CHAPTER 2

LITERATURE REVIEW AND CONCEPTUAL/THEORETICAL FRAMEWORK

This chapter describes a literature review and a theoretical framework for the study. The literature review includes an overview of osteoporosis, quantitative ultrasound sonometry and osteoporosis assessment, outcome and impact of osteoporosis, risk reduction of osteoporosis in the elderly, research on educational osteoporosis prevention programs, and review of theories related to health behavior. A presentation of the theoretical framework of the study is at the end of the chapter.

Literature Review and Related Researches

Overview of Osteoporosis

Definition of Osteoporosis

Various operational definitions of osteoporosis have been proposed. The World Health Organization (WHO) defines osteoporosis based on bone mass density (BMD): the mass of normal bone per unit volume expressed as a T-score that is the number of deviations from the "Young Adult" reference. Osteoporosis is diagnosed when BMD is a 2.5 standard deviation (SD) or more below the average BMD for young adults. Measurements between 1 and 2.5 SD below normal are defined as osteopenia (National Osteoporosis Society, n.d.-a). Using these criteria causes controversy among experts because of the difficulty of accurate measurement and standardization between measurement and sites. At a Consensus Development Conference, osteoporosis was defined as "a skeletal disorder characterized by compromised bone strength predisposing a person to an increased risk of fractures." In this definition, bone strength principally refers to the integration of bone density and bone quality. Bone density is expressed as grams of mineral per area or volume, while bone quality refers to architecture, turn over, damage accumulation, and mineralization (Consensus Conference, 2001).

Basic Physiology of Bones

Bone is a living tissue that is constantly changing. There are two basic types: cortical and trabecular bone. Cortical bone is dense and compact layers, located mostly on the outer surface of bones. Trabecular or "spongy bone" is a series of thin plates (trabeculae) which form the interior meshwork of bones. The trabecular bone predominates in the vertebrae, proximal femur, and distal radius (Burke, 2000). Overall, the adult skeleton is about 80% cortical and 20% trabecular bone (Goss, 1998). Both cortical and trabecular bones contribute to the strength of a bone, and they are made up of three components including protein matrixes, mineralized bone, and bone cells. The protein matrix gives bone its flexibility and consists of type I collagen fibers and proteoglycans. The mineral bone is composed of minerals, calcium, phosphate, magnesium, sodium, and carbonate, and is the source of the compressional strength of bone. Bone cells include osteoblasts and osteoclasts that are largely responsible for bone mineral homeostasis and maintaining bone mass (Clark & Bruyere, n.d).

Osteoclasts are the bone cells responsible for bone resorption, and osteoblasts are responsible for bone formation. The resorption and formation of bone by osteoclasts and osteoblasts is termed bone remodeling. An understanding of normal bone remodeling is necessary to appreciate the pathophysioloy of osteoporosis. A bone remodeling cycle is complete in 180 to 200 days, and it is comprised of a sequence of four processes including initiation, resorption, reversal, and formation (Dempster & Lindsay, 1993). The initiation or activation depends on retraction of the linking cells, derived from osteoblasts, which normally cover all bone surfaces. Once activation has occurred, osteoclasts remove organic and inorganic bone components for 2 to 3 weeks, creating lacunae on the bone surface. This occurs in the resorption process. Then, bone resorption is reversed over the course of 7 to 10 days in a process that appears to be mediated in part by growth factors released by bone matrix. During this so-called reversal process, osteoblasts fill in the resorption lacunae with new osteoid. This process is called formation.

Throughout life, bone is constantly being formed and resorbed. If the remodeling cycle was completely efficient, bone would be neither lost nor gained. Whenever the bone remodeling is uncoupled or imbalanced (increase resorption over formation), bone loss occurs (Marcus, 1994). The activity of bone formation predominates from infancy through young adulthood, resulting in a steady growth of bone mass (Ilich, Badenhop, & Matkovic, 1996). The bone remodeling imbalance develops in old age. The quantity of bone replaced by formation is not equivalent to the sum previously removed, so a small bone deficit persists after each cycle. If persons with low bone mass continue loss of bone at each cycle of bone remodeling, they will develop osteoporosis in earlier years because bone mass density and fracture risk are determined both by the rate of bone loss and by the maximal bone mineral acquired at skeletal maturity, known as peak bone mass (Marcus, 1994). Thus, peak bone mass is the principal factor determining the remaining bone mass level.

Peak bone mass is the highest level of bone mass achieved, between ages 30 and 35, because of normal growth. Peak bone mass is considered to be the "Bone Bank" for the remainder of adult life. It is maintained for about the next 10-15 years after it is achieved, and then age-related bone loss begins (Ott, 1990). It is obvious that the peak bone mass level and the rate of bone loss throughout the life are the main determinants of osteoporosis.

