Model (Fishbein & Ajzen 1986).

Although some studies have reported an increase in dietary calcium intake with education intervention (Aree-Ue et al. 2005; Manios et al. 2007; Tussing & Chapman-Novakofski 2005), not all intervention trials have been successful (Ziccardi et al. 2004). For example, Ribeiro and Blakeley (2001) found that although an osteoporosis workshop significantly increased osteoporosis knowledge, there was no significant change in dietary calcium intake. However, participants in this study reported a high mean baseline dietary calcium intake (1,179mg/day), which may explain why there were no significant differences between baseline and follow-up dietary calcium intakes. Moreover, the method of dietary calcium intake assessment was a brief description of the amount of specific foods eaten over the past week. Although participants were asked to give quantities using household measures, answers were very vague and some were discarded. Therefore, estimates of dietary calcium intake in this study may not be precisely accurate (Ribeiro & Blakeley 2001).

In Sedlak et al.'s study (2000), three different types of osteoporosis education intervention did not produce a change in dietary calcium intake. Therefore, in contrast to Aree-Ue et al.'s (2005) and Sedlak et al.'s (2007) studies, an increase in osteoporosis knowledge did not predict an increase in dietary calcium intake or exercise.

In Werner's systematic review (2005) mentioned previously, ten osteoporosis intervention studies were evaluated. Only four out of these ten trials showed a positive change in health behaviour. Three of these trials used interactive methods of teaching. Therefore, to increase the likelihood of an increased dietary calcium intake, intervention trials need to consist of workshops that actively involve the participants, such as group discussions and problem solving exercises (Turner et al. 2004). This will help enhance self-efficacy and overcome any barriers to calcium intake women may be facing, which has been found to predict dietary calcium intake (Schmiege et al. 2007; Von Hurst & Wham 2007; Wham & Worsley 2003).

In summary, although some osteoporosis interventions have not found an increase in dietary calcium intake, others that have focused on enhancing self-efficacy and perceived osteoporosis susceptibility as well as decreasing perceived barriers to calcium intake have reported a significant increase in dietary calcium intake. It has been suggested that interactive group discussions that recognize and overcome individual barriers as well as developing support networks to encourage regular physical activity are more effective. This may provide a key tool in future interventions for the prevention of osteoporosis.

Table 10: Summary of Osteoporosis Education Intervention Trials for the Prevention of Osteoporosis

Reference	Participant Characteristics	Education Intervention	Methodology	Main Results	Notes
Aree-Ue et al. (2005)	• 47 elderly Thai women • Mean age of 69.0 years	• 4 week intervention program • Week 1 – basic education course to cover definition of osteoporosis, risk factors and consequences followed by a group discussion • Week 2 – benefits of dietary calcium, food sources of calcium as well as identifying barriers to consuming calcium-rich foods. Discussions on how to overcome these barriers were encouraged • Week 3 – benefits of physical activity were emphasized. Participants were given a pedometer • Week 4 – participants were	• Dietary calcium intake was assessed with a calcium FFQ at baseline and 6 months post-intervention • Frequency of physical activity was also determined	• At the 6 month follow-up, there was a significant ↑ in dietary calcium intake from 491mg/day to 647mg/day • Participants also reported an ↑ in exercise frequency (particularly walking) • Possibly due to an ↑ in osteoporosis knowledge and perceived susceptibility to osteoporosis as well as a ↓ in perceived barriers to calcium intake	The small sample size and convenience sampling limits ability to generalize these results. Future studies required with control group

Table 10 continued: Summary of Osteoporosis Education Intervention Trials for the Prevention of Osteoporosis

Reference	Participant Characteristics	Education Intervention	Methodology	Main Results	Notes
		encouraged to take part in regular physical activity • At the end of the program, information on topics were posted out and discussed at the 2 and 4 month follow-ups			
Curry et al. (2002)	• 188 elderly women from churches, retirement centres and senior citizen centres in Texas, US • Mean age of 76.4 years	• Intervention covered basics of osteoporosis, including definition, risk factors, causes, prevention, diagnosis and treatment • Session was 30 minutes followed by 30 minutes for discussion • Handouts were given at the end	• Osteoporosis knowledge was assessed using the 12-item Osteoporosis Knowledge Questionnaire and Osteoporosis Risk Checklist before and immediately after intervention	• Mean knowledge score significantly ↑ from 6.9 out of a possible maximum of 12 to 10.0 post-intervention	There were no measures of behavioural changes; therefore, it is unknown whether this increase in knowledge would result in an increase in dietary calcium intake

Table 10 continued: Summary of Osteoporosis Education Intervention Trials for the Prevention of Osteoporosis

Reference	Participant Characteristics	Education Intervention	Methodology	Main Results	Notes
Manios et al. (2007)	• 75 postmenopausal women from Athens, Greece • Mean age of 60.0 years	• Intervention was based on the HBM and the Social Cognitive Theory to ↑ awareness, self-efficacy and dietary calcium intake • Participants attended classes every 2 weeks for 5 months	• 39 participants were randomly assigned to the IG • Dietary calcium intake was measured with 3 x 24 hour recalls at baseline and 5 months	• Mean dietary calcium intake in the IG significantly ↑ from 681.6mg/day to 1248.5mg/day • CG reported no change in dietary calcium intake calcium supplements • 23% went to see a GP. Of those, 42% were given bone resorption inhibition medication • 80% of women discussed the program with other women, which will help ↑ awareness to other women not involved in the intervention	Study was over a short period of 5 months. Whether ↑ in dietary calcium intake would persist is unknown. Hence, participants may differ in perceived susceptibility and seriousness compared to the drop out group, which may have affected the results. In addition, there was no CG

Table 10 continued: Summary of Osteoporosis Education Intervention Trials for the Prevention of Osteoporosis

Reference	Participant Characteristics	Education Intervention	Methodology	Main Results	Notes
Ribeiro & Blakeley (2001)	• 138 women from women's institutes in Newfoundland, Canada • Mostly between ages of 45-69 years	• Intervention was a day long program covering many aspects of osteoporosis, including risk factors, prevention of falls, consequences and treatment	• 59 participants were assigned to the IG • The remaining 79 served as the CG • Questionnaire was administered pre-, post-intervention and at a 6 month follow-up in the IG • Questionnaire was administered at baseline and at 8 months for the CG • Questionnaire covered risk factors, prevention, symptoms of diagnosis • Behavioural measures were also measured, such as frequency of exercise, smoking status, alcohol and caffeine consumption, use of calcium and vitamin D supplementation and use of HRT	• There was a slight ↑ in dietary calcium intake in the IG from 1179mg/day to 1319mg/day after 6 months. However, this did not reach statistical significance • There was no significant effect of the workshop on the level of physical activity or the number of participants taking vitamin D or calcium supplementation	Participants in this study were generally healthy with a high mean baseline dietary calcium intake. Sampling was based on a convenience sample and can not be generalized to other populations
Sedlak et al. (2000)	• 84 women in total • 31 college graduates aged under 25 years • 35 women from a	• 3 intervention programs – brief, intermediate and intense	• Osteoporosis knowledge and health beliefs were measured with the OKT and OHBS, respectively at baseline and 3 weeks post-intervention	• Osteoporosis knowledge significantly ↑ in all 3 groups • The only behavioural change was a ↓ in caffeine	The use of heterogenous samples for each intervention group

Table 10 continued: Summary of Osteoporosis Education Intervention Trials for the Prevention of Osteoporosis

Reference	Participant Characteristics	Education Intervention	Methodology	Main Results	Notes
	• local university in Ohio, US aged between 22-83 years (community-sample) • 18 nurses aged between 32-59 years	• Brief – administered to the nurses, which was a single 45 minute education session • Intermediate – administered to the community sample, which was 3 education sessions over 3 weeks • Intense – administered to the college graduates, which involved the 3 education sessions with additional assignments	• Any change in behaviour was measured with the Osteoporosis Preventing Behaviour Survey	consumption in the intense program group	may have affected outcomes
Sedlak et al. (2007)	• 203 postmenopausal women • Mean age of 56.6 years	• IG received a free DXA scan	• At baseline, all paticipants completed the OPBS, OKT, OHBS and OSES • Those women who were randomly assigned to the IG received the DXA scan after 2 weeks • The CG were offered the scan at 12 months	• Knowledge ↑ in both groups and were not significantly different between groups • Percieved susceptibility ↑ in IG compared to a ↓ in the CG • CG perceived more barriers to calcium intake compared to	Recruitment was based on a convenient, community-based sample and results can not be generalized to

Table 10 continued: Summary of Osteoporosis Education Intervention Trials for the Prevention of Osteoporosis

Reference	Participant Characteristics	Education Intervention	Methodology	Main Results	Notes
				the IG • Significant ↑ in dietary calcium intake in IG • Significant ↑ in use of HT in IG (18.8%) compared to CG (5.9%) • No difference between groups on perceived benefits of calcium intake or self-efficacy • No difference between groups on exercise, smoking or alcohol intake	other populations. Although dietary calcium intake ↑ over 12 months, it began to ↓ between 6 and 12 months. This suggests a need for on-going support for long-term behavioural change
Turner et al. (2004)	• 342 women from local settings in Arkansas, US	• Intervention was created based on the HBM to ↑ perceived susceptibility and seriousness of osteoporosis, ↓ perceived barariers and ↑ benefits of dietary calcium intake and physical activity	• Step 1 – all women who were interested were asked to attend a general educational session • Step 2 – participants were asked to sign up to a nutritional class, which focused on the benefits of dietary calcium intake for bone health. Food	• Results indicated a positive response and feedback from participants • Of the 392 women who attended the initial education class, 381 continued onto the nutrition class, 375 completed	Measures of success such as a change in dietary calcium intake and participation in physical activity were not taken.

Table 10 continued: Summary of Osteoporosis Education Intervention Trials for the Prevention of Osteoporosis

Reference	Participant Characteristics	Education Intervention	Methodology	Main Results	Notes
		as well as ↑ self-efficacy • Primary goal was to create a successful intervention program for the prevention of osteoporosis for women	sources of dietary calcium were discussed • Step 3 – participants were asked to sign up to the supplements class, where the benefits of calcium supplementation and vitamin D were discussed • Step 4 – women were asked to sign up to the exercise class, which focused on the benefits of exercise as well as guidelines and recommendations • Step 5 – participants were asked to sign up for a bone density scan using DXA, which was followed by an individual consultation to review the scan results • Step 6 – an individual exercise program was developed based on the DXA results	the supplements class, 350 women attended the exercise class and 342 women completed the entire program	Therefore, future research is required to determine whether the positive feedback from an intervention program like this one would result in a change in behaviour, such as increased dietary calcium intake and physical activity in women

Table 10 continued: Summary of Osteoporosis Education Intervention Trials for the Prevention of Osteoporosis

Reference	Participant Characteristics	Education Intervention	Methodology	Main Results	Notes
			• Step 7 – individual risks, such as lifestyle factors were addressed by the consultant		
Tussing & Chapman-Novakofski (2005)	• 42 women from University of Illinois, Chicago • Mean age of 48.0 years	• Intervention was formulated based on the HBM and Theory of Reasoned Action Model • Handouts were given at the end of each workshop	• All 42 women attended a short lecture and workshop each week for 8 weeks • Dietary calcium intake was measured at baseline and at the end of the last class with a calcium FFQ • OHBS was used to determine change in health beliefs at baseline and end of 8 weeks	• Dietary calcium intake significantly ↑ after 8 weeks from 644mg/day to 821mg/day • Perceived susceptibility to osteoporosis and benefits of dietary calcium significantly ↑ • 3 self-efficacy questions explained 14% of dietary calcium intake variance	Caution should be taken when interpreting results because no CG was used and the sample was based on a convenience sample of staff members form the University
Ziccardi et al. (2004)	• 194 first and final year nursing students from northeast Ohio • 86 first year student (82 females and 4	• Students were selected because final year students had completed osteoporosis sessions at the college, whereas first year students had not	• Osteoporosis knowledge and health beliefs were measured with the OKT and OHBS, respectively • Other instruments used were the Osteoporosis Preventing Behaviours Survey and the OSES	• Final year students had a significantly ↑ OKT score compared to the first year students, with a mean score of 77.9% compared to 63.7%, respectively	Sample size was reasonably small. Future research required to strengthen results with a larger,

Table 10 continued: Summary of Osteoporosis Education Intervention Trials for the Prevention of Osteoporosis

Reference	Participant Characteristics	Education Intervention	Methodology	Main Results	Notes
	males) with a mean age of 22.8 years • 108 final year students (101 females and 7 males) with a mean age of 24.8 years			• Mean dietary calcium intake were 406mg/day and 369mg/day for the final year and first year students, respectively • There were no differences in the amount of weight-bearing exercise, dietary calcium intake or intake of caffeinated products between the two groups	more culturally-diverse sample from more universities

↓ decrease; ↑ increase; CG, Control Group; DXA, Dual-Photon Absorptiometry; FFQ, Food Frequency Questionnaire; HBM, Health Belief Model; HT, Hormone Therapy; IG, Intervention Group; OHBS, Osteoporosis Health Belief Scale; OKT, Osteoporosis Knowledge Test; OPBS, Osteoporosis Preventing Behaviors Survey; OSES, Osteoporoiss Self-Efficacy Scale; US, United States

2.6 Summary

Osteoporosis is a serious systematic, skeletal disorder characterized by a decrease in bone strength and density and hence, increased susceptibility to fractures. In New Zealand, one in three women over the age of 50 years will suffer from an osteoporosis-related fracture (Cornwall & Davey 2004). As the Asian population is the fastest growing ethnic group in New Zealand (New Zealand Statistics 2006b), it is likely that the prevalence of osteoporosis in Asian women will also increase dramatically. This will have a large negative impact on the New Zealand health system and health costs for osteoporosis-related fractures are expected to double by the year 2011 (Cooper 1999).

Dietary calcium intake is the number one nutritional factor that affects bone mineral status and therefore, susceptibility to osteoporosis. This has been demonstrated in numerous clinical studies on prepubertal and adolescent girls (Bonjour et al. 1997; Cadogan et al. 1997; Dibba et al. 2000; French et al. 2000; Zhu et al. 2008) as well as postmenopausal women (Lau et al. 2002b; Meunier 1999; Moschonis & Manios 2006; Nordin 1997; Shea et al. 2002; Storm et al. 1998). Milk and milk products provide an excellent source of dietary calcium. Other sources include sardines, canned fish, soy, legumes and green leafy vegetables.

The recommended dietary intake for calcium is 1,000mg/day for women aged between 19 and 50 years. For those over the age of 50 years, a daily intake of 1,300mg of calcium is recommended (MOH 2006b). According to the 1997 NNS (Russell et al. 1999), the New Zealand mean dietary calcium intake within the female population was 735mg/day. Studies in India have also reported low dietary calcium intake in women, which was accompanied by a high intake of phytates from cereals and rice (Harinarayan et al. 2004 and 2007; Shatrugna et al. 2005). There have been no studies to date on dietary calcium intake within the South Asia women population in New Zealand. Therefore, one of the aims of the present study is to estimate dietary calcium intake in a sample of South Asian women living in Auckland, New Zealand. Because little is known about the dietary habits of South Asian women in New Zealand, a food diary is more likely to capture actual total energy and dietary calcium intake compared to a FFQ and 24 hour recall (Chinnock 2006; Koebnick et al. 2005; Margetts & Nelson 1997).

Other factors that affect an individual's susceptibility to osteoporosis include serum vitamin D levels (Dawson-Hughes et al. 1997; Di Daniele et al. 2004; Lee & Jiang 2008), which is largely determined by the amount of UV exposure, frequency and type of physical activity (Bassey 2000; Kelley 1998a, 1998b, 2001; Nelson et al. 1991; Pesonen et al. 2005), genetic predisposition (Babbar et al. 2006; Brown et al. 2005; Chumlea et al. 2002; Flynn 2003; Meena et al. 2007; Pulkkinen et al. 2004), hormonal or menopause status (Suresh & Naidu Dhananjaya 2006; Shatrugna et al. 2005), and other lifestyle factors, such as cigarette, alcohol and caffeine use.

Prevention of osteoporosis is critical as deterioration in bone mass can not be reversed. Some studies have found a greater level of osteoporosis knowledge to predict a higher dietary calcium intake (Blalock et al. 1996). On the other hand, a number of other studies have not reported this positive relationship (Chang 2006a; Terrio & Auld 2002; Martinez-Garcia 2004).

Studies on the level of osteoporosis knowledge have consistently found a lack of knowledge with women of all ages (Curry et al. 2002; Gerend et al. 2006; Ribeiro et al. 2000; Terrio & Auld 2002; Ungan & Tümer 2001; Wallace 2002; Wizenberg et al. 2003). Commonly misunderstood areas include dietary sources of calcium (Ungan & Tümer 2001), benefits of physical activity (Ribeiro et al. 2000), the benefits of HRT (Ribeiro et al. 2000; Terrio & Auld 2002; Williams et al. 2002) and other lifestyle risk factors, such as smoking and caffeine and alcohol consumption (Gerend et al. 2006; Ungan & Tümer 2001). Studies on osteoporosis knowledge in Asian women have generally found a good understanding of lifestyle risk factors, such as dietary calcium intake and regular exercise, but a poor understanding of genetic risk factors (Babbar et al. 2006; Carlsson & Johnson 2004; Saw et al. 2003). There have been no studies to date on osteoporosis knowledge in South Asian women in New Zealand. The present study attempts to measure level of osteoporosis knowledge using the OKT developed by Kim et al. (1991a) in a sample of South Asian women, living in Auckland, New Zealand.

One reason why knowledge does not always predict behaviour is the strong influence of internal health beliefs. The HBM was first developed in the 1950s by Rosenstock (1960) and has been used successfully in a number of health-related trials. The model proposes that behaviour of disease prevention is determined by perception of seriousness of the disease and susceptibility of developing the disease as well as perceived benefits and barriers to taking action.

Whilst some studies have found perceived susceptibility to osteoporosis to predict a higher dietary calcium intake (Wallace 2002), others have found contradicting results (Chang 2006b; Gerend et al. 2006; Schmiege et al. 2007; Werner et al. 2003). Evidence of the direct relationship between perceived seriousness of the disease and dietary calcium intake has also been conflicting (Chang 2006a; Wallace 2002).

Perceived benefits of consuming a diet rich in calcium has been strongly linked to actual dietary calcium intakes (Blalock et al. 1996; Gulliver & Horwath 2001a) and may also be related to self-efficacy (Schmiege et al. 2007) and perceived barriers to calcium intake (Schmiege et al. 2007). Barriers to milk and milk product consumption may be a misconception regarding the nutritional value of milk and milk products (Gulliver & Horwath 2001a; von Hurst & Wham 2007; Wham & Worsley 2003), perceived value for money (Wham & Worsely 2003) and inconvenience (Blalock et al. 1996),

In the present study, perception of susceptibility and seriousness of osteoporosis and perceived benefits and barriers to dietary calcium intake will be measured in a sample of South Asian women living in Auckland, New Zealand. The tool used will be the OHBS developed and validated by Kim et al. (1991b). The relationship between osteoporosis knowledge, health beliefs and dietary calcium intake in these South Asian will be examined. Secondly, the relationship between subscales of the OKT and OHBS as well as participants' demographic characteristics will be determined.

This study will provide a greater understanding of dietary habits of South Asian women living in Auckland, New Zealand, including total energy and dietary calcium intake. It will also provide information on the level of osteoporosis knowledge and health beliefs that can be used for future osteoporosis prevention interventions.

CHAPTER 3: METHODOLOGY

3.1 Study Design

The present study used a cross-sectional study design. This study was a sub-study of the Surya Study. The main aim of the Surya Study was to investigate metabolic syndrome, vitamin D and bone status in South Asian women living in Auckland, New Zealand: a randomized, controlled vitamin D intervention, which consisted of two phases. The aims of phase one were to describe the health and lifestyle of women of South Asian origin living in Auckland; to investigate the relationship between nutrition and lifestyle, and health and disease; and to identify 100 women with measurable insulin resistance to participate in a vitamin D intervention trial (phase two). Phase two was a randomized controlled trial with vitamin D supplementation to investigate the effectiveness of a given dose on serum vitamin D status and the effect of improved vitamin D status on insulin resistance and bone markers. A total number of 250 women, ≥20 years, were recruited. The present study concerns itself in particular with the cross-sectional data that were collected from the 250 women at baseline. As there was a five month period of recruitment, there were a total of 102 women recruited for the study. This was before the recruitment cut-off date of 31st July 2007.

3.2 Participants

3.2.1 Recruitment of Participants

Participants were recruited through the distribution of posters and leaflets in a number of venues around Auckland, including General Medical Practices with a high proportion of South Asian patients, Auckland Indian Women's Club, Auckland Indian Senior Citizens Club and temples. Women were invited to participate in the study through advertisements in suburban and Auckland newspapers and in India media, such as television, radio and newspapers, including a short documentary on a channel popular with Indian viewers. A participant screening questionnaire (appendix 1), participant information sheet (appendix 2) and consent form (appendix 3) were mailed out to women who expressed interest in the study. Eligible participants were contacted via telephone to arrange an appointment for data collection. Recruitment began on the 21st of Februrary 2007 and ended 31st of July 2007.

3.2.2 Participant Selection

All participants were female and 20 years of age or above. Either the participant, both parents, or all grandparents who were born in India, Pakistan, Bangladesh or Sri Lanka – collectively called South Asia, were included in the study and was determined using a screening questionnaire (Appendix 1).

3.2.3 Participant Exclusion

Those who were currently pregnant or breastfeeding or planning pregnancy in the near future were excluded from the study. Those who had rheumatoid arthritis, major systemic illness, significant renal dysfunction, hypoparathyroidism, diabetes requiring medication or those who were using cholecalciferol (25 hydorxyvitamin D_3) supplements exceeding 1,000IU/day or any form of calcitriol (1,25 dihydroxyvitamin D_3) were also excluded from the study.

3.3 Ethical Approval and Considerations

The Surya Study was reviewed and approved by the Massey University Human Ethics committee: Southern A, Application 06/67. Professor John O'Neill, Chair, Massey University Human Ethics Committee: Southern A, telephone 06 350 5799 extension 8635, email: humanethicsoutha@massey.ac.nz. Confidentiality of participants was ensured by assigning identification numbers for each participant. No harm to participants was envisioned and any discomfort during measurement processes was minimized by the researchers. All participants read an information sheet (Appendix 2) and signed a consent form (Appendix 3) before any data was collected. All participants were informed that participation was optional and that they could withdraw from the study at any time.

3.4 Data Collection

Participants were informed by letter about the date, time and location of the testing session.

3.4.1 Demographics and Medical History

An interviewer based questionnaire was used to collect demographic information, medical history, family history, medication and supplement use, smoking status, alcohol use and menstrual status (Appendix 4). Alcohol consumption of less than one standard unit every two weeks was regarded as zero.

3.4.2 Anthropometric Measurements

Participants were asked to remove their shoes before measurements were made. Participants' weight was measured on electronic scales (Tanita THD-464, Japan) to within 100g. Height was measured by a trained anthropometrist using a calibrated wall mounted or portable stadiometer (Holtain Ltd, CRYMYCH DYFED, Britain) to within 100mm. Measurements were then used to calculate body mass index.

3.4.3 Questionnaires

Permission to use the OKT and the OHBS was granted by Professor Phyllis Gendler at the Grand State University. Although the OKT and OHBS had been previously validated amongst a Caucasian population (Kim et al. 1991a, 1991b), they have not been validated for South Asian women. This is an area for future research. Due to time constraints, pilot testing was not completed and is a major limitation for the present study.

A web-site was created for participants to complete the questionnaire on-line. Participants were given an information sheet with the website address, user name, password and their identification number (Appendix 5). Participants were asked to enter their family and first name, as well as their identification number before beginning the questionnaire. If participants did not have access to a computer with internet connection, they were invited to complete the questionnaire on-site. Participants were encouraged to complete the questionnaire within a couple of days of their testing session. The questionnaire contained a total of 75 items. Upon completion, participants submitted the questionnaire by clicking the 'submit' button. If there were any unanswered items, participants were asked to check back through the questionnaire to answer any items highlighted in red. This ensured completion of all submitted questionnaires.

Osteoporosis Knowledge Test

Knowledge about osteoporosis was measured using the OKT (Appendix 6) created and validated by Kim et al. (1991a). For the purpose of this study, the following subscales in the OKT were looked at:

- General knowledge (items 1-9);
- Food sources of calcium (items 17-21);
- Recommended intakes and supplementation of calcium (items 22-24).

Item six was modified from 'being a white women with fair skin' makes it more likely to get osteoporosis to 'being a women of South Asian origin'. Two additional items regarding the type of vitamin required for calcium absorption and the best source of this vitamin was added on to the end of the OKT (Von Hurst & Wham 2007). Answers were coded by assigning '1' for correct answers and '0' for incorrect answers. The total maximum score was 26.

Osteoporosis Health Belief Scale

Beliefs about Osteoporosis were measured using the OHBS, also created and previously validated by Kim et al. (1991b) (Appendix 7). For the purpose of this study, the following subscales in the OHBS were looked at:

- Perceived susceptibility (items 27-32);
- Perceived seriousness of the disease (items 33-38);
- Perceived benefits of dietary calcium intake in preventing osteoporosis (items 44-49);
- Perceived barriers to calcium intake (items 56-61);
- Health Motivation (items 62-67).

The OHBS used a 5-point likert scale from 'strongly agree' to 'strongly disagree'. Answers were coded and scored by assigning '1' for 'strongly disagree' answers and '5' for 'strongly agree' answers. Possible scores for each subscale ranged from 6 to 30 with a low score indicating a low perception and a high score indicating a high perception.

3.4.4 Dietary Assessment

Dietary information was collected using a four day food diary, including one weekend day (Appendix 8). Instructions on how to accurately complete the food diary were explained verbally in detail to all participants in addition to clearly written instructions in the food diary. Participants were instructed to predict portion sizes using either standard household measuring aids (e.g. measuring cups and spoons), natural measures (e.g. pieces, slices) or comparisons (e.g. deck of cards). A set of standard household measuring aids were provided if participants did not have any at home. Participants were encouraged to eat as normally as possible. A self-addressed envelope was provided for participants to return the completed food diary. All food diaries were checked for completion by two postgraduate nutrition students and an Indian dietitian to ensure portion sizes, recipes and food descriptions were all clearly described. The postgraduate students consulted with the dietitian to ensure the depth of information provided by the participants were consistent. Any incomplete or unclear information were rectified by contacting participants.

Average dietary calcium intake was assessed over four reported days using FoodWorks Professional Edition (version 4.00.1158, Xyris Software, Pty Ltd., Australia). The dietitian from India entered the data and the data was then checked by two postgraduate nutrition students. Nutrient analysis was performed on all the completed food diaries. The data in Foodworks were supplemented by recipes from Raina et al. (2001) and Thangman (1988) to include cultural dishes from South Asia and using data from Indian food composition tables (Gopalan et al. 1999). Average dietary calcium intakes were reported in mg/day as well as in relation to total energy.

All foods consumed were categorized into food groups (Table 11) and percentage of dietary calcium intake from each food group were calculated using the SPSS package version 14 (SPSS Inc., Chicago, IL, USA).

Table 11: Food Groups

Food Group	Examples of Food Items Included
Milk	Cow, milk powder, flavoured milk, milkshakes
Yoghurt	Plain, fruit flavoured, curd rice
Cheese	Blue vein, camembert, cheddar, cottage, cream, mozzarella, processed, spread, sauce, cheese scones
Ice cream and Cream	All ice creams, standard cream, dip made with cream, gulab jamun
Bread	All types of bread (white, wholemeal, wholegrain), rolls, buns, sweet buns, pita, tortilla, crumpet, sandwiches, chapatti, naan, puris, paratha
Cereals	Cornflakes, muesli, porridge, bran, rice bubbles, ragi porridge
Rice	White, brown, fried, sushi, rice cakes, dosa, tamarind rice, jeera rice, sweet rice, rice flakes
Noodles and Pasta	Egg noodles, rice noodles, instant, pasta salad, spaghetti, fettuccini, chow mein
Dark Green Vegetables	Silverbeet, broccoli, spinach
Other Vegetables	All other vegetables including mixes (coleslaw, salads, stir-fries)
Fruit	All fruits, canned, fresh, cooked and dried
Fish and Seafood	All fish (canned, fresh, dried, crumbed, battered), prawns, whitebait
Meats	All red meats (beef, lamb, veal, mutton), poultry (chicken, duck, turkey) and pork (bacon, sausage, sausage roll), mixed dishes (meat stir-fries, stew, beef lasagne), salami, meat pies, chicken nuggets
Eggs	Poached, boiled, scrambled, omelette
Legumes	All beans (green, kidney, mung, Mexican, mixed), tufu, soybean,

Table 11 continued: Food Groups

Food Groups	Examples of Food Items Included
	hummus, chickpeas, vada, gram (red, green, black), idli, kichidi
Nuts and Seeds	Almonds, cashew nuts, chestnut, walnuts, peanuts, hazelnuts, pistachio nuts, peanut butter, mixed nuts and seeds, pumpkin seeds, sunflower seeds, sesame seeds, fennel seed, cumin seed, mustard seed
Curry Dishes	Vegetable, legume, meat seafood and egg curries (milk-based, yoghurt-based, cream-based, coconut cream-based, tomato-based, dry)
Snack Foods and Confectionary	Cakes, muffins, slices, biscuits, crackers, pancakes, custard pudding, potato chips, muesli and cereal bars, chocolate, sweets
Non-Milk Based Beverages	All coffees, juices, soft-drinks and tea, soy-based (So Good, Vitasoy), cordial, energy drinks
Fats and Oils	Butter, margarine, Olivio, Olivani, canola, sunflower, vegetable, olive, soybean, flaxseed, ghee
Fast foods	McDonalds, KFC, Pizza Hut, Burger King
Others	Sauces (tomato, soy, chilli), vinegar, spices, salt, jams and other spreads (vegemite, marmite), chutney (apple, coconut, tomato, mint, coriander), salad dressings

Basal metabolic rate of participants were calculated using the Schofield equation (Schofield et al. 1985) to calculate total energy intake to basal metabolic rate ratio (TEI:BMR). Participants who have under-reported were identified by using the Goldberg cut-off score of 1.2 (Goldberg et al. 1991).

3.5 Statistical Analysis

Data was analyzed using the SPSS package version 14 (SPSS Inc., Chicago, IL, USA). All variables were tested for normality using the Kolmogorov-Smirnov and Shapiro-Wilk tests and homogeneity using the Levene test. If data was not normal, it was normalized by performing logarithmic transformations. All variables were described using the mean and standard deviation (SD) for parametric data or medians and 25 and 75 percentiles for non-parametric data. Geometric means and 95% confidence intervals were calculated for logarithmic transformed data. Frequencies and percentages were reported for categorical data. Pearson's correlation coefficient was calculated for parametric data and Spearman's correlation coefficient for non-parametric data between predictor and predicted variables. In addition, partial correlations were calculated between mean dietary calcium intake and osteoporosis knowledge and health beliefs to control for confounding variables, including age, marital status, family history, use of a dietary supplement use and total energy intake.

Multiple regression models using the stepwise variable selection method were used to predict the significance and level of contribution of each predictor variable (participant characteristics, osteoporosis knowledge and beliefs) on the predicted variable (dietary calcium intake in relation to total energy intake).

CHAPTER 4: RESULTS

4.1 Participant Characteristics and Demographic Data

Completed data were available for a total number of 102 women. The majority of women in the study were born in India (70.6%), married (85.3%), premenopausal (77.5%) and well-educated. Prevalence of family history of osteoporosis, personal diagnosis of osteoporosis and the use of some form of oral estrogen within this group of women were low. One participant (1.0%) had been diagnosed with osteoporosis and seven (6.86%) had a family history of osteoporosis. Thirty eight women (37.3%) used some form of dietary supplement. These included calcium, vitamin D, iron, multi-vitamins, vitamin C, vitamin B, evening primrose oil and omega 3 fatty acids (Figure 10). All participants were non-smokers and drinks per week were minimal with only nine participants (8.82%) reporting having one to five drinks per week and two (1.96%) reporting having more than five drinks per week. Participant characteristics and demographic information are summarised in Table 12.

Table 12: Characteristics of Study Participants (n=102)

	Mean	**SD**	**Frequency (percentage)**
Age (years)	41.6	9.91	
BMI (kg/m²)	25.5	4.55	
Country of Birth			
India			72 (70.6)
Pakistan			2 (1.96)
Sri Lanka			7 (6.86)
Fiji			8 (7.84)
Other			13 (12.7)
Years in New Zealand [1]	6.0	4.00, 10.0	
Years of Education [1]	16.0	14.0, 18.0	
Marital Status			
Married			87 (85.3)
Not Married			15 (14.7)
Menopausal Status			
Premenopausal			79 (77.5)
Postmenopausal			23 (22.5)

Table 12 continued: Characteristics of Study Participants (n=102)

	Mean	SD	Frequency (percentage)
Osteoporosis Diagnosis			
Yes			1 (1.0)
No			101 (99.0)
Family History of Osteoporosis			
Yes			7 (6.86)
No			95 (93.1)
Oral Estrogen Use			
HRT			2 (1.96)
Birth Control			1 (1.0)
None			99 (97.0)
Use of a Dietary Supplement			
Yes			38 (37.3)
No			64 (62.7)
Use of Calcium Supplement			
Yes			16 (15.7)
No			86 (84.3)
Use of Vitamin D Supplement			
Yes			5 (4.90)
No			97 (95.1)
Cigarettes per day [1]	0.0	0.0, 0.0	
Drinks per week [1]	0.0	0.0, 0.0	

[1] Non-normally distributed data are expressed as median (25, 75 percentiles)

BMI, Body Mass Index; HRT, Hormone Replacement Therapy; SD, Standard Deviation

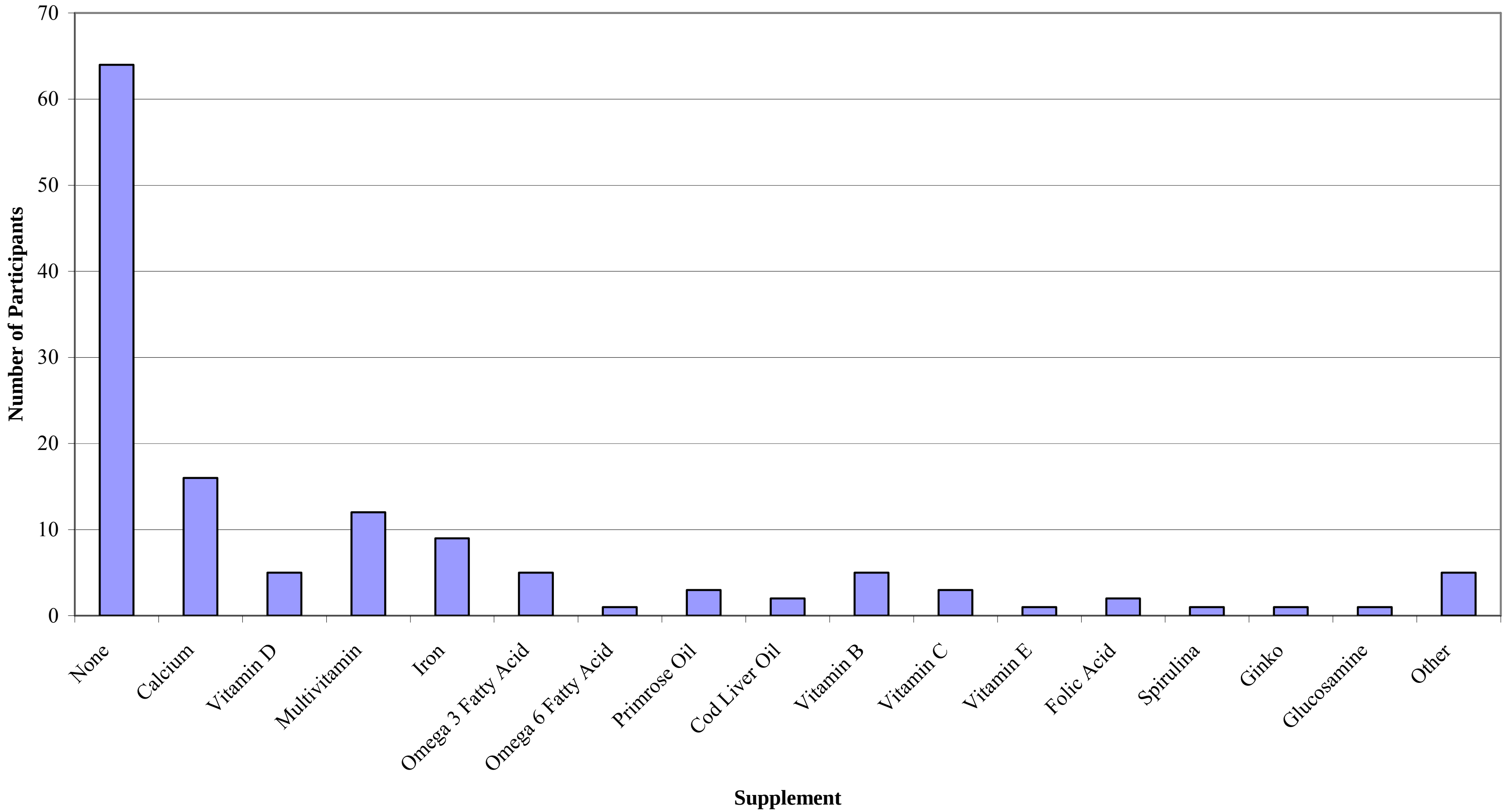

Figure 10: Supplement Use by Participants

4.2 Dietary Intake

Mean total energy, carbohydrate, protein, fat and calcium intake are presented in Table 13.