The Pathophysiology of Age-Related Osteoporosis

Osteoporosis is classified as two different syndromes: Postmenopausal osteoporosis (Type I) and Age-related osteoporosis (Type II) (Goss, 1998).

Postmenopasual osteoporosis (Type I). Type I osteoporosis affects women within 15 to 20 years after menopause. This type of osteoporosis affects primarily trabecular bone (80% of the effect); there is minimal cortical bone loss associated with this type. Since the rate of trabecular bone loss is threefold the premenopausal rate, without suitable treatment women can lose 10% to 30% of bone mass. This condition brings atraumatic fractures in women in the vertebrae, ankle, and distal radius (Riggs & Melton, 1990).

Age-related osteoporosis (Type II). Type II or age-related osteoporosis occurs in men and women 70 years or older. The four factors significant to age-related osteoporosis are decreased osteoblast function, decreased calcium and vitamin D absorption, biochemical imbalances, and sex hormone deficiencies. These factors result from three major mechanisms: age-related endocrine changes, age-related changes in tissue function, and age-related changes in bone remodeling.

Age-related endocrine changes include imbalances in parathyroid hormone (PTH) and calcitonin, vitamin D, testosterone and estrogen, and growth hormone (GH) and insulin-link factor I (IGF-I) metabolisms. The serum concentration of PTH increases with advancing age. The mechanisms responsible for increasing PTH secretion are decreased intestinal calcium (Ca) absorption and impaired renal maintenance of calcium during the aging process. Thus, serum PTH concentration is increased, and it contributes to bone loss by inducing osteoclast activity (Clark & Bruyere, n.d; Halloran & Bikle, 1999). With advancing age, the dietary intake of vitamin D decreases only slightly or remains the same, but the decrease in cutaneous production of vitamin D results in a decrease in serum vitamin D levels. This may decrease the ability of 1, 25, – dihydroxy-vitamin D to promote intestinal absorption of calcium (Eastell et al., 1991).

Estrogen deficiency has been linked to an over increase of PTH in postmenopausal women, but testosterone deficiency had no effect on serum PTH (Halloran & Bikle, 1999). Conversely, gradual loss of gonadal function may contribute to the development of age-related osteoporosis in ageing males (Clark & Bruyere, n.d; Kessenich & Rosen, 1996). However, replacement testosterone in hypogonadal men can increase serum 1, 25,-dihydroxy-vitamin D levels the same as estrogen replacement in women can. Serum 1, 25, -dihydroxy-vitamin D level is influenced not only by a decrease of sex hormones, but also by a decrease of GH and IGF-I (Halloran & Bikle, 1999).

Age-related changes in tissue function are predominant in parathyroid gland, kidney, intestinal, and bone functions. The parathyroid gland is responsible for regulating Ca levels associated with serum PTH. Ageing may impair Ca binding between Ca-receptors and the pathway regulating PTH release leading to bone loss. In addition, with advancing age, impaired renal metabolism of vitamin D to active metabolites of the vitamin may enhance bone loss by lowering serum 1,25 dihydroxy-vitamin D levels (Clark & Bruyere, n.d). The intestinal absorption of vitamin D does not change, but decrease in Ca absorption of 10-30% is usually observed in the elderly (Halloran & Bikle, 1999).

Age-related changes in bone remodeling indicate that the amount of bone reformed during the remodeling cycle decreases in men and women with age. Age-related bone loss, therefore, is an unavoidable consequence of bone remodeling. The rate of bone loss may be different between the two sexes. Bone loss begins earlier and increases more rapidly in females than in males, with an accelerated phase in postmenopausal years. During this period, women can lose up to 30% of their bone mass because a lack of estrogen causes acceleration for the first 5-10 years after menopause. After this period, a gradual but continual loss of bone occurs, and the rate of bone loss becomes similar for both sexes after the age of 70. Bone loss persists until the age of 85 to 90 years (Ilich et al., 1996). However, bone loss in men and women is different. Men lose bone primarily by trabecular thinning and women primarily by trabecular perforations (Steiniche & Eriksen, 1999).

Risk Factors Associated with Osteoporosis

A number of studies identified the factors related to osteoporosis development: hormone deficiency, genetic, medications, anthropometric, diet, lifestyle, and physical inactivity.