Table 13: Participant Dietary Intake (n=102)

	Mean	SD	MOH Recommendation[3]
Total Energy Intake (kJ/day)	6920	1331	
Total Carbohydrate Intake (g/day)	219	48.1	
Energy Contribution from Carbohydrates (%)	53.3	6.60	45-65
Total Protein Intake (g/day) [2]	59.6	56.5, 62.8	
Energy Contribution from Protein (%) [2]	14.8	14.2, 15.3	15-25
Total Fat Intake (g/day)	59.5	15.8	
Energy Contribution from Fat (%)	31.4	5.43	20-35
Total Calcium Intake (mg/day) [2]	685	630, 744	>1,000
Total Calcium Intake in relation to Total Energy Intake (mg/kJ) [1]	0.10	0.08, 0.12	

[1] Non-normally distributed data are expressed as median (25, 75 percentiles)

[2] Expressed as geometric mean (95% confidence interval)

[3] Nutrient Reference Values for Australia and New Zealand published by Ministry of Health (2006b)

SD, Standard Deviation

Mean contribution of carbohydrate (53.3±6.60%) and fat (31.4±5.4%) as a percentage of total daily energy intake were within the recommendations by Ministry of Health of 45-65% and 15-25% total energy intake, respectively (MOH 2006b). Contribution of protein to total daily energy intake was just below the recommendation of at least 15% of total energy intake at 14.8%. Mean dietary calcium intake in this sample of women was 685mg/day and did not meet the RDI of at least 1,000mg/day (MOH 2006b). Only 13 or 12.7% of participants consumed a mean dietary calcium intake >1,000mg/day. The main food sources of dietary calcium were milk (29.0%), curry dishes (14.9%), non-milk based beverages (10.2%), bread (8.09%), yoghurt (7.11%), snack foods and confectionary (3.60%) and cheese (3.47%) (Figure 11). It is important to keep in mind when interpreting these results that 49% of participants were found to be under-reporting their dietary intake. This was based on the TEI:BMR ratio (Schofield et al. 1985), using the Goldberg cut-off of <1.2 (Goldberg et al. 1991). This high percentage of under-reporting was not surprising as previous studies have demonstrated under-reporting to be a common issue, particularly in overweight and obese women (Bedard et al.

2004; Chinnock 2006; Marks et al. 2006; Rennie et al. 2007; Trabulsi & Schoeller 2001). Therefore, reports of dietary calcium intake are also likely to be under-estimated.

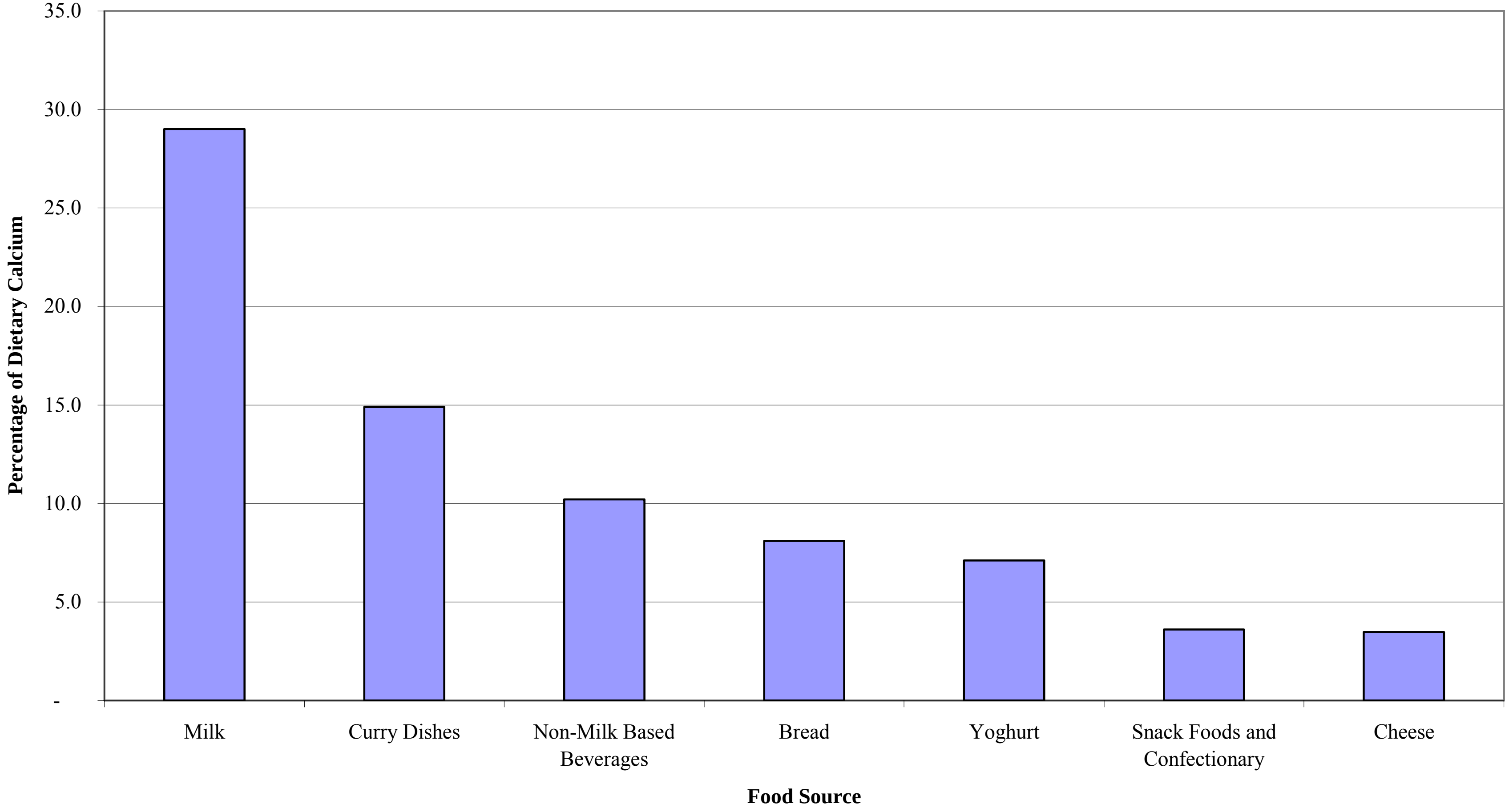

Figure 11: Major Food Sources of Dietary Calcium

4.3 Osteoporosis Knowledge

Results from the OKT developed by Kim et al. (1991a) produced a mean overall score of 15.1±4.14 (mean ± SD) out of a total maximum of 26 or 57.9%. Correct and incorrect responses to each question are presented in Table 14.

Table 14: Percentage of Correct and Incorrect Responses from the Osteoporosis Knowledge Test (n=102)

	Item	Correct	Incorrect
	Risk factors of Osteoporosis		
	Do the following make it more or less likely that someone will develop osteoporosis? [1]		
1	Having a diet low in milk products:	70.6	29.4
	More likely; less likely; neutral		
2	Being menopausal:	52.0	48.0
	More likely; less likely; neutral		
3	Having big bones:	20.6	79.4
	More likely; less likely; neutral		
4	Having a diet high in green leafy vegetables:	73.5	26.5
	More likely; less likely; neutral		
5	Having a mother or grandmother who had osteoporosis:	59.8	40.2
	More likely; less likely; neutral		
6	Being a women of South Asian origin:	32.4	67.6
	More likely; less likely; neutral		
7	Having ovaries surgically removed:	23.5	76.5
	More likely; less likely; neutral		
8	Taking cortisone for long time:	40.2	59.8
	More likely; less likely; neutral		
9	Exercising on a regular basis:	80.4	19.6
	More likely; less likely; neutral		
	Exercise Knowledge		
	Multiple Choice [1]		
10	The best type of exercise to reduce a person's chance of developing osteoporosis:	57.8	42.2
	Swimming; walking briskly; doing kitchen chores		
11	The best type of exercise to reduce a person's chance of developing osteoporosis:	33.3	66.7
	Bicycling; yoga; housecleaning		
12	Frequency of exercise to strengthen bones:	88.2	11.8
	1 day a week; 2 days a week; 3 or more days a week		
13	Least amount of time to exercise to strengthen bones:	74.5	25.5

Table 14 continued: Percentage of Correct and Incorrect Responses from the Osteoporosis Knowledge Test (n=102)

	Item	Correct	Incorrect
	< 15 minutes; 20 -30 minutes; > 45 minutes		
14	During exercise to build strong bones, breathing should be: *Just a little faster; so fast that talking is not possible; much faster, but talking is possible*	40.2	59.8
15	The best type of exercise to reduce a person's chance of developing osteoporosis: *Jogging or running; golfing using golf cart; gardening*	70.6	29.4
16	The best type of exercise to reduce a person's chance of developing osteoporosis: *Bowling; laundry; aerobic dancing*	93.1	6.9
	Calcium Knowledge		
	Multiple Choice [1]		
17	Good source of calcium: *Apple; cheese; cucumber*	82.4	17.6
18	Good source of calcium: *Watermelon; corn; canned sardines*	46.1	53.9
19	Good source of calcium: *Chicken; broccoli; grapes*	48.0	52.0
20	Good source of calcium: *Yoghurt; strawberries; cabbage*	94.1	5.9
21	Good source of calcium: *Ice cream; grapefruit; radishes*	57.8	42.2
22	Recommended amount of calcium intake for an adult: *100-300mg/day; 400-600mg/day; >800mg/day*	18.6	81.4
23	How much milk should an adult drink to meet the daily recommendation: *½ glass; 1 glass; 2 or more glasses*	40.2	59.8
24	A person should take calcium supplementation if: *Skips breakfast; does not get enough calcium from diet; over 45 years old*	79.4	20.6
	Vitamin D Knowledge		
	Multiple Choice [1]		
25	Vitamin required for calcium absorption: *A; C; D*	60.8	39.2
26	The best source of vitamin required for calcium absorption: *Oranges; cheese; sunlight*	67.6	32.4
	Total Mean Osteoporosis Knowledge Score	**57.9% or 15.1** [2]	

[1] Correct answers are underlined

[2] Total maximum Osteoporosis Knowledge Score was 26

4.3.1 Knowledge of Risk Factors of Osteoporosis

Participant's knowledge of risk factors of osteoporosis was assessed with items 1-9 of the OKT (Kim et al. 1991a). Most participants knew that a diet low in milk products increases the chances of getting osteoporosis (item one) with 70.6% correct responses. In contrast, the lowest scoring items in this section of the OKT were items three (having big bones decreases your chances of getting osteoporosis), six (being a women of South Asian origin increases your chances of getting osteoporosis) and seven (having ovaries surgically removed increases your chances of getting osteoporosis) with 20.6%, 32.4% and 23.5% correct responses, respectively. About half of all participants (52.0%) knew that being menopausal increases your chances of getting osteoporosis (item two). In addition to the importance of milk products in the diet for reducing the risk of osteoporosis, most participants (73.5%) also knew that a diet high in green leafy vegetables can help reduce the chances of getting osteoporosis (item four). However, knowledge of family history as a risk factor for osteoporosis was less well understood with 59.8% correct responses (item five). Likewise, knowledge of the risk of taking cortisone for a long time (item eight) as a risk factor for osteoporosis was reasonably low with 40.2% correct responses. On the other hand, the majority of participants (80.4%) knew that regular exercise can help decrease the chances of getting osteoporosis (item nine).

4.3.2 Knowledge of Exercise and Osteoporosis

Knowledge of the benefits of exercise as well as the type of exercise for the prevention of osteoporosis was assessed with items 10-16 in the OKT (Kim et al. 1991a). Although knowledge of exercise and osteoporosis was not a main objective in the present study, results from these items in the OKT will be briefly reported but will not be discussed further.

Items assessing knowledge of the type of exercise for the prevention of osteoporosis produced a mixed response. Although most knew that jogging or running (70.6%) and aerobic dancing (93.1%) were the best types of exercise to reduce a person's chances of developing osteoporosis, only 57.8% and 33.3% knew that walking briskly and bicycling were other effective types of weight-bearing exercise, respectively. Most women knew that three or more days a week of exercise is required to strengthen bones (88.2%) and each session should be 20-30 minutes duration (74.5%). On the other hand, knowledge of the intensity of exercise was less well understood with less than half of participants (40.2%) responding correctly to item 14, that breathing should be 'much faster, but talking is possible' during exercise.

4.3.3 Knowledge of Calcium and Osteoporosis

Knowledge of the benefits of dietary calcium for the prevention of osteoporosis was assessed with items 17-24 in the OKT (Kim et al. 1991a). The lowest scoring item in the entire questionnaire was item number 22 regarding the recommended amount of calcium intake for adults; only 18.6% of participants responded correctly. In addition, 59.8% of women responded incorrectly to item 23 regarding the number of servings of milk required each day to meet the daily recommendation. Most participants knew that yoghurt (94.1%) and cheese (82.4%) are good dietary sources of calcium, whereas ice cream (57.8%), canned sardines (46.1%) and broccoli (48.0%) were less well-know dietary sources. Finally, most participants (79.4%) thought that a person should be taking calcium supplements if they were not getting enough calcium in their diet (item 24).

4.4 Osteoporosis Health Beliefs

Participant's perception of susceptibility and seriousness of osteoporosis, dietary calcium benefits and barriers and health motivation was assessed with the OHBS (Kim et al. 1991b); responses are presented in Table 15. Although all statistical analysis were completed based on the 5-point likert scale scoring system as described in the 'Methodology' section, for practical reasons, responses to the OHBS will be reported with 'strongly agree' and 'agree' responses combined together as 'agree' and 'strongly disagree' and 'disagree' responses combined together as 'disagree'.

The Cronbach Alpha scores (α) for each subscale and total OHBS were: perceived susceptibility α=0.87; perceived seriousness α=0.78; benefits of dietary calcium intake α=0.75; barriers to dietary calcium intake α=0.79; health motivation α=0.69; total OHBS α=0.76. Inter-item correlation scores showed good correlation between items within each subscale. However, a number of inter-item correlation scores for the entire OHBS were below 0.3. Therefore, total OHBS scores were not used for analysis.

Table 15: Percentage of Disagree, Neutral and Agree Responses from the Osteoporosis Health Belief Scale (n=102)

	Item	Disagree	Neutral	Agree
	Perceived Susceptibility to Osteoporosis			
27	Your chances of getting osteoporosis are high	24.5	41.2	34.3
28	Because of your body build, you are more likely to develop osteoporosis	34.3	40.2	25.5
29	It is extremely likely that you will get osteoporosis	45.1	37.3	17.6
30	There is a good chance that you will get osteoporosis	32.4	38.2	29.4
31	You are more likely than the average person to get osteoporosis	42.2	34.3	23.5
32	Your family history makes it more likely that you will get osteoporosis	55.9	24.5	19.6
	Perceived Seriousness of Osteoporosis			
33	The thought of having osteoporosis scares you	18.6	14.7	66.7
34	If you had osteoporosis you would be crippled	39.2	28.4	32.4
35	Your feelings about yourself would change if you got osteoporosis	32.4	20.6	47.1
36	It would be very costly if you got osteoporosis	12.7	28.4	58.8
37	When you think about osteoporosis you get depressed	34.3	38.2	27.5
38	It would be very serious if you got osteoporosis	22.5	27.5	50.0
	Perceived Benefits of Exercise			
39	Regular exercise prevents problems that would happen from osteoporosis	2.0	9.8	88.2
40	Regular exercise helps build strong bones	2.0	6.9	91.2
41	Exercising to prevent osteoporosis also improves the way your body looks	2.9	4.9	92.2
42	Regular exercise cuts down the chances of broken bones	10.8	20.6	68.6

Table 15 continued: Percentage of Disagree, Neutral and Agree Responses from the Osteoporosis Health Belief Scale (n=102)

	Item	Disagree	Neutral	Agree
43	You feel good about yourself when you exercise to prevent osteoporosis	2.9	8.8	88.2
	Perceived Benefits of Calcium Intake			
44	Taking in enough calcium prevents problems from osteoporosis	2.9	10.8	86.3
45	You have lots to gain from taking in enough calcium to prevent osteoporosis	2.0	13.7	84.3
46	Taking in enough calcium prevents painful osteoporosis	2.9	21.6	75.5
47	You would not worry as much about osteoporosis if you took in enough calcium	11.8	27.5	60.8
48	Taking in enough calcium cuts down on your chances of broken bones	3.9	12.7	83.3
49	You feel good about yourself when you take in enough calcium to prevent osteoporosis	2.9	19.6	77.5
	Perceived Barriers to Exercise			
50	You feel like you are not strong enough to exercise regularly	68.6	13.7	17.6
51	You have no place where you can exercise	84.3	6.9	8.8
52	Your spouse or family discourages you from exercising	90.2	6.9	2.9
53	Exercising regularly would mean starting a new habit which is hard for you to do	52.9	17.6	29.4
54	Exercising regularly makes you uncomfortable	81.4	10.8	7.8
55	Exercising regularly upsets your every day routine	67.6	14.7	17.6
	Perceived Barriers to Calcium Intake			
56	Calcium rich foods cost too much	73.5	15.7	10.8
57	Calcium rich foods do not agree with you	72.5	15.7	11.8
58	You do not like calcium rich foods	80.4	13.7	5.9

Table 15 continued: Percentage of Disagree, Neutral and Agree Responses from the Osteoporosis Health Belief Scale (n=102)

	Item	Disagree	Neutral	Agree
59	Eating calcium rich foods means changing your diet which is hard to do	71.6	19.6	8.8
60	In order to eat more calcium rich foods you have to give up other foods that you like	68.6	14.7	16.7
61	Calcium rich foods have too much cholesterol	48.0	36.3	15.7
	Health Motivation			
62	You eat a well-balanced diet	18.6	39.2	42.2
63	You look for new information related to health	2.9	13.7	83.3
64	Keeping healthy is very important for you	2.9	2.0	95.1
65	You try to discover health problems early	5.9	18.6	75.5
66	You have a regular health check-up even when you are not sick	40.2	25.5	34.3
67	You follow recommendations to keep you healthy	4.9	24.5	70.6

4.4.1 Perceived Susceptibility to Osteoporosis

Overall, participants had a low perception of susceptibility to osteoporosis as most women (>65%) responded 'strongly disagree', 'disagree' or 'neutral' to the perceived susceptibility items (items 27-32). For example, only 17.6%, 29.4% and 34.3% of participants agreed with the statements 'it is extremely likely that you will get osteoporosis' (item 29), 'there is a good chance that you will get osteoporosis' (item 30) and 'your chances of getting osteoporosis are high' (item 27), respectively. Moreover, only 19.6% of participants agreed that because of their family history, they are more likely to get osteoporosis (item 32). The mean score for perceived susceptibility was 17.0±4.45 with a score of six indicating a low perceived susceptibility to osteoporosis and a score of 30 indicating a high perception of susceptibility.

4.4.2 Perceived Seriousness of Osteoporosis

Participants generally perceived a medium perception of seriousness of osteoporosis (items 33-38). The mean perceived seriousness of osteoporosis score was 19.3±3.87 with a higher score indicating a high perception of seriousness (possible score range was 6-30). At least half of all participants agreed to items 33 ('the thought of having osteoporosis scares you'), 36 ('it would be very costly if you got osteoporosis) and 38 ('it would be very serious if you got osteoporosis'). On the other hand, only 27.5% agreed that getting osteoporosis would be depressing (item 37) and 32.4% agreed that osteoporosis is a crippling disease (item 34).

4.4.3 Perceived Benefits of Exercise

Although participants' perception of the benefits of exercise was not an objective of the present study, responses to items 39-43 will be briefly reported since it is part of the whole OHBS questionnaire, but will not be discussed any further. Based on the OHBS, participants believed that regular physical activity can help prevent the onset of osteoporosis. The median score was 20.0 (95% confidence intervals 19.7, 20.8) out of a possible maximum of 30. At least 88% of participants agreed with all items in this subscale, with the exception of item 42 – 'regular exercise cuts down the chances of broken bones' with 68.6% 'agree' responses. However, 88.2% agreed with both statements, 'regular exercise prevents problems that would happen from osteoporosis' and 'you feel good about yourself when you exercise to prevent osteoporosis'. Similarly, 91.2% and 92.2% of participants agreed that 'regular exercise helps build strong bones' and 'exercising to prevent osteoporosis also improves the way your body looks', respectively. Therefore, these South Asian women held strong beliefs that regular exercise can help build strong bones and hence, prevent osteoporosis and complications associated with the disease.

4.4.4 Perceived Benefits of Dietary Calcium Intake

Overall, participants believed that a high dietary calcium intake would be beneficial for the prevention of osteoporosis (items 44-49). The median score of perceived benefits of dietary calcium intake was 23.5 (95% confidence intervals 22.7, 23.8) with a higher score indicating a high perception of benefits (possible score range was 6-30). More than 60% of all participants agreed with all statements in this subscale. For example, 86.3% believed that 'taking in enough calcium prevents problems from osteoporosis' (item 44), 84.3% agreed that they 'have lots to gain from taking in enough calcium to prevent osteoporosis (item 45) and 83.3% believed that 'taking in enough calcium cuts down on your chances of broken bones' (item 48).

4.4.5 Perceived Barriers to Exercise

Although assessment of perceived barriers to exercise was not an outcome of the present study, responses to this subscale in the OHBS will be reported but will not be discussed further. Based on the responses to items 50-55, participants did not perceive many barriers to exercise with a mean score of 13.1±4.03 out of a possible maximum of 30, with a higher score indicating a perception of greater barriers. A place to exercise (item 51), family or spouse support (item 52) and feeling uncomfortable (item 54) were not barriers to exercise for this sample of South Asian women. On the other hand, not feeling strong enough (item 50) and introducing exercise as a new habit that would upset participants' daily routine (items 53 and 55) were more likely to be perceived barriers to regular exercise with 17.6%, 29.4% and 17.6% 'agree' responses, respectively.

4.4.6 Perceived Barriers to Dietary Calcium Intake

Participants generally perceived low barriers to calcium intake as a high percentage of participants ‘disagreed’ and ‘strongly disagreed’ with items 56-61. The mean perceived barriers to dietary calcium intake score was 13.4±3.77 with a higher score indicating a high perception of barriers (possible score range was 6-30). For example, 80.4% of participants disagreed with the statement ‘you do not like calcium rich foods’ (item 58) and 73.5% of participants disagreed with item 56, which stated ‘calcium rich foods cost too much’. Similarly, 72.5% disagreed with ‘calcium rich foods do not agree with you’ (item 57) and 71.6% disagreed with item 59, which stated ‘eating calcium rich foods means changing your diet which is hard to do’. In contrast, only 48% of participants disagreed with ‘calcium rich foods have too much cholesterol’ (item 61), while 36.3% had a neutral opinion and 15.7% agreed.

4.4.7 Health Motivation

Participants reported a very high health motivation based on the responses from items 62-67. The mean health motivation subscale score was 22.4±3.04 with a higher score indicating a high health motivation (possible score range was 6-30). With the exception of two items in this section, at least 70% of participants ‘agreed’ or ‘strongly agreed’ with each item. For example, 83.3% agreed that they look for new health information, 95.1% agreed that keeping healthy is very important for them, 75.5% agreed that they tried to discover health problems early on and 70.6% believed that they follow the recommendations to keep healthy. On the other hand, only 34.4% agreed that they have regular check-ups even when they are not sick (item 66) and 42.2% believed that they eat a well-balanced diet (item 62).

4.5 Relationships between Demographic Characteristics, Dietary Calcium Intake, Osteoporosis Knowledge and Osteoporosis Health Beliefs

Correlation coefficients between demographic characteristics, dietary calcium intake, osteoporosis knowledge and osteoporosis health beliefs are presented in Table 16.

Table 16: Correlation Coefficients (R) Between Demographic Characteristics, Dietary Calcium Intake, Osteoporosis Knowledge and Osteoporosis Health Beliefs (n=102)

	Dietary Calcium Intake (mg/day)	Total OKT score	Perceived Susceptibility to Osteoporosis	Perceived Seriousness of Osteoporosis	Perceived Benefit of Calcium Intake	Perceived Barriers to Calcium Intake	Health Motivation
Age (years)	0.15 [1]	0.08 [1]	0.08	-0.12	-0.11	0.03	0.25*
BMI (kg/m²)	0.04 [1]	-0.09 [1]	0.10	0.02	-0.08	0.02	0.04
Years in New Zealand	0.18	0.19	-0.02	-0.02	-0.08	-0.08	0.03
Years of Education	-0.17	0.15	0.07	-0.09	0.11	-0.12	0.09
Marital Status	-0.16 [1]	-0.02 [1]	0.10	0.08	-0.04	0.20*	-0.14
Menopausal Status	0.10 [1]	0.04 [1]	0.09	-0.15	-0.07	0.09	0.05
Family History of Osteoporosis	0.03 [1]	0.21* [1]	0.31**	-0.23*	0.10	-0.07	0.02
Use of a Dietary Supplement	0.28** [1]	-0.06 [1]	0.06	-0.15	0.00	-0.27**	0.28**
Use of Calcium Supplement	0.13 [1]	-0.14 [1]	0.17	-0.15	0.03	-0.20*	0.09
Use of Vitamin D Supplement	0.22* [1]	0.18 [1]	-0.17	-0.15	0.14	-0.20*	0.26**
Total OKT score	0.06 [1]		0.01	-0.04	0.15	-0.16	-0.15
Perceived Susceptibility to Osteoporosis	-0.11	0.01		0.17	-0.0	0.28**	-0.15
Perceived Seriousness of Osteoporosis	-0.06	-0.04	0.17		-0.01	0.19	-0.18
Perceived Benefit of Calcium Intake	0.09	0.15	-0.04	-0.01		-0.27**	0.09
Perceived Barriers to Calcium Intake	-0.32**	-0.16	0.28**	0.19	-0.22**		-0.18
Health Motivation	0.30**	-0.15	-0.15	-0.18	0.09	-0.18	

Spearman's Correlation Coefficients were calculated for non-normally distributed data and ordinal data.

[1] Pearson's Correlation Coefficient were calculated for normally distributed data and categorical data with no more than two categories. Logarithm of dietary calcium intake was used for calculations

* Correlation is significant at the $P<0.05$ level (2-tailed)

** Correlation is significant at the $P<0.01$ level (2-tailed)

BMI, Body Mass Index; OKT, Osteoporosis Knowledge Test

Correlation analysis revealed a few significant correlations between osteoporosis knowledge and health beliefs and demographic characteristics. For example, age was found to be significantly correlated with health motivation (R=0.25; P=0.01). Marital status was significantly correlated with perceived barriers to calcium intake (R=0.20; P=0.05). Having a family history of osteoporosis was significantly correlated with a number of measures, including total OKT score (R=0.21; P=0.03), perceived susceptibility to osteoporosis (R=0.31; P<0.01) and perceived seriousness of osteoporosis (R=-0.23; P=0.02). No other significant correlations were found with any other demographic data, such as BMI, years in New Zealand, years of education or menopausal status.

The use of dietary supplements, including calcium and vitamin D supplements, was found to significantly correlate with a number of variables. For example, the use of a calcium supplement was significantly negatively correlated with perceived barriers to calcium intake (R=-0.20; P=0.04). The use of a vitamin D supplement as well as the use of any dietary supplement was significantly correlated with mean dietary calcium intake (R=0.22; P=0.02 and R=0.28; P=0.01, respectively), perceived barriers to calcium intake (R=-0.20; P=0.04 and R=-0.27; P=0.01, respectively) as well as health motivation (R=0.26; P=0.01 and R=0.28; P<0.01, respectively). No other significant correlations were found with the use of a dietary supplement.

The main objective of the present study was to determine the relationship between osteoporosis knowledge and beliefs with dietary calcium intake. There was no evidence of such a relationship between osteoporosis knowledge and dietary calcium intake (R=0.06; P=0.54). Likewise, dietary calcium intake was not significantly correlated with perceived susceptibility to osteoporosis (R=-0.11; P=0.28), perceived seriousness of osteoporosis (R=-0.06; P=0.55) or perceived benefits of calcium intake (R=0.09; P=0.39). On the other hand, a significant inverse correlation was found between dietary calcium intake and perceived barriers to calcium intake (R=-0.32; P<0.01) as well as health motivation (R=0.30; P<0.01). Similar correlation coefficients were calculated for the relationships between dietary calcium intake and OKT and OHBS scores after controlling for potential confounding factors (age, marital status, family history of osteoporosis, use of a dietary supplement and total energy intake).

There were no significant relationships found between the OKT and the OHBS subscales. However, there were two significant correlations between subscales of the OHBS. Firstly, perceived susceptibility was significantly correlated with perceived barriers to calcium intake (R=0.28; P=0.01). Secondly, perceived barriers to calcium intake was significantly inversely correlated with perceived benefits of calcium intake (R=-0.22; P=0.01). No other significant correlations were found within the OHBS subscales. Similar correlation coefficients were calculated while controlling for possible confounding variables listed above.

4.6 Predictors of Dietary Calcium Intake

Variables entered and removed from the regression model are presented in Table 17. Using the stepwise method in a regression model, health motivation, perceived barriers to calcium intake and the use of a dietary supplement significantly predicted dietary calcium intake. Health motivation alone predicted 15.2% of the variance in dietary calcium intake. Health motivation combined with perceived barriers to calcium intake predicted 23.5% of the variance in dietary calcium intake. When the use of a dietary supplement was added to the model, all three variables predicted 27.0% variance of dietary calcium intake. All other variables were removed from the model.

Table 17: Stepwise Regression Model of Mean Dietary Calcium Intake in Relation to Total Energy Intake (n=102)

Model	Variables Entered	Variables Removed	Cumulative R^2	Partial Correlation	Significance (P)
1	Health Motivation		0.15		<0.001*
2	Health Motivation				
	Perceived Barriers to Calcium Intake		0.24		<0.001*
3	Health Motivation				
	Perceived Barriers to Calcium Intake				
	Use of a Dietary Supplement		0.27		<0.001*
		Years of Education		-0.15	0.13
		Years in New Zealand		0.11	0.26
		Perceived Benefits to Calcium Intake		-0.11	0.28
		Perceived Seriousness of Osteoporosis		0.11	0.28

Table 17 continued: Stepwise Regression Model of Mean Dietary Calcium Intake in Relation to Total Energy Intake (n=102)

Model	Variables Entered	Variables Removed	Cumulative R^2	Partial Correlation	Significance (P)
		Use of a Vitamin D Supplement		0.11	0.29
		BMI (kg/m²)		0.10	0.35
		Menopausal Status		0.06	0.54
		Marital Status		-0.04	0.67
		Family History of Osteoporosis		0.04	0.72
		Total OKT score		0.02	0.81
		Perceived Susceptibility to Osteoporosis		0.02	0.84
		Use of a Calcium Supplement		-0.01	0.90
		Age (years)		-0.01	0.92

BMI, Body Mass Index; OKT, Osteoporosis Knowledge Test

CHAPTER 5: DISCUSSION

The aim of the present study was to determine the relationship between dietary calcium intake and osteoporosis knowledge and beliefs in a sample of South Asian women living in Auckland, New Zealand. This is the first study to investigate dietary intakes, level of osteoporosis knowledge and osteoporosis health beliefs among such a population group in New Zealand.

5.1 Participant Characteristics

Most of the South Asian women included in this study were of Indian descent, recent immigrants, married, premenopausal, non-smokers and did not consume any alcohol. These latter characteristics differ to the New Zealand Asian population where prevalence of smoking in 2006 was 4.5% within the Asian female population (MOH 2007) and 52.9% of Asian women were non-drinkers ('had not drunk alcohol in the past 12 months') (MOH 2008). The prevalence of personal and family history of osteoporosis was low within this sample of women.

Compared to all the New Zealand population of women, these South Asian women were slightly older (mean age of 41.6 years vs. median age of 36.7 years) and well-educated (Statistics New Zealand 2006a, 2006b). A total of 13% of the total Auckland population possess an undergraduate degree or equivalent (Statistics New Zealand 2002), whereas half of these South Asian women had sixteen years of education, which is equivalent to an undergraduate degree. This was not surprising as the skilled migrant category law, which is the most common category of immigration, requires specialized skills and knowledge gained through certificates, diplomas, bachelor degrees or a post-graduate qualification (Immigration New Zealand 2005).

A lower BMI cut-off value of >23kg/m^2 and >25kg/m^2 for overweight and obese individuals, respectively has been suggested for Asian Indians as they have been found to exhibit a significantly higher fasting insulin and fasting glucose as well as a higher body fat percentage compared to Caucasians of similar age and BMI (Choo 2002; Deurenberg et al. 2002; Dudeja et al. 2001; Raji et al. 2001). Based on these recommendations, the mean BMI of the South Asian women in this study (25.5kg/m^2)

would classify them as obese. This was higher compared to the New Zealand Asian women population (median of 23.5kg/m²) (MOH 2008).

Compared to all the New Zealand female population in the 1997 NNS (Russell et al. 1999), a lower percentage of South Asian women reported using a dietary supplement (37.3% vs. 59.0%). However, more South Asian women reported using a calcium supplement compared to the New Zealand female population (15.7% vs. 4.0%). There were no reports of vitamin D supplement use as a separate category in the 1997 NNS. Rather, use of fat soluble vitamins and ß-carotene supplements were categorized together; 2.0% of New Zealand women reported using a supplement in this category compared to 4.9% in the current study who reported using a vitamin D supplement. The reason why more South Asian women reported using a calcium and vitamin D supplement compared to the New Zealand female population is unknown and could be an area for further research.

5.2 Dietary Intake

5.2.1 Total Energy Intake

Keeping in mind that 49% of participants under-reported their dietary intakes, the reported mean total energy intake per day was low in this sample of women compared to the results for all New Zealand women in the 1997 NNS (6920±1331kJ/day vs. 7969±81.4kJ/day) (Russell et al. 1999). No other studies to-date have measured dietary intakes in Asian women in New Zealand. Shah et al. (2005) also reported a higher mean energy intake compared to the current study of 7294±2312kJ/day. However, Shah et al.'s (2005) sample of Indian immigrants living in the US included both males and females; hence, a higher mean energy intake compared to this sample of women was expected. Under-reporting is a common phenomenon in all dietary assessment methods and may be due to a number of reasons, such as inconvenience of keeping a food diary (and not recording all foods and beverages consumed) as well as social desirability or observation bias. In addition, women and overweight or obese individuals are more likely to under-report their dietary intakes (Bedard et al. 2004; Chinnock 2006; Marks et al. 2006; Rennie et al. 2007). Moreover, the accuracy of reporting portion sizes in these women is unknown. Therefore, actual total energy intake among this sample of South Asian women was probably higher than reported. To date, no other studies in New

Zealand have investigated dietary intake among the South Asian population and the reasons for under-reporting are not known.

5.2.2 Total Macronutrient Intake

Dietary Carbohydrate Intake

Dietary carbohydrate intake in this sample of South Asian women was higher compared to the women of the 1997 NNS for all New Zealand women (53.3% vs. 47.0% of total energy intake) (Russell et al. 1999). This falls within the higher range of the MOH recommendation (45-65% of total energy intake) (MOH 2006b). Other studies have also reported comparable dietary carbohydrate intakes in Indian women of 57.0% (Jonnalagadda & Diwan 2002) and 55.0% (Shah et al. 2005) of total energy intake. This probably reflects a higher intake of high carbohydrate foods, such as breads and rice. Although the food diaries suggested a high prevalence of vegetarianism, this can not be assumed soley based on a four day food diary. This could be an important area of research for future projects due to the implication of calcium-absorption inhibition associated with a high phytate and oxalate intake.

Dietary Protein Intake

Compared to the New Zealand female population (Russell et al. 1999), these South Asian women reported a lower dietary protein intake (14.8% vs. 16.0% of total energy intake). Since almost half of these South Asian women were recognized as under-reporters, it is possible that total dietary protein intake was higher than reported and similar to New Zealand women. However, other authors have reported mean dietary protein intakes of 12.6% (Jonnalagadda & Diwan 2002) and 12.0% (Shah et al. 2005) of total energy intake among Indian women. Therefore, dietary protein intake among the South Asian women population may fall below the recommended 15-25% of total energy intake (MOH 2006b). This could be partly explained by a high prevalence of vegetarianism among the Indian culture (Goswami et al. 2000; Harinarayan 2005). The prevalence of vegetarianism was not measured among this sample of South Asian women and could be explored in future research.

Dietary Fat Intake

Mean fat intake of these South Asian women was 31.4% of total energy intake, which was considerably lower compared to the 1997 NNS results for all New Zealand women (35.0% of total energy intake) (Russell et al. 1999). Other authors have observed similar dietary fat intakes in Indian women of 33.1% (Jonnalagadda & Diwan 2002) and 33.0% (Shah et al. 2005) of total energy intake. Therefore, South Asian women appear to consume less dietary fat compared to New Zealand women, but are within the recommended dietary guidelines (20-35% of total energy intake) (MOH 2006b).

5.2.3 Dietary Calcium Intake

In this study, the mean dietary calcium intake was below the RDI and only 13 (12.7%) participants consumed the recommended ≥1,000mg/day. Compared to the New Zealand population of women (Russell et al. 1999), this sample of South Asian women had a lower mean dietary calcium intake (685mg/day vs. 735mg/day) and was more likely to have an inadequate intake (87% vs. 25%). However, based on dietary calcium intake in relation to total energy intake, these South Asian women consumed 0.10mg/kJ compared to 0.09mg/kJ of dietary calcium in New Zealand women (Russell et al. 1999). Therefore, when dietary calcium intake is measured in relation with total energy intake, the two population groups were comparable. It should also be kept in mind that 49% of these women were identified as under-reporters of dietary intake; hence, their true dietary calcium intake is likely to be higher.