Hormone deficiency factors. There are a number of hormones which play a significant role in bone metabolism. These are testosterone, cortisone, thyroid hormone, parathyroid hormone, thyrocalcitonin, insulin, estrogens, progesterone, and growth hormone (Sankaran, 2000). However, estrogens have been widely recognized as having an essential role in the maintenance of bone strength.

It is accepted that loss of estrogen after menopause is a known cause for developing osteoporosis in women. A deficiency in circulating estrogen concentration is related to an increase in osteoclast-mediated bone resorption. Estrogen deficiency induces the release of cytokines interleukin-1 (IL-1) and tumor necrosis factor alpha (TNF-a) from blood monocytes. These factors promote bone resorption. In addition, the estrogen mediated increase in bone resorption leads to decreased parathyroid hormone secretion, which decreases production of 1, 25-dihydroxyvitamin D and increases renal calcium excretion. Because decreased circulating serum 1, 25 – dihydroxyvitamin D causes impaired calcium absorption, it may increase bone loss (Clark & Bruyere, n.d). Women who undergo early menopause (before the age of 45) due to surgical history, such as hysterectomy and oophorectomy will have lost bone much earlier than is usual. They are likely to have a very low estrogen level. Thus, the risk of osteoporosis may be higher than normal (Leslie, 2000).

Even though estrogen deficiency is confirmed in female osteoporosis, recent research has shown that estrogen deficiency may also be a leading cause of male osteoporosis (Melton et al., 2000). A study conducted in 63 men admitted to an endocrinology clinic in Aarhus, Denmark found that, based on history, clinical examination, and extensive biochemical testing, 42 of the 63 were classified as having osteoporosis. Of these 42 patients, 14 (33%) exhibited serum estradiol levels below the normal range, whereas only two of these patients (3%) showed male hypogonadism with serum testosterone below the normal range. The researchers concluded that estrogen deficiency is much more prevalent than androgen deficiency in male osteoporosis (Carlsen, Soerensen, & Eriksen, 2000). Thus, estrogen deficiency is likely an important factor associated with osteoporosis both in women and in men.

Genetic factors. A genetic association with osteoporosis is evident. A number of studies on family members have strongly suggested that genetic factors determine bone density. A woman with positive family history (whose mother or grandmother suffered from osteoporosis) was more likely to be at an increased risk of developing osteoporosis (Barthe et al., 1998; Goss, 1998). Furthermore, the vitamin D receptor (VDR) gene has been found to be an important determinant of bone mass in Caucasians, whereas there is no association between the vitamin D receptor (VDR) and bone mass density in Thai people. A study in Thai postmenopausal women showed that the instances in the populations of the bb-VDR genotype, the Bb-VDR genotype, and the BB-VDR genotype were 85%, 14% and 1% respectively, whereas the bb-VDR genotype, Bb-VDR genotype, and BB-VDR genotype in Caucasian groups were 28%, 50%, and 22%, respectively. Intestinal vitamin D absorption levels in Thai people with the bb-VDR genotype were significantly higher than those with genotype Bb or BB (Ongphiphadhanakul et al., 1997).

Medication factors. Many medications can create conditions that reduce bone density. A study conducted on 9,704 ambulatory elderly, ages 65 years or older, found that a history of thiazide use and total number of years of use were negatively associated with bone mass. Among current users, each 5 year period of thiazide use was associated with a 1.2% decrease in distal radius bone mass. In addition, women currently using thyroid hormone supplementation had 3.6% lower bone mass at the mid radius. Moreover, bone mass was decreased in those women who reported a history of current steroid use (Bauer et al., 1993). Other medications including anticoagulant agents, anticonvulsants, excessive doses of thyroid hormones and aluminum-containing antacid contribute to bone loss as well (Drugay, 1997).

Anthropometric factors. Body weight as associated with osteoporosis has been supported in several studies. Retrospective cohort studies in Britain and Sweden have shown that weight in infancy is a significant determinant of bone mass in adulthood (Cooper et al., 1995; Cooper et al., 1997). A study of 189 women and 224 men aged 63 to 73 years revealed 12-15% differences between BMD (at the spine and hip) in the highest and lowest weight group at 1 year of age (Cooper et al., 1997). A recent study reported that women in the lower weight categories and losing 5% or more of their baseline weight had significantly more bone loss. Whereas women who gained 5% or more of their baseline weight lost less bone or had slight gains in BMD than did women with lower baseline weights. In the findings from the same study, men also showed more bone loss in the lower weight quartiles compared with those who had the highest weight quartile (Hannan et al., 2000). Taller women had higher bone mass; each 10-cm increase in height was associated with a 5.7% increase in bone mass (Bauer et al., 1993).

Dietary factors. Essential to bone health are calcium and vitamin D. Peak