Other studies with Indian women immigrants living in the US have reported similar dietary calcium intakes of 0.087mg/kJ (Shah et al. 2005) and 0.11mg/kJ (Jonnalagadda & Diwan 2002). On the other hand, dietary calcium intake among women living in India have been found to be much lower at 0.03-0.04mg/kJ (Harinarayan et al. 2004, 2007; Shatrugna et al. 2005) and are commonly associated with a high fibre, oxalate and phytate intake from rice and cereals (Jonnalagadda & Diwan 2002). These are known inhibitors of dietary calcium absorption (Kass-Wolff 2004; New 1999; Nordin 1997) and hence, further enhance the problem of a low dietary calcium intake within the Indian population.

Milk, curry dishes (predominantly from milk and yoghurt-based dishes), non-milk based beverages, breads and yoghurt were the main food sources of dietary calcium among these South Asian women. Contribution of milk to dietary calcium intake was lower compared to the New Zealand female population (29.0% vs. 39.0%) (Russell et al. 1999). Soy-based beverages were included in the non-milk based beverages food group, which alone contributed to 2.4% of dietary calcium intake. Hence, increasing consumption of low-fat milk, yoghurt and soy-based beverages among South Asian women can help to increase dietary calcium intake for osteoporosis prevention. Dietary calcium intake from breads was higher compared to the 1997 NNS results for females (8.09% vs. 2.0%) (Russell et al. 1999). On the other hand, contribution of cheese to dietary calcium intake among these South Asian women was lower compared to the results from the 1997 NNS (3.47% vs. 11.0%) (Russell et al. 1999). Snack foods contributed a further 3.6% of dietary calcium and were predominantly from cakes, muffins and foods that contained chocolate, such as biscuits and muesli bars.

These studies suggest that South Asian women are consuming a diet low in calcium, which contribute to the development of osteoporosis in later life (Cadogan et al. 1997; Dawson-Hughes et al. 1997; Di Daniele et al. 2004; Moschonis & Manios 2006; Nowson et al. 1997). The main food sources of dietary calcium intake were milk, curry dishes, non-milk based beverages, such as soy milk, breads and yoghurt. Hence, it is crucial that dietary calcium intakes are increased in South Asian women through effective public health measures by promoting larger consumption of these food groups.

5.3 Osteoporosis Knowledge

The total mean score of the OKT in this sample of South Asian women was 57.9% or 15.1 out of a possible maximum score of 26. This mean score indicated that these South Asian women have a low level of osteoporosis knowledge, which may therefore predict a low dietary calcium intake (Blalock et al. 1996). However, as mentioned previously, the OKT has not been validated for the use by South Asian women living in New Zealand and this is a limitation of the study.

Other studies have also found a low level of osteoporosis knowledge in women (Ailinger et al. 2005; Doheny et al. 2007; Sedlak et al. 2000; Spencer 2007). For example, in von Hurst and Wham's (2007) and Carlsson and Johnson's (2004) studies, mean OKT scores were 63.0% and 50.0%, respectively. Estok et al.'s (2007) 12 month education intervention found a mean OKT score of 68.3% in a sample of postmenopausal women in the US.

In the current study, correlation analysis showed a significant relationship between family history and total OKT score (R=0.21; P=0.03). However, it should be kept in mind that only a small number of participants (seven) had a family history of osteoporosis. Hence, interpretation of these results should be made with caution and followed-up with future studies using greater sample sizes that includes more participants with a family history of osteoporosis.

By contrast, other studies that have included a higher percentage of women with a family history of osteoporosis have not found a significant relationship between family history and osteoporosis knowledge. For example, although 44.6%-64.0% of women in all three age groups (25-35 years; 36-49 years and >49 years) had a family history of osteoporosis in Hernandez-Rauda and Martinez-Garcia's study (2004), no significant relationship was found with osteoporosis knowledge. Likewise, both Chang (2006b) and Werner et al. (2003) found no difference in the level of osteoporosis knowledge between those women who had a first-degree relative with osteoporosis (FDR group) and those who did not (non-FDR group). The percentage of women in the FDR group in these studies were 46.9% and 38.1%, respectively. Hence, the significant relationship between osteoporosis knowledge and family history of osteoporosis found in the current study is not supported by other studies.

Although other researchers have found level of osteoporosis knowledge to be positively related to age (Terrio & Auld 2002; von Hurst & Wham 2007) as well as education (Hernandez-Rauda & Martinez-Garcia 2004; Ungan & Tümer 2001; von Hurst & Wham 2007; Vytrisalova et al. 2007), no significant relationship was found in the current study. It is possible that due to the homogenous group with the greatest percentage of these South Asian women being highly educated, no significant relationship between osteoporosis knowledge and level of education was seen.

In summary, the overall level of osteoporosis knowledge among these South Asian women was low, which may predict a low dietary calcium intake (Blalock et al. 1996). Those with a family history of osteoporosis were found to have a higher level of osteoporosis knowledge. Although this relationship sounds plausible it is not supported by previous research. In addition, although previous studies have found age and education to be related to osteoporosis knowledge, no significant relationship was found in the current study.

5.3.1 Knowledge of Risk Factors of Osteoporosis

Osteoporosis risk factors includes both genetic and lifestyle risk factors. Within this sample of South Asian women, 70.6% and 73.5% knew that a diet high in milk products (item one) and green leafy vegetables (item four) helps to prevent osteoporosis, respectively. Comparatively, von Hurst and Wham (2007) reported at least 87.0% and 70.2% correct responses to each item within their sample of New Zealand women, respectively.

Knowledge of the importance of regular exercise for the prevention of osteoporosis was good among this sample of South Asian women with 80.4% correct responses to item nine (exercising on a regular basis makes it less likely for a person to get osteoporosis). Other studies have also demonstrated this high level of knowledge with at least 89.3% correct responses (von Hurst & Wham 2007; Ziccardi et al. 2004).

Although knowledge regarding the importance of calcium rich food sources and regular exercise was high among this group of South Asian women, knowledge of genetic risk factors of osteoporosis were less convincing, including bone size (item three), having a family history of osteoporosis (item five) and being a women of South Asian origin (item six).

Comparative to the present study, Ziccardi et al. (2004) and von Hurst and Wham (2007) both found that at least 70% of participants did not recognize bone size as a risk factor of osteoporosis. Enhancing awareness of this risk factor is particularly important for Asian women as they are genetically determined to have a smaller frame and hip axis (Choo 2002; Deurenberg et al. 2002; Pulkkinen et al. 2004).

In the present study, there was a lack of awareness of family history being a risk factor of osteoporosis. Likewise, Saw et al. (2003) found only 30.5% of participants to recognize this risk factor. On the contrary, both Ziccardi et al. (2004) and von Hurst and

Wham (2007) found at least 79% of women in their studies to recognize family history as a risk factor of osteoporosis. In addition, Carlsson and Johnson (2004) reported 73.0% of participants in their study to recognize this risk factor of osteoporosis. This greater level of knowledge may be explained by a higher percentage of women in Carlsson and Johnson's study (2004) to report having a family history of osteoporosis compared to the current study (15% vs. 6.9%).

The current study found 32.4% of women were aware that being a woman of South Asian origin increases the chances of getting osteoporosis (item six). In accordance, von Hurst and Wham (2007) found no more than 26% of women in their study to recognize ethnicity as a risk factor. Both Ziccardi et al. (2004) and Carlsson and Johnson (2004) found ~50% of participants identified ethnic background as a risk factor. Hence, knowledge of ethnic background as a risk factor of osteoporosis seems to be an area that requires strengthening.

Among these South Asian women, knowledge regarding osteoporosis susceptibility associated with estrogen deficiency (i.e. menopausal status and having ovarian surgery) was lacking. Similarly, although at least 76% of women in von Hurst and Wham's study (2007) and 83.7% first year nursing students in Ziccardi et al.'s study (2004) knew the risks associated with menopause, no more than 52.2% and 41.9% of these women, respectively, realized that having ovarian surgery also increases the risk of osteoporosis.

The risk of 'taking cortisone for a long time' for bone health was inadequately recognized as a risk factor for osteoporosis by these South Asian women. Von Hurst and Wham (2007) also found a relatively low knowledge with 46.5%-66.8% correct responses across the three age groups. In Ziccardi et al.'s study (2004), most final year nursing students responded correctly to this item (77.4%), whereas first year students were less confident with this question (41.9% correct responses). This indicates that osteoporosis education may increase awareness of the risks associated with taking certain medications over a long period of time. This in turn may motivate those women at risk to seek professional advice and treatment for osteoporosis prevention.

Both genetic and lifestyle risk factors contribute to the development of osteoporosis. Although knowledge of the importance of a diet rich in calcium and exercise for the prevention of osteoporosis was good among these South Asian women, knowledge of genetic risk factors were lacking. Nonetheless, mean dietary calcium intake was still below the RDI and this suggests knowledge alone does not necessarily result in appropriate dietary behaviour.

5.3.2 Knowledge of Calcium and Osteoporosis

It is important for women to be able to identify dietary sources of calcium in order to consume a diet rich in calcium. Within this sample of South Asian women, most could identify dairy sources of dietary calcium, particularly yoghurt (94.1%) and cheese (82.4%) whereas other non-dairy food sources were less well-known, such as broccoli (48.0%) and canned sardines (46.1%). It is interesting that only 57.8% correctly identified ice cream as a source of dietary calcium. It is possible that these women perceived grapefruit and radishes as 'healthier' foods compared to ice cream and hence, chose these as their response to this item.

Von Hurst and Wham (2007) and Ziccardi et al. (2004) both found that most women (at least 84.0%) could identify dairy sources of dietary calcium. On the other hand, just over half of the women in von Hurst and Wham's study (2007) correctly identified broccoli as a good source of dietary calcium and no more than 67.0% of participants in Ziccardi et al.'s study (2004) correctly identified canned sardines as a source of dietary calcium. Therefore, increasing knowledge on non-dairy sources of dietary calcium may help to increase dietary calcium intake among women, particularly those who are lactose intolerant or dislike the taste of milk and milk products.

Among this sample of South Asian women, although 79.4% recognized that a person should be taking calcium supplements if they are not getting enough calcium through the diet, only 16 (15.7%) reported using a calcium supplement, despite a low mean dietary calcium intake. It is possible that these women did not realize that their dietary calcium intakes were inadequate as most participants (81.4%) could not correctly identify the RDI for dietary calcium. This has been a common finding in other studies (Ford et al. 2007; Giangregorio et al. 2007; Matthews et al. 2006; von Hurst & Wham 2007; Ziccardi et al. 2004). The majority of these women (59.8%) also did not realize that two or more glasses of milk a day would provide an adult with the recommended amount of dietary calcium. Therefore, it is possible that these South Asian women were unaware that their dietary calcium intakes were inadequate and hence, did not take any measures to increase it with calcium supplementation.

In summary, consistent with results from most other studies, knowledge among these South Asian women of dairy sources of dietary calcium (i.e. yoghurt and cheese) were good, whereas other non-dairy food sources (i.e. broccoli and canned sardines) were less convincing. Nevertheless, it is promising that most women in this study recognized dairy foods to be a good source of dietary calcium as they have greater bioavailability than non-dairy food sources (Kass-Wolff 2004; Nordin 1997). Knowledge regarding the RDI for dietary calcium and the number of servings of milk required each day to meet the RDI were lacking. Although most understood that calcium supplementation could compliment an inadequate dietary calcium intake, only a small number of participants reported using a calcium supplement. Therefore, efforts must be made to identify the reasons behind this lack of correlation between knowledge and behaviour and implement strategies to increase dietary calcium intake from foods.

5.4 Osteoporosis Health Beliefs

In addition to the present study, numerous other studies have established that a higher level of osteoporosis knowledge does not necessarily result in a higher dietary calcium intake (Hernandez-Rauda & Martinez-Garcia 2004; Sedlak et al. 2000; Wallace 2002). In fact, it is a complex interaction between knowledge and health beliefs as well as cultural and economic influences that determines an individual's action (Ali & Twibell 1995; Chan et al. 2007; Martin et al. 2004; Rosenstock 1960; Rozin 1996; Schmiege et al. 2007). The present study administered the OHBS to a sample of South Asian women living in Auckland, New Zealand. Although the OHBS had been validated amongst Caucasian women (Kim et al. 1991b), its validity and reliability for the use by South Asian women living in New Zealand is unknown. Therefore, these results must be intepereted with caution.

5.4.1 Perceived Susceptibility to Osteoporosis

In this study, participants perceived a low susceptibility to osteoporosis with a mean score of 17.0±4.45 out of a possible maximum of 30. Both Doheny et al. (2007) and Estok et al. (2007) reported similar perceived osteoporosis susceptibility scores of 17.1±5.31 and 17.0±5.35, respectively. These women were predominantly Caucasian and were older compared to these South Asian women (mean age of 56.6 years and 56.7 years, respectively vs. 41.6 years). Numerous other studies have also found women to perceive a low susceptibility to osteoporosis across a wide range of age groups and ethnic backgrounds (Carlsson & Johnson 2004; Cline & Worley 2006; Gerend et al. 2006; Matthews et al. 2006; von Hurst & Wham 2007; Williams et al. 2002). Hence, these studies demonstrate that women generally do not perceive themselves to be susceptible to osteoporosis.

It is possible that due to the lack of knowledge regarding genetic risk factors of osteoporosis among these South Asian women, they perceived a low susceptibility to osteoporosis. In addition, considering the low prevalence of personal and family history of osteoporosis, it was expected that these South Asian women did not perceive themselves to be at risk.

Another possible explanation for low perceived osteoporosis susceptibility could be the absence of any physical symptoms of osteoporosis. It has been postulated that most individuals do not perceive themselves to be at risk of a disease until they begin to experience physical symptoms (Laslett et al. 2004). As osteoporosis is a 'silent disease' and the prevalence of osteoporosis is much higher after menopause (Cornwall & Davey 2004; Shatrugna et al. 2005), it is not surprising that most of these South Asian women did not perceive they were at risk. Enhancing awareness of genetic risk factors of osteoporosis as well as focusing on the importance of prevention early on in life may help to increase perceived susceptibility of osteoporosis in women.

5.4.2 Perceived Seriousness of Osteoporosis

The mean perceived seriousness score was just above the median score of 15 out of a possible 30 (19.3 ± 3.87). This indicates that these South Asian women neither had a high or low perception of seriousness of osteoporosis. Both Estok et al. (2007) and Doheny et al. (2007) found similar perceived seriousness scores of 18.7 ± 4.04 and 18.7 ± 4.08, respectively. Cost (item 36) and being scared of getting osteoporosis (item 33) were believed to be the most serious consequences associated with osteoporosis among this sample of South Asian women.

Measures of feelings associated with being diagnosed with osteoporosis produced a wide range of ‘agree’ responses (25.7%-66.7%). Comparatively, 64.0% of women in von Hurst and Wham’s study (2007) agreed that it would be serious if they got osteoporosis and 22.5% agreed that osteoporosis is a crippling disease. Carlsson and Johnson (2004) found 46.0% of participants to agree that their feelings about themselves would change if they got osteoporosis and 50.0% agreed that the thought of having osteoporosis scares them. These studies demonstrate that women generally do not believe osteoporosis is a serious disease.

In the current study, perceived seriousness of osteoporosis was significantly negatively correlated with a family history of osteoporosis ($R=-0.23$; $P=0.02$). However, due to the low prevalence of family history of osteoporosis among these South Asian women, further studies are required with larger sample sizes.

It is evident that women generally do not perceive osteoporosis to be a highly serious disease with severe consequences. Education interventions are required to increase women’s awareness of the seriousness of osteoporosis and the impact it can have later in life. This may help to motivate women to increase their dietary calcium intake in order to prevent the onset of osteoporosis.

5.4.3 Perceived Benefits of Dietary Calcium Intake

The South Asian women perceived a high dietary calcium intake to be beneficial for the prevention of osteoporosis with a median score of 23.5 (95% confidence intervals 22.7, 23.8) out of a possible maximum of 30. Similar perceived calcium benefit scores were also reported by Estok et al. (2007) and Doheny et al. (2007) of 22.7 ± 3.51 and 22.6 ± 3.45, respectively.

Von Hurst and Wham (2007) found 91.3% of women agreed that adequate calcium prevents problems with osteoporosis and 77.9% agreed that they would not worry about osteoporosis if they ate foods with calcium. On the other hand, less than 60% of these women ‘agreed’ to all other items within this subscale of the OHBS and only 7.0% agreed that they feel good about themselves when they take enough calcium. This was considerably lower compared to the current study, which may be accounted by differences in demographic characteristics between the two study groups, such as ethnicity.

In summary, women generally perceive many benefits of a diet rich in calcium for the prevention of osteoporosis. Despite this high perception of benefits of calcium intake among this sample of South Asian women, 87.3% did not meet the RDI for dietary calcium. Therefore, factors other than perceived benefits of calcium intake must influence an individual's actual dietary calcium intake.

5.4.4 Perceived Barriers to Dietary Calcium Intake

The mean score for perceived barriers to calcium intake was 13.4±3.77 out of a possible maximum of 30, indicating a low perception of barriers. Both Doheny et al. (2007) and Estok et al. (2007) found comparable perceived calcium barrier scores of 12.4±3.85 and 12.3±3.78, respectively.

It is apparent that most participants in this study did not perceive cost of dairy foods as a barrier to dietary calcium intake (item 56). Likewise, von Hurst and Wham (2007) found most (82.7%) disagreed cost was a barrier. Women in both studies were well-educated and can therefore be assumed to be financially stable. Nevertheless, because socioeconomic status was not measured in both studies, further research is required to determine whether cost is a barrier in specific socioeconomic groups.

Taste (item 58) and changing current dietary behaviours (items 59 and 60) were also not perceived as barriers to dietary calcium intake within this sample of South Asian women. In addition, most participants did not believe that calcium-rich foods 'disagreed with them'. This was expected as many cultural South Asian dishes are dairy based, such as yoghurt and cottage cheese curries and home-made milk curd. This has also been found amongst New Zealand European women (von Hurst & Wham 2007). More research within the New Zealand population is necessary to strengthen these preliminary findings.

The wide discrepancy of responses to item 61 indicated a slight misunderstanding or uncertainty regarding cholesterol content of milk and milk products among these South Asian women. This has been a common finding in other New Zealand studies. For example, von Hurst and Wham (2007) found 77.2% of women in their study to ‘agree’ that calcium-rich foods were high in cholesterol and more than 27% of participants believed that milk was high in cholesterol in Wham and Worsley’s study (2003). Gulliver & Horwath (2001a) found body weight and a perception that milk was high in cholesterol and energy to be the most significant barriers for predicting milk consumption. Hence, it is crucial that public health messages strongly emphasize the nutritional value of low-fat dairy products, including the low fat and cholesterol content as well as the high calcium content.

In summary, these South Asian women did not perceive many barriers to calcium intake, such as cost, calcium-rich foods disagreeing with them, taste or changing their current dietary habits. On the other hand, in accordance with other New Zealand studies, some of these South Asian women believed that calcium-rich foods are high in cholesterol and this belief may therefore pose as a barrier to dietary calcium intake.

5.4.5 Health Motivation

These South Asian women reported a high health motivation with a mean score of 22.4±3.04 out of a possible maximum of 30. Likewise, Doheny et al. (2007) and Estok et al. (2007) reported a health motivation score of 23.4±3.42 in both studies. This high health motivation may be an important trigger for implementing relevant public health promotions for osteoporosis prevention and increasing dietary calcium intake in women.

In conclusion, the current study strengthens previous research indicating that women generally do not perceive themselves to be susceptible to osteoporosis and also do not believe that osteoporosis is a serious disease. On a more positive note, these South Asian women were highly health motivated, perceived a high calcium intake to be of benefit for the prevention of osteoporosis and also did not perceive many barriers to calcium intake. However, there may be some misunderstanding regarding cholesterol content of milk and milk products, which may impact on dairy product consumption. Thus, it is important for osteoporosis prevention programs to educate women on the nutritional content of low-fat milk and milk products to increase dietary calcium intake in women.

5.5 Relationships between Demographic Characteristics, Dietary Calcium Intake, Osteoporosis Knowledge and Osteoporosis Health Beliefs

5.5.1 Relationship between Osteoporosis Knowledge and Dietary Calcium Intake

Correlation analysis showed no significant relationship between OKT score and dietary calcium intake among this sample of South Asian women (R=0.06; P=0.54). Therefore, a higher level of osteoporosis knowledge did not predict a greater dietary calcium intake, possibly due to the influence of internal health beliefs as well as cultural and socioeconomic factors (Martin et al. 2004; Rosenstock 1960; Rozin 1996; Schmiege et al. 2007).

A number of studies have also found no relationship between osteoporosis knowledge and dietary calcium intake (Burke-Doe et al. 2008; Chang 2006a; Terrio & Auld 2002; Wallace 2002). Ziccardi et al. (2004) found that although final year nursing students had a significantly higher OKT score compared to the first year students, there were no differences in dietary calcium intake. A multivariate analysis by Hernandez-Rauda and Martinez-Garcia (2004) showed osteoporosis knowledge score to be unrelated to dietary calcium intake. Both Sedlak et al. (2000) and Estok et al. (2007) found no effect of an osteoporosis education intervention on dietary calcium intake.

On the other hand, Chang's (2006a) stepwise regression analysis found osteoporosis knowledge to be the most significant predictor of dietary calcium intake. In Piaseu et al.'s (2002) education intervention, follow-up at two weeks showed dietary calcium intake to be indirectly influenced by osteoporosis knowledge via self-efficacy. Therefore, Piaseu et al. (2002) concluded that both knowledge and self-efficacy are important factors for increasing dietary calcium intake.

In summary, the results from the present study strengthen previous research displaying no direct relationship between osteoporosis knowledge and dietary calcium intake among these South Asian women. Therefore, enhancing osteoporosis knowledge alone may be insufficient for implementing an increase in dietary calcium intake.

5.5.2 Relationship between Perceived Susceptibility and Seriousness of Osteoporosis with Dietary Calcium Intake

Perceived Susceptibility to Osteoporosis

Based on the theoretical approach of the HBM, it was anticipated that a higher perception of susceptibility to osteoporosis would predict a greater dietary calcium intake. However, results from the present study showed no relationship between perceived susceptibility to osteoporosis and dietary calcium intake (R=-0.11; P=0.28).

Similarly, Chang (2006b) found that although those women who had a first degree relative with osteoporosis perceived greater osteoporosis susceptibility compared to those who did not have a family history of osteoporosis, dietary calcium intakes were not significantly different between groups. In addition, Estok et al. (2007) found no significant correlation between mean perceived susceptibility score and dietary calcium intake at baseline, six months or 12 months after an education intervention.

By contrast, Wallace (2002) found perceived susceptibility to osteoporosis to be a significant predictor of dietary calcium intake, explaining 8.8% of the variance. Sedlak et al. (2007) showed a significant increase in perceived susceptibility in the treatment group compared to the control group at the 12 month follow-up, which was also associated with a significantly higher dietary calcium intake. In Tussing and Chapman-Novakofski's (2005) intervention trial, a significant increase in dietary calcium intake was associated with a significant increase in perceived susceptibility to osteoporosis. However, no control group was used in this study; hence it can not be said for certain that the intervention increased perceived susceptibility, which in turn resulted in an increase of dietary calcium intake.

Gerend et al. (2006) found those women who perceived a high susceptibility to osteoporosis attributed it to genetic factors and believed that it was out of their control. On the other hand, those who perceived a low susceptibility believed that it was due to their behaviours and that they could take action to protect themselves from the disease. Likewise, Chang (2004) showed that although women believed they were susceptible to osteoporosis, they also believed that prevention was too difficult. It was proposed by Chang (2004) that this may be due to a lack of a clear understanding of the disease.

Consequently, it is possible that those South Asian women who perceived high osteoporosis susceptibility attributed it to genetic factors and therefore, perceived greater barriers to dietary calcium intake. Indeed, correlation analysis between subscales of the OHBS found perceived susceptibility to osteoporosis to be significantly correlated with perceived barriers to calcium intake (R=0.28; P=0.01). This may explain why there was no significant relationship between perceived osteoporosis susceptibility and dietary calcium intake because those women who perceived a high susceptibility to osteoporosis also perceived many barriers to calcium intake.

Perceived susceptibility to osteoporosis was also found to be significantly correlated with family history of osteoporosis (R=0.31; P<0.01). Likewise, both Chang (2006b) and Werner et al. (2003) found those women who had a family history of osteoporosis reported a greater perceived osteoporosis susceptibility compared to those without a family history of osteoporosis. The present study did not differentiate dietary calcium intake between those with and without a family history of osteoporosis and this may be an area of interest in future studies.

Perceived Seriousness of Osteoporosis

According to the HBM, an individual who perceives serious consequences of a disease will be more likely to take action to prevent it compared to those who have a low perception of seriousness (Rosenstock 1960). However, there was no significant relationship between perceived seriousness to osteoporosis and dietary calcium intake in the present study (R=-0.06; P=0.55). Comparatively, both Estok et al. (2007), Sedlak et al. (2007) and Blalock et al. (1996) found no significant relationship between dietary calcium intake and perceived seriousness of osteoporosis. The absence of a relationship between perceived osteoporosis seriousness and dietary calcium intake could be partly explained by the small number of participants who reported a family history of osteoporosis.

In summary, both perceived susceptibility and seriousness of osteoporosis were not found to be related to dietary calcium intake within this sample of South Asian women. Moreover, it is possible that those who perceive a high susceptibility, possibly due to a family history, also perceive many barriers to calcium intake. Hence, it may be more effective for osteoporosis health prevention programs to focus on other osteoporosis beliefs, such as perceived barriers to calcium intake.

5.5.3 Relationship between Perceived Benefits and Barriers to Dietary Calcium Intake and Health Motivation with Dietary Calcium Intake

Perceived Benefits of Dietary Calcium Intake

Although women in the present study had a strong belief that dietary calcium was important for the prevention of osteoporosis, correlation analysis revealed no relationship between perceived benefits of calcium intake and dietary calcium intake ($R=0.09$; $R=0.39$).

Similarly, Estok et al. (2007) found no significant relationship between dietary calcium intake and perceived benefits of calcium intake, pre- or post-intervention. Both Wallace (2002) and Piaseu et al. (2002) found no significant correlation between perceived benefits of calcium intake with dietary calcium intake. Hence, these studies suggest that enhancing perceived benefits of calcium intake alone may not be effective for increasing dietary calcium intake in women.

On the contrary, both Blalock et al. (1996) and Gulliver and Horwath (2001a) found perceived benefits of calcium intake to significantly predict stage of change to increase calcium intake in their sample of women. Moreover, Gulliver and Horwath (2001a) found perceived calcium benefits to be the most significant predictor of dietary calcium intake, explaining 17.6% of the variance. In Ali and Twibell's study (1995), perceived benefits of calcium intake was significantly correlated with dietary calcium intake from milk ($R=0.52$; $P<0.001$) as well as total dietary calcium intake from milk, yoghurt, foods and supplements ($R=0.27$; $P<0.01$). However, due to the small sample size ($n=100$), Ali and Twibell (1995) recommended replicating their study with a larger sample size to provide stronger evidence towards effective ways to implement a high dietary calcium intake for the prevention of osteoporosis.

The conflicting findings on the effect of perceived benefits of calcium intake on dietary calcium intake demonstrate the complexity between health beliefs and behaviour. Although some previous studies have found a direct relationship between perceived benefits of calcium intake and actual dietary calcium intake, no such relationship was found in the present study. Hence, osteoporosis health prevention programs that focus solely on the benefit of a high calcium diet may not be effective for increasing dietary calcium intake in all women, possibly due to perceived barriers to calcium intake as well as cultural and socioeconomic factors (Martin et al. 2004; Rosenstock 1960; Rozin 1996; Schmiege et al. 2007).

Perceived Barriers to Dietary Calcium Intake

In accordance to the HBM, correlation analysis showed a significant inverse relationship between perceived barriers to calcium intake and dietary calcium intake ($R=-0.32$; $P<0.01$). Likewise, both Estok et al. (2007) and Ali and Twibell (1995) reported significant correlations (ranged from $R=-0.23$ and $R=-0.48$) between dietary calcium intake and perceived barriers to calcium intake. Schmiege et al. (2007) showed a significant correlation between perceived barriers to calcium intake and intention to consume calcium ($R=-0.43$; $P<.01$), which was significantly related to actual dietary calcium consumption at six months ($R=0.45$; $P<0.001$). Chang (2004) found women in this study to believe they were at risk of developing osteoporosis and that there were many benefits of osteoporosis prevention. However, they felt that prevention was difficult and may be related to a lack of knowledge. In Sedlak et al.'s study (2007), those women in the treatment group reported fewer barriers to dietary calcium intake at the 12 month follow-up compared to the control group. This was associated with a significantly higher dietary calcium intake.

Contrary to the current study, Wham and Worsley (2003) found cost and value for money to be significant barriers to milk consumption. Therefore, Wham and Worsley's study (2003) demonstrated the importance of socioeconomic status and perceived value for money of milk and milk products as a barrier to dietary calcium intake for other populations living in New Zealand.

Correlation analysis within OHBS subscales found a significant negative correlation between perceived barriers to calcium intake and perceived benefits of calcium intake ($R=-0.22$; $P=0.01$). Therefore, those South Asian women who perceived great benefits of consuming a calcium-rich diet also perceived fewer barriers to dietary calcium intake. These results indicate that increasing awareness of the benefits of a high calcium diet for the prevention of osteoporosis may help to decrease perceived barriers to calcium intake or vice versa. Due to the cross-sectional design of the study, a cause-and-effect relationship can not be established.

Perceived barriers to calcium intake was also significantly associated with marital status (R=0.20; P=0.05). The reason for this is unclear and can not be established in the present study. However, it is hypothesized that cultural barriers come into play and married women put their families' needs ahead of their own and hence, perceived greater barriers to consuming a diet rich in calcium. Barriers may be inconvenience, lack of time or preparation of foods that the other family members preferred, which may be low in dietary calcium. Future research is required to determine what the barriers are for married women and ways these barriers can be overcome. Due to this significant correlation, it is possible that marital status acted as a confounding factor for dietary calcium intake. However, correlation between dietary calcium intake and perceived barriers to calcium intake remained significant even after controlling for marital status.

In summary, consistent with other studies, dietary calcium intake in these women were significantly associated with perceived barriers to calcium intake. In addition, perceived calcium barriers were also associated with perceived benefits of calcium intake and marital status. Consequently, it is crucial that individual barriers are identified for different groups of women and strategies to overcome each barrier are implemented accordingly.

Health Motivation

Among this sample of South Asian women, health motivation was significantly correlated with dietary calcium intake (R=0.30; P<0.01). Comparatively, Estok et al. (2007) reported a significant correlation between dietary calcium intake and health motivation at baseline (R=0.24), six months post-intervention (R=0.16) and 12 months post-intervention (R=0.18). In Wallace's study (2002), those participants who had been classified into the high dietary calcium intake, high frequency of exercise group had significantly higher health motivation compared to those in the low dietary calcium, low frequency of exercise group. Thus, enhancing health motivation may be an important component for public health promotions focused on increasing dietary calcium intake in women.

5.6 Predictors of Dietary Calcium Intake

Stepwise regression analysis showed health motivation, perceived barriers to calcium intake and the use of a dietary supplement to significantly predict dietary calcium intake, together explaining 27.0% of the variance in dietary calcium intake ($P<0.01$). All other variables were removed from the model due to insignificant P values.

5.6.1 Health Motivation

Health motivation was the single most significant predictor of dietary calcium intake among this sample of South Asian women, explaining 15.2% of the variance. Likewise, Blalock et al. (1996) found those women who were currently thinking about or planning to increase dietary calcium intake had considerably greater health motivation.

In the present study, correlation analysis found health motivation to be significantly related to age ($R=0.25$; $P=0.01$), which was also reported in von Hurst and Wham's study (2007). Due to this significant finding, age may be a confounding factor between health motivation and dietary calcium intake. However, even after controlling for age, correlation between health motivation and dietary calcium intake remained significant.

Current physical symptoms act as an important motivator to health behaviours (Laslett et al. 2004), which may explain why older women in the current study were more highly health motivated. However, osteoporosis prevention begins in early childhood and adolescence before PBM is attained (Bonjour et al. 2007; Chan et al. 2007; French et al. 2000; Henry et al. 2004; Weaver 2008). Therefore, osteoporosis prevention interventions may need to focus on young adolescent girls as well as women approaching menopause to increase awareness, health motivation and consumption of calcium-rich foods.

5.6.2 Perceived Barriers to Dietary Calcium Intake

Health motivation and perceived barriers to calcium intake combined explained 23.5% of the variance in dietary calcium intake ($P<0.01$). Within this sample of South Asian women, having to give up other foods in order to consume more calcium-rich foods and the perception that calcium-rich foods are too high in cholesterol were the strongest barriers to calcium intake.

Blalock et al. (1996) found inconvenience alone to predict 30.4% of the variance in dietary calcium intake and was the most significant factor for predicting calcium stage. Therefore, in order to increase dietary calcium intake in women, there is an opportunity for the food industry to produce products that make the consumption of milk and milk products convenient and easily accessible to the consumer. This may involve special shelf stable packaging designs or snack packs that are easy to use and can be consumed on-the-go.

In Hernandez-Rauda and Martinez-Garcia's study (2004), a multivariate analysis model found lactose intolerance (R=-0.24; P<0.001), household income (R=0.23; P=0.003), age (R=0.19; P=0.005) and coffee consumption (R=-0.15; P=0.025) to be the most significant predictors of total dietary calcium intake. However, independent of household income, about 75% of women <49 years of age consumed <600mg/day of dietary calcium. Therefore, efforts must be made to increase dietary calcium intake in women from a wide range of socioeconomic backgrounds. Women who are lactose intolerant should be advised to consume other calcium-rich foods, such as canned sardines, broccoli and soy foods. In addition, a decrease in caffeinated drinks should be recommended as they often replace milk and milk-based drinks (New & Bonjour 2003; Russell et al. 1999).

Collectively, it is clear that a number of barriers operate together to determine an individual's dietary calcium intake and may depend on demographic characteristics as well as personal taste preferences. Therefore, osteoporosis prevention interventions should target these personal factors to enhance applicability for each individual.

5.6.3 Dietary Supplement Use

A significant correlation was found between the use of a dietary supplement and a vitamin D supplement with dietary calcium intake (R=0.28; P=0.01 and R=0.22; P=0.02, respectively). However, stepwise regression analysis found only the use of a dietary supplement to be a significant predictor of dietary calcium intake. In combination with health motivation and perceived barriers to calcium intake, these three factors explained 27.0% of the variance in dietary calcium intake. Therefore, the use of a dietary supplement only contributed an additional 3% variance of dietary calcium intake. The elimination of the use of a vitamin D supplement from the model may be explained by the small number of women who reported using a vitamin D supplement (4.9%).

The use of a dietary supplement and vitamin D supplement were found to significantly correlate with health motivation (R=0.28; P<0.01 and R=0.26; P=0.01, respectively). However, as demonstrated above, the small number of participants who reported using a vitamin D supplement poses the question of statistical power of this significant correlation. In addition, due to the cross-sectional design of the study, it can not be determined whether a high health motivation causes the use of a dietary supplement or vice versa.

The use of a dietary supplement, a calcium supplement as well as a vitamin D supplement were all significantly negatively correlated with perceived barriers to calcium intake (R=-0.27; P=0.01; R=-0.20; P=0.04 and R=-0.20 P=0.04, respectively). Cline & Worley (2006) found those women who had a high perception of susceptibility to osteoporosis as well as few barriers and many benefits of calcium supplementation use for the prevention of osteoporosis, were more likely to be report current use of a calcium or vitamin D supplement. It is probable that these relationships were mediated through a high health motivation. In other words, those who used a dietary supplement were highly health motivated and hence, perceive fewer barriers to calcium intake or vice versa. Due to the cross-sectional design of the current study, a direct cause and effect relationship can not be concluded.

A high health motivation has also been related to a high self-efficacy (Blalock et al. 1996; Piaseu et al. 2002), which in turn, results in a high dietary calcium intake (Ievers-Landis et al. 2003; Piaseu et al. 2002; Tussing & Chapman-Novakofski 2005; Wallace 2002; Wizenberg et al. 2005). For example, Manios et al. (2007) and Aree-Ue et al. (2005) demonstrated the effectiveness of osteoporosis education interventions for increasing dietary calcium intake. Manios et al.'s (2007) five month education intervention was based on the HBM and Social Cognitive Theory, which focused on increasing osteoporosis awareness and calcium self-efficacy. Aree-Ue et al.'s (2005) four week intervention covered osteoporosis risk factors, consequences and prevention as well as identification of personal calcium and exercise barriers. In Solomon et al.'s (2006) eight month intervention trial, those who were mailed out osteoporosis information including diagnosis, prevention and treatment, were more likely to get a BMD test and made changes around the home to prevent falls. This may have prevented future falls and fractures in these women.

Ali and Twibell (1995) found those women who consumed more dietary calcium had a greater self-efficacy, believed that their health status was internally controlled, perceived a better health status as well as fewer barriers and more benefits of dietary calcium intake. Hence, it is possible that those South Asian women who were highly motivated perceived greater control over their health as well as fewer barriers to calcium intake and hence, had a higher dietary calcium intake. This relationship has been demonstrated in other studies (Baheiraei et al. 2006; Conn et al. 2003). For example, those women in Raab et al.'s study (1999) who started using a calcium supplement as a result of the intervention were more likely to believe that osteoporosis could be prevented by changing their personal habits.

In summary, high health motivations as well as perceived barriers to calcium intake are important factors for predicting dietary calcium intake. Women who used a dietary supplement were also more likely to be consuming a diet rich in calcium and was related to a high health motivation and low perception of barriers to calcium intake. A large number of studies have consistently established the importance of increasing osteoporosis awareness, calcium self-efficacy and health motivation as well as overcoming personal barriers to calcium intake for increasing dietary calcium intake in women. Therefore, interventions that focus primarily on these factors may be the most effective method for the prevention of osteoporosis.

5.7 Limitations of the Study and Recommendations for Future Research

The present study was the first study in New Zealand to determine dietary intakes and osteoporosis knowledge and health beliefs in a sample of South Asian women. These women were based on a convenience sample from the Auckland area; hence, results can not be generalized to other areas of New Zealand. Future studies are therefore required with a larger, more representative sample of South Asian women over a wider geographical region of New Zealand. Moreover, similar studies overseas will also provide a greater level of understanding regarding osteoporosis knowledge, beliefs and dietary intakes among South Asian women.

Participant recruitment of these South Asian women was concentrated in areas of Auckland where a strong community presence has been identified (Central and South Auckland). Moreover, ~65% of all Asians live in Auckland, of which 27% are Indians. Although great efforts were made to target a representative group of the South Asian women population, these women may differ from other South Asian women in Auckland in age, socioeconomic status and a greater health motivation or interest in health and hence, a higher level of osteoporosis knowledge. In addition, those women who were able to communicate in English were probably more likely to take part in the study. Therefore, these results can not be generalised to the general South Asian population in Auckland.

Nevertheless, these South Asian women may be representative of the population in relation to education level, health status and length of residency. The immigration law requires immigrants to have an acceptable standard of health, including a low likelihood of being a danger to public health and the costs or demands on New Zealand health services as well as an ability to perform functions on which they have been granted entry (Immigration New Zealand 2007). In addition, the skilled migrant category, which is the main line of entry into New Zealand, states that immigrants must be aged between 20-55 years and requires specialized skill and knowledge gained through certificates, diplomas, bachelor degrees or a post-graduate qualification (Immigration New Zealand 2005). According to the 2006 census (Statistics New Zealand 2006a), there are now more recent immigrants compared to the 2001 data. In 2006, 32.3% of immigrants had lived in New Zealand for less than four years compared to 27.5% in 2001. Therefore, these recently migrated, well-educated, middle-aged South Asian women with a low prevalence of osteoporosis may be representative of the Auckland South Asian population.

Despite best efforts to obtain an accurate picture of participant's daily dietary intakes, 49% of participants were recognized as under-reporters. This demonstrates the effect of observation bias as well as under-reporting due to the inconvenience of recording a four day food diary and hence, the possibility of under-reporting consumption of snack foods throughout the day. Nonetheless, a four day food diary has been shown to be the best method for assessing total energy intake (Chinnock 2006; Koebnick et al. 2005;

Winichagoon 2008) as well as total dietary calcium intake (Bonifacj et al. 1997; McNaughton et al. 2005). In addition, under-reporting is a common phenomenon in all methods of dietary assessment (Jakes et al. 2004; Kelemen 2007) and has been shown previously to be common in overweight and obese women (Bedard et al. 2004; Chinnock 2006; Marks et al. 2006; Rennie et al. 2007; Trabulsi & Schoeller 2001). Additional studies that assess dietary intake in South Asian women will provide a clearer picture of their dietary habits, particularly dietary calcium intake. A debriefing session with a nutritionist to obtain more detailed information based on a four day food diary may also help to improve assessment of dietary intake (Cantwell et al. 2006).

Although participants were advised to use household measures to record their dietary intakes over the four days, the use of accurate measuring aids to record food intake as well as precision of using such aids are unknown. The high percentage of women who were found to be under-reporters suggests that portion size of foods recorded were possibly largely under-estimated. This may be due to inaccurate measuring skills, inconsistent use of measuring aids, reporting estimates rather than exact measures or intentionally under-reporting portion sizes.

When dietary records of foods were ambiguous or when participants did not provide detailed recipes for mixed dishes, dietary analysis was based on interpretation by the researcher, an Indian dietitian and with the use of recipe books (Gopalan et al. 1999; Raina et al. 2001; Thangman 1988). This limits the accuracy of capturing true dietary intakes of these South Asian women. Additional studies that assess dietary intakes in South Asian women will help to provide a clearer picture of dietary habits in these women.

Although the four day food diary provides an indication of the proportion of women who were vegetarian, this can not be assumed based on four days of dietary record alone. Prevalence of vegetarianism can be investigated in future research and may provide useful information for dietary advice to increase dietary calcium intake for osteoporosis prevention.

As the OKT was designed for use in Caucasian women, it was modified for use in this study group of South Asian women. Item six in the OKT was amended from ‘being a white women with fair skin' makes it more likely to get osteoporosis, to 'being a women of South Asian origin' makes it more likely to get osteoporosis. Although this change seems plausible, it may have affected the validity of the questionnaire. In addition, the OKT and OHBS were validated for Caucasian women (Kim et al. 1991a, 1991b) and have not been validated for other ethnic groups. This provides an opportunity for future research in developing a validated osteoporosis knowledge and health beliefs questionnaire for women of other ethnic groups, such as South Asian women.

Further research may also include measures of bone density and bone biomarkers to provide a clearer picture of the seriousness and prevalence of osteoporosis as well as associations of BMD with osteoporosis knowledge, beliefs and lifestyle factors.

Despite these limitations, the current study provides evidence of dietary intakes in South Asian women, particularly dietary calcium intake. The high percentage of South Asian women who did not meet RDI for dietary calcium intake requires further investigation. This is potentially a serious problem as the South Asian population within Auckland, New Zealand continues to grow.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS FOR OSTEOPOROSIS PREVENTION

6.1 Conclusions

Amongst this sample of South Asian women, overall osteoporosis knowledge was inadequate with a mean OKT score of 57.9%. Although most knew the importance of a high dietary calcium intake from milk and green leafy vegetables as well as regular exercise for the prevention of osteoporosis, knowledge regarding genetic risk factors, such as family history, estrogen deficiency, bone size and ethnic background, was lacking. Yoghurt and cheese were well-known sources of dietary calcium, whereas ice cream, broccoli and canned sardines were less familiar food sources. Many could not identify the RDI for dietary calcium as well as the number of servings of milk required each day to meet the RDI. Most participants knew that a calcium supplement could compensate for a low dietary calcium intake. However, despite the low mean dietary calcium intake amongst these South Asian women (685mg/day), only 16 or 15.7% reported using a calcium supplement. Moreover, there was no significant relationship between OKT score and dietary calcium intake.

These South Asian women perceived a low susceptibility and seriousness of osteoporosis. Those who had a family history of osteoporosis perceived greater osteoporosis susceptibility but also believed that osteoporosis was not a serious disease. There was no evidence of a significant relationship between perceived susceptibility and seriousness of osteoporosis with dietary calcium intake.

These South Asian women perceived many benefits of a high dietary calcium intake for the prevention of osteoporosis and did not perceive many barriers to dietary calcium intake. Those women who were married perceived more barriers to calcium intake. In addition, those women who perceived many barriers to calcium intake also perceived fewer benefits of calcium intake for the prevention of osteoporosis. Levels of health motivation were high among these women and this was significantly associated with increased age.

Health motivation, perceived barriers to calcium intake and the use of a dietary supplement were the three significant predictors of dietary calcium intake. The use of a dietary supplement was also significantly correlated with health motivation and perceived barriers to calcium intake. Therefore, these three factors interacted closely to determine dietary calcium intake amongst these South Asian women.

6.2 Recommendations for Osteoporosis Prevention

In the present study, perceived barriers to calcium intake, such as the perception that milk and milk products are high in cholesterol and the belief that calcium-rich foods did not agree with them, were significantly correlated to dietary calcium intake. Education on the health benefits of milk and milk products is therefore essential, as well as ways to enhance self-efficacy. In addition, education should begin at a young age to ensure a high PBM is attained by the third decade of life and to prevent a rapid decline in BMD thereafter (Ma et al. 2007; Weaver 2008). Addressing personal barriers and ways to overcome them may be a key component to increase dietary calcium intake in women and has been previously shown to be effective (Blalock et al. 1996; Solomon et al. 2006; Tussing & Chapman-Novakofski 2005; Wallace 2002). This may involve group discussions and on-going support groups to ensure lifestyle changes are maintained (Ailinger et al. 2005; Aree-Ue et al. 2005; Laslett et al. 2004; Manios et al. 2007; Sedlak et al. 2007; Turner et al. 2004). The addition of regular weight-bearing exercise programs as well as free bone scans may further aid in the prevention of osteoporosis. This may also help to increase health motivation, which was also found to be significantly related to dietary calcium intake in this study.

Milk, curry dishes (predominantly milk and yoghurt-based dishes) and non-milk based beverages, such as soy-based drinks were found to be the major food sources of dietary calcium among these South Asian women. As a result, health promotions could focus on increasing consumption of these major food sources to ensure cultural acceptability by the South Asian population. Married women were found to perceive more barriers to calcium intake. Therefore, promoting these culturally acceptable calciuim-rich foods could be targeted at young married women. In addition, reasons why married women perceived greater barriers to calcium intake could be explored in future research.

It is possible that although these South Asian women perceived many benefits of a high dietary calcium intake for the prevention of osteoporosis, actual dietary calcium intake was inadequate because they considered they were already getting enough calcium. Although knowledge was not found to be related to dietary calcium intake, increasing awareness of the number of servings of milk and milk products required each day to meet dietary requirements may increase dietary calcium intake among South Asian women. Moreover, perceived barriers were significantly and negatively associated with perceived benefits of calcium intake. Hence, increasing knowledge, awareness and the benefits of a high calcium diet may result in increased dietary calcium intake via a decrease in perceived barriers.

The present study found a significant correlation between perceived susceptibility to osteoporosis and perceived barriers to calcium intake. It is hypothesized that those women who believed they were at risk of developing osteoporosis also believed that it was due to genetic factors and was therefore out of their control. Therefore, osteoporosis prevention interventions may need to identify those women who believe they are at risk and encourage them to take control via increased self-efficacy. For example, the use of available treatments, such as HRT and calcium and vitamin D supplementation should be strongly encouraged, in addition to a calcium-rich diet and regular physical activity. Daily calcium and vitamin D supplementation has also been suggested by the New Zealand Guidelines Group (Gillespie et al. 2003) and may be more cost effective than other treatments.

Health professionals, such as general practitioners and nurses, are at the forefront of diagnosis and treatment of osteoporosis for the general public (Laslett et al. 2004; Matthews et al. 2006; Ribeiro et al. 2000). Studies have found many patient benefits when osteoporosis is discussed with health care professionals, such as an increase in the level of osteoporosis knowledge (Ungan & Tümer 2001; Williams et al. 2002) and a greater likelihood for use of calcium supplementation (Orces et al. 2003) as well as hormone therapy or medication (Sedlak et al. 2007). Moreover, health professionals can provide individually tailored interventions to patients, which have been recommended by a number of authors (Ailinger et al. 2005; Cline & Worley 2006; Theroux & Taylor, 2003). However, osteoporosis knowledge among health professionals is lacking (Berarducci 2004; Chen et al. 2005; Pèrez-Edo et al. 2004; Werner 2005). As a result, osteoporosis prevention is not a common topic of discussion between health professionals and patients and many are not followed-up for bone scans or treatment (Bliuc et al. 2006). Hence, educating and encouraging physicians to discuss osteoporosis with patients is a crucial component of osteoporosis prevention. According to Giangregorio et al. (2007), many health professionals prefer obtaining information through work presentations, magazines, journals and pamphlets. Moreover, 11% of those studied requested more resources to give to patients. Therefore, health professionals in all health settings need to be effectively trained whilst providing them with structured guidelines for risk analysis and information to give patients (Ailinger et al. 2005; Vytrisalova et al. 2007).

According to the New Zealand Guidelines Group (Gillespie et al. 2003), multidisciplinary and multifactorial intervention programs has been shown to help reduce the incidence of falls in community-dwelling elderly people. Gillespie and others (2003) suggested implementing muscle strengthening and balancing exercise as well as advice on how to reduce the risk of falls within the home environment to significantly reduce the incidence of fractures. This combined with efforts to increase dietary calcium intake may reduce the risk of osteoporosis in vulnerable women.

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APPENDIX ONE

PARTICIPANT SCREENING QUESTIONNAIRE

Massey University
Institute of Food, Nutrition and Human Health
Massey University
Albany, Auckland
New Zealand

Subject Identifier	

Surya Study
An investigation of the relationship between nutrition and risk factors for disease in South Asian women

---

Thank you for your interest in our research.
To ensure that you fill the criteria for the study, we need you to answer the questions in the form below. If you have any queries or concerns about the form, please feel free to call me, Pamela von Hurst, on 414 0800 ext. 41205 during working hours.

When you have completed this form, please use the enclosed postage-paid envelope to return it to: Pamela von Hurst, Institute of Food, Nutrition and Human Health, Massey University, Albany, Auckland.

Participant details

First Name: -- Family name --

Name you would like to be called by: --

Street address: --

Suburb: --

Phone (home): -- Phone (mobile): --

Email: --

Which of the above is the best way to contact you during the day? --------------------------------------

---

Date of birth:		Years in New Zealand	
Country of birth:		State:	
If you were NOT born in India, Pakistan, Bangladesh or Sri Lanka, please complete the section below.			
Father's country/region of birth:		Mother's country/region of birth:	
Maternal grandfather's country/region of birth:		Maternal grandmother's country/region of birth:	
Paternal grandfather's country/region of birth:		Paternal grandmother's country/region of birth:	

Please turn over and complete the brief medical history

Medical History

Have you ever been diagnosed with any of the following:

	Tick box	Comments
Diabetes (Type 1)	Yes ☐	....
Diabetes (Type 2)	Yes ☐	....
Kidney disease	Yes ☐	....
Cancer	Yes ☐	....
Sarcoidosis	Yes ☐	....
Hypercalcaemia	Yes ☐	....

Are you currently suffering from any other illness not listed above?

....

....

....

Medication:

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

....

....

....

....

Supplements:

Are you taking any dietary supplements, minerals, vitamins etc.? Please list:

....

....

....

....

Any comments or questions?

Please note below, or contact Pamela von Hurst on 414 0800 ext. 41205, or 021 162 0817
or email p.r.vonhurst@massey.ac.nz

Thank you for your interest, we will be contacting you soon.

APPENDIX TWO

PARTICIPANT INFORMATION SHEET

Institute of Food, Nutrition and Human Health
Massey University
Albany, Auckland, New Zealand

Surya Study
An investigation of the relationship between nutrition and risk factors for disease in South Asian women

Information for Participants

You are invited to take part in a university research project investigating the nutritional status of South Asian women, and its relationship with risk factors for diabetes, cardiovascular disease and bone health. The principal investigator (details below) is a PhD candidate in Nutritional Science at Massey University.

Principal Investigator:	**Supervisor:**
Pamela von Hurst Institute of Food, Nutrition and Human Health Massey University, Albany Tel: 414 0800 ext 41205 Email: P.R.vonHurst@massey.ac.nz	Dr Jane Coad Institute of Food, Nutrition and Human Health Massey University, Palmerston North Tel: 414 0800 ext 5962 Email: J.Coad@massey.ac.nz

We are looking for 300-350 South Asian women to participate in this study.
To fit in to our study you should:

Have been born in South Asia (or have parents or grandparents who were born there).
Be female, over 20 years of age.
Be willing to fast overnight for 10 to 12 hours and not drink any alcohol on the day before you come into the lab.
Not be pregnant, breast-feeding or planning in the near future.
Not be taking any medications which might interfere with our tests (we will ask you questions about your health).

If you decide you would like to take part in this study you will be first asked to complete a questionnaire which includes a medical history to ensure that you fit the needs of the study. If you do, we will then invite you to the Human Nutrition Unit at Massey University or another Auckland centre, where you will spend an hour with a researcher who will measure and weigh you, and take your blood pressure. You will be asked to provide a blood sample of about 25ml (about 5 tea-spoons) which will be taken at the same time. You will be asked to complete another questionnaire about your beliefs and knowledge about osteoporosis and a medical history form. Finally, you will be given a diary to complete with details about the foods you eat and what activities (such as walking and exercise) you do during the period of a week.

About the study

Phase 1 of the study seeks to recruit 300 women who were themselves born in the South Asian continent, or whose parents or grandparents were born there. The study is intended to find out about the nutritional status of South Asian women, how much vitamin D they get

from their normal diet and daily activities, and how their diet affects other aspects of their health especially glucose tolerance and bone health.
Involvement in this part of the study would include the following:

- The researcher would make an appointment for you to visit the Massey University, Albany campus or another Auckland location, early in the morning before you have breakfast. We will reimburse you for your travel costs. You would first have blood samples taken (about 25 ml which is equivalent to about 5 tea-spoons). This "Fasting blood sample" needs to be taken early in the morning before you eat or drink (other than water). You also need to avoid alcohol in the 24-hour period before the blood test.

- Some of the blood taken will be analysed for calcium, vitamin D, glucose and insulin levels, B vitamins, lipid and cholesterol levels, fibrinogen and parathyroid hormone (which affects calcium handling by the body). Part of the sample will be stored at the laboratory at Massey University where a genetic analysis will be done to look for variations in the vitamin D receptor gene when the blood samples from all the subjects in the study have been collected.

- Next you would be offered a light breakfast meal (of fruit, cereal, milk, yoghurt, bread, tea and coffee). We will then measure your height, weight and waist and hip circumference. All measurements will be made by female researchers over light clothing so you do not need to get undressed. We will then also take your blood pressure measurement

- The researcher will give you a food and activity diary for you to complete over the following week or so and mail back.

We would also like to invite you to return to Massey at a later date to give you a bone density scan. DEXA bone densitometry is quick, accurate, non-invasive method of assessing bone health and risk for osteoporosis (fragile bones in older age) which does not involve anaesthetic. The amount of X-ray dose is very small (about the same as the average person receives from background radiation in one day or less than one tenth of the dose used in a standard chest X-ray).

It is possible that results from the blood tests in phase 1 of the study might show some potentially abnormal results (such as very high blood glucose levels or very low vitamin D levels) that should be investigated further. If any such problems are identified, we will invite you to come back to Massey to discuss these with the study doctor, Dr Shashikala Bhuthoji, who is a registered medical practitioner who works in the Massey University Health Centre. She may advise you to contact your General Practitioner or will contact your General Practitioner on your behalf if you prefer.

Phase 2
Phase 2 of the study seeks to recruit 100 women from the first part of the study who were found to have high blood glucose levels or other markers of metabolic syndrome in the blood sample taken at the start of the study but are not taking any medication for diabetes. This part of the study will investigate the relationship between vitamin D and glucose intolerance. It is an intervention study which means that participants will be given either 4 small capsules containing a vitamin D supplement, or 4 small capsules of identical appearance which do not contain vitamin D, daily for a period of 6 months. During that period we will assess your vitamin status and blood glucose and insulin levels.

Participation in the study would also involve visiting a Diagnostic MedLab on 3 othe occasions to have a fasting blood sample taken (in total about 19 mls which is equivalent t about 4 tea-spoons). These need to be taken early in the morning before you eat.

At some point during the 6 month period, you will need to come to Massey University Nutrition Laboratory where we will give you a bone density scan. DEXA bone densitometry is quick, accurate, non-invasive method of assessing bone health and risk for osteoporosis (fragile bones in older age) which does not involve anaesthetic. The amount of X-ray dose is very small (about the same as the average person receives from background radiation in one day or less than one tenth of the dose used in a standard chest X-ray).

Risks and benefits

There will be no charges made for any of the tests that you undertake. The principal benefit of taking part in this study is that you contribute to our better understanding of the health problems of South Asians in New Zealand. Over recent years the number people from these regions living in New Zealand has greatly increased but we know very little about the health of this growing segment of our population.

There are no personal risks to your health, but the blood tests and bone density scan could potentially identify undiagnosed health problems. If any such problems are identified, we will invite you to come back to Massey to discuss these with the study doctor, Dr Shashikala Bhuthoji, who is a registered medical practitioner who works in the Massey University Health Centre. She may advise you to contact your General Practitioner. At your request, we would be happy to contact your General Practitioner for you.

Participation

You are under no obligation to accept this invitation to take part in this research study. If you decide to participate, you have the right to:

- decline to answer any particular question;
- withdraw from the study (at any time without having to give a reason);
- 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

General

If you want to discuss any aspect of this study you should contact the Principal Investigator, Pamela von Hurst at Massey University, 414 0800 ext. 41205.

If you have any queries or concerns regarding your rights as a participant in this study you may wish to contact a Health and Disability Advocate, telephone 0800 555 050.

At the conclusion of the study we will provide a report of the outcome to those involved in the study, we will also hold a meeting to discuss the results which you can attend if you wish. We anticipate that the anonymous results will be published in an international medical journal.

Confidentiality

No material which could personally identify you would be used in any reports on this study. Information collected from you in the study will be stored securely in the Department of Nutrition and will only be available to study personnel, unless you request that we release it some other individual (such as your General Practitioner). When the study is completed, all material will be destroyed.

Genetic testing

Each person has a DNA make-up (their genes) which is different from that of everybody else - except in the case of identical twins. This genetic make-up is a mixture of the genes of our parents. The precise way they are mixed varies from child to child within the same family, so having the same parents does not mean that two children will have exactly the same genes. We already know that some health conditions and disorders are definitely inherited through the genes (hereditary conditions), but we do not know how many conditions are explained by genetic inheritance. Inherited genes may explain why some people are more resistant and some people more prone to disorders which have not yet been identified as hereditary. The research in which you are invited to participate will investigate genetic make-up to look for any link.

Because the research investigates genetic make-up, this identifies a participant and their particular genetic characteristics. This information is confidential and will not be disclosed, stored, or used in any way without the informed consent of the participant.

We have no intention of claiming the right, ownership or property in your individual genetic information or that of your kinship group. You consenting to participate in DNA sampling of the proposed study will not be construed as creating any right or claim on the part of the researcher to your genetic information.

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 Injury Prevention, Rehabilitation and 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.

Please feel free to contact the researcher if you have any questions about this study.

This project has been reviewed and approved by the Massey University Human Ethics Committee: Southern A, Application 06/67. If you have any concerns about the conduct of this research, please contact Professor John O'Neill, Chair, Massey University Human Ethics Committee: Southern A, telephone 06 350 5799 x 8635, email humanethicssoutha@massey.ac.nz

APPENDIX THREE

PARTICIPANT CONSENT FORM

Institute of Food, Nutrition and Human Health
Massey University
Albany, Auckland, New Zealand

Surya Study
An investigation of the relationship between nutrition and risk factors for disease in South Asian women

PARTICIPANT CONSENT FORM

This consent form will be held for a period of five (5) years

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 FOUR

PARTICIPANT DETAILS AND MEDICAL HISTORY FORM

Massey University
Institute of Food, Nutrition and Human Health
Massey University
Albany, Auckland
New Zealand

Subject Identifier	

Surya Study
An investigation of the relationship between nutrition and risk factors for disease in South Asian women

---

DoB:

Participant details

First Name: Family name
Name you would like to be called by:
Street address:
Suburb:
Phone (home): Phone (mobile):
Email:

General Practitioner
Address
Phone No:

Medical History

Have you ever been diagnosed with any of the following:

	Tick for yes	Comments
High blood pressure	☐	....
Heart disease	☐	....
Angina	☐	....
Stroke	☐	....
Cancer	☐	....
Osteoporosis	☐	....
Lupus or ME	☐	....
Rheumatoid arthritis	☐	....
Psoriasis	☐	....
Tuberculosis	☐	....

Other ....

Does anyone in your immediate family (that is blood relatives) have any of the following conditions that you are aware of? If possible, please tell us the gender of the person, and the age at which they were diagnosed

Diabetes ....
Cardiovascular disease ....
Osteoporosis ....

Marital status ....

Years of education (from age 5)..

Country of birth:... **Years in NZ**...

Dental Health

Do you have, or have you had any treatment for, periodontal (gum) disease Yes ☐ No ☐

How many of your adult teeth have been extracted?...

Medication:

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

....

....

HRT/birth control...

Supplements:

Are you taking any dietary supplements, minerals, vitamins etc.? Please list:

....

....

Do you chew betel nut (paan) in any form? If so, please describe what form, and the frequency of use.

....

....

Do you smoke cigarettes? Yes ☐ No ☐

If yes, how many per day ....

If no, have you ever smoked? .... For how many years...

Do you drink alcohol? Yes ☐ No ☐

If yes, approximately how many standard drinks per week ....

When was your last period? ....

Weight (kg)		Height (cm)	BMI
Waist		Hip:	Ratio
Blood pressure #1		#2	#3
Temperature			

Recall for DEXA bone density scan (optional) **Y** **N**

APPENDIX FIVE

OSTEOPOROSIS QUESTIONNAIRE INFORMATION SHEET

Surya Study Osteoporosis questionnaire

The Osteoporosis knowledge and attitudes survey is a web-based questionnaire. It can be completed on-site when you come to Massey for your blood tests etc., or you can complete it later from any computer that is connected to the internet.

If you choose the latter, you will need the following information and instructions.

Web site address: http://www.nutritionist.net.nz/surya2007

User name: ....surya

Password:........................bones

When you enter the questionnaire you are asked for identification details as follows:

Family name: [ ]

First name: [ ]

ID: [ ] this is your ID number for the study

When you have completed the questionnaire, click the "submit" button. If nothing happens, check back through the form for any items marked in red – these must be completed before the form can be submitted.

To assist us with keeping track of data, it would be appreciated if you could complete the questionnaire within a couple of days of your appointment at Massey.

If you have any questions or problems with the website, please email or phone for help:
Pamela von Hurst 414 0800 ext 41205, p.r.vonhurst@massey.ac.nz

Many thanks for your help with our study,

The Surya Study Team

APPENDIX SIX

OSTEOPOROSIS KNOWLEDGE TEST (OKT)

Survey of your views about osteoporosis

Osteoporosis (os-te-o-po-ro-sis) is a condition in which the bones become very brittle and weak so that they break easily.

Please enter your name and subject id:

Family name: [ ]

First name: [ ]

ID: [ ]

Below is the 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, or
Less Likely to get osteoporosis ,or
It has nothing to do with (**neutral**) getting osteoporosis ,or
You **Don't Know**.

Please read each statement and select **ONE ANSWER** for each of the following questions.

1	Eating a diet LOW in milk products	☐ 1. More Likely ☐ 2. Less Likely ☐ 3. Neutral ☐ 4. Don't Know
2	Being menopausal, "change of life"	☐ 1. More Likely ☐ 2. Less Likely ☐ 3. Neutral ☐ 4. Don't Know
3	Having big bones	☐ 1. More Likely ☐ 2. Less Likely ☐ 3. Neutral ☐ 4. Don't Know

4	Eating a diet high in dark green leafy vegetables	1. More Likely 2. Less Likely 3. Neutral 4. Don't Know
5	Having a mother or grandmother who had osteoporosis	1. More Likely 2. Less Likely 3. Neutral 4. Don't Know
6	Being a woman of South Asian origin	1. More Likely 2. Less Likely 3. Neutral 4. Don't Know
7	Having ovaries surgically removed	1. More Likely 2. Less Likely 3. Neutral 4. Don't Know
8	Taking cortisone (steroids e.g. Prednisone) for long time	1. More Likely 2. Less Likely 3. Neutral 4. Don't Know
9	Exercising on a regular basis	1. More Likely 2. Less Likely 3. Neutral 4. Don't Know

For the next group of questions, choose one answer from the 4 choices. If you think there is more than one answer, choose the best answer. If you are unsure, select Don't Know.

Please read each statement and select **ONE ANSWER** for each of the following questions.

10	Which of the following exercises is the **best way** to reduce a person's chance of getting osteoporosis	☐ 1. Swimming ☐ 2. Walking briskly ☐ 3. Doing kitchen chores, such as washing dishes or cooking ☐ 4. Don't Know
11	Which of the following exercises is the **best way** to reduce a person's chance of getting osteoporosis?	☐ 1. Bicycling ☐ 2. Yoga ☐ 3. Housecleaning ☐ 4. Don't Know
12	**How many days a week** do you think a person should exercise to strengthen the bones?	☐ 1. 1 day a week ☐ 2. 2 days a week ☐ 3. 3 or more days a week ☐ 4. Don't Know
13	What is the **LEAST AMOUNT OF TIME** a person should exercise on each occasion to strengthen the bones?	☐ 1. Less than 15 minutes ☐ 2. 20 to 30 minutes ☐ 3. More than 45 minutes ☐ 4. Don't Know
14	Exercise makes bones strong, but it must be **hard enough to make breathing**:	☐ 1. Just a little faster ☐ 2. So fast that talking is not possible ☐ 3. Much faster, but talking is possible ☐ 4. Don't Know

15	Which of the folowing exercises is the **best way** to reduce a person's chance of getting osteoporosis?	☐ 1. Jogging or running for exercise ☐ 2. Golfing using golf cart ☐ 3. Gardening ☐ 4. Don't Know
16	Which of the following exercises is the **best way** to reduce a person's chance of getting osteoporosis?	☐ 1. Bowling ☐ 2. Doing laundry ☐ 3. Aerobic dancing ☐ 4. Don't Know

Calcium is one of the nutrients our body needs to keep bones strong.

Please read each statement and select **ONE ANSWER** for each of the following questions.

17	Which of these is a good source of calcium?	☐ 1. Apple ☐ 2. Cheese ☐ 3. Cucumber ☐ 4. Don't Know
18	Which of these is a good source of calcium?	☐ 1. Watermelon ☐ 2. Corn ☐ 3. Canned Sardines ☐ 4. Don't Know
19	Which of these is a good source of calcium?	☐ 1. Chicken ☐ 2. Broccoli ☐ 3. Grapes ☐ 4. Don't Know

20	Which of these is a good source of calcium?	1. Yoghurt 2. Strawberries 3. Cabbage 4. Don't Know
21	Which of these is a good source of calcium?	1. Ice cream 2. Grapefruit 3. Radishes 4. Don't Know
22	Which of the following is the recommended amount of calcium intake for an adult?	1. 100 mg - 300 mg daily 2. 400 mg - 600 mg daily 3. 800 mg or more daily 4. Don't Know
23	How much milk must an adult drink to meet the recommended amount of calcium?	1. 1/2 glass daily 2. 1 glass daily 3. 2 or more glasses daily 4. Don't Know
24	Which of the following is the **best reason** for taking a calcium supplement?	1. If a person skips breakfast 2. if a person does not get enough calcium from diet 3. If a person is over 45 years old 4. Don't Know
25	Which vitamin is required for the absorption of calcium?	1. A 2. C 3. D 4. Don't Know

26	What is the best source of the vitamin required for calcium absorption?	☐ 1. Oranges ☐ 2. Cheese ☐ 3. Sunlight ☐ 4. Don't Know

APPENDIX SEVEN

OSTEOPOROSIS HEALTH BELIEF SCALE (OHBS)

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, indicate 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 feel you should believe or how you think we want you to believe. We need the answers that best explain how **you** feel.

Please read each statement and select **ONE BEST** option that explains what you believe.

27	Your chances of getting osteoporosis are high.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
28	Because of your body build, you are more likely to develop osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
29	It is extremely likely that you will get osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree

30	There is a good chance that you will get osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
31	You are more likely than the average person to get osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
32	Your family history makes it more likely that you will get osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
33	The thought of having osteoporosis scares you.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
34	If you had osteoporosis you would be crippled.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree

35	Your feelings about yourself would change if you got osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
36	It would be very costly if you got osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
37	When you think about osteoporosis you get depressed.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
38	It would be very serious if you got osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
39	Regular exercise prevents problems that would happen from osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree

40	Regular exercise helps to build strong bones.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
41	Exercising to prevent osteoporosis also improves the way your body looks.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
42	Regular exercise cuts down the chances of broken bones.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
43	You feel good about yourself when you exercise to prevent osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree

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

Please read each statement and select **ONE BEST** option that explains what you believe.

44	Taking in **enough calcium** prevents problems from osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
45	You have lots to gain from taking in **enough calcium** to prevent osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
46	Taking in **enough calcium** prevents painful osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
47	You would not worry as much about osteoporosis if you took in **enough calcium**	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree

48	Taking in **enough calcium** cuts down on your chances of broken bones.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
49	You feel good about yourself when you take in **enough calcium** to prevent osteoporosis.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
50	You feel like you are not strong enough to exercise regularly.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
51	You have no place where you can exercise.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
52	Your spouse or family discourages you from exercising.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree

53	Exercising regularly would mean starting a new habit which is hard for you to do.	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
54	Exercising regularly makes you uncomfortable.	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
55	Exercising regularly upsets your every day routine.	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
56	Calcium rich foods cost too much.	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
57	Calcium rich foods do not agree with you.	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

58	You do not like calcium rich foods.	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
59	Eating calcium rich foods means changing your diet which is hard to do.	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
60	In order to eat more calcium rich foods you have to give up other foods that you like.	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
61	Calcium rich foods have too much cholesterol	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree
62	You eat a well-balanced diet.	1. Strongly Disagree 2. Disagree 3. Neutral 4. Agree 5. Strongly Agree

63	You look for new information related to health.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
64	Keeping healthy is very important for you.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
65	You try to discover health problems early.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
66	You have a regular health check-up even when you are not sick.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree
67	You follow recommendations to keep you healthy.	☐ 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Neutral ☐ 4. Agree ☐ 5. Strongly Agree

APPENDIX EIGHT

FOUR DAY FOOD DIARY

Subject number:	

Institute of Food, Nutrition and Human Health
Massey University
Albany, Auckland, New Zealand

Surya Study
An investigation of the relationship between nutrition and risk factors for disease in South Asian women

4-day food and activity diary

When you have completed this diary, please return it to Pamela von Hurst at the address below. A stamped, addressed envelope is provided for this purpose

Principal Investigator:
Pamela von Hurst
Institute of Food, Nutrition and Human Health
Massey University,
Private Bag 102 904, North Shore Mail Centre.
Tel: 414 0800 ext 41185, Mobile 021 162 0817
Email: p.r.vonhurst@massey.ac.nz

WHAT TO DO?

- There are three parts to this booklet. Part 1 is a food diary.
- Complete this diary for four days, one of which should be a weekend day
- If possible record food at the time of eating or just after – try to avoid doing it from memory at the end of the day.
- Include all meals, snacks, and drinks, even tap water.
- Include anything you have added to foods such as sauces, gravies, spreads, dressings, etc.
- Use a new line for each food and drink. You can use more than one line for a food or drink. See the example in the first two pages.
- Use as many pages of the booklet as you need.
- Part 2 is a questionnaire about how you use oil, ghee, butter etc.
- Complete the questionnaire by ticking the appropriate boxes.
- Part 3 is an activity diary. Please turn to page 20 for instructions on recording your physical activity.

<u>Describing Food and Drink</u>

- Provide as much detail as possible about the type of food eaten. For example brand names and varieties / types of food.

  Examples: Cheese – Mainland, Edam
  Milk – Meadowfresh Calci-trim milk
  Breakfast cereal – Sanitarium Natural Muesli
  Pasta – Wholegrain pasta

- Give details of all the cooking methods used. For example, fried, grilled, baked, poached, boiled…

- When using rice and lentils etc. please note if your measurement is taken before or after cooking.

- Record recipes of home-prepared dishes where possible and the proportion of the dish you ate. There are blank pages for you to add recipes or additional information.

Recording the amounts of food you eat

It is important to also record the quantity of each food and drink consumed. This can be done in several ways.

- By using household measures – for example, cups, teaspoons and tablespoons. E.g. 1 cups frozen peas, 1 heaped teaspoon of sugar.
- By weight marked on the packages – eg. a 425g tin of baked beans, a 32g cereal bar, 600ml Coke
- Weighing the food – this is an ideal way to get an accurate idea of the quantity of food eaten, in particular for foods such as meat, fruits, vegetables and cheese.
- For bread – describe the size of the slices of bread (eg. sandwich, medium, toast)
- Using comparisons – eg. Meat equal to the size of a pack of cards, a scoop of ice cream the size of a hen's egg.

Eat as normally as possible - don't adjust what you would normally eat just because you are keeping a diet record and be honest!

All information provided in this diary will be treated with the strictest confidence. No one outside the study will have access to this.

Thank you for taking part in this important study.
We are really grateful for the time you are giving.

Date________________________________ **DAY 1**

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed (units, measures, weight)
Example 7:55 AM	Rice, moong dahl, peas (recipe attached)	1 cup cooked
" "	Plain Greek yoghurt (Puhoi brand)	Half a small pot
" "	Orange juice (Citrus Tree with added calcium- nutrition label attached)	1 glass (275 ml)
10 AM	Raw Apple (gala)	Ate all of apple except the core, Apple was 125g

DAY 1 continued

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Recipes (Day One)

Recipes (Day Two)

Date________________________________ **DAY 2**

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Day 2 continued

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed

Date________________________________ **DAY 3**

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed (units, measures, weight)

Day 3 continued

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed (units, measures, weight)

Recipes (Day Three)

Recipes (Day Four)

Date______________________________ **DAY 4**

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed (units, measures, weight)

Day 4 continued

Time food was eaten	Complete description of food (food and beverage name, brand, variety, preparation method)	Amount consumed (units, measures, weight)

Thank you for your help with the Surya Study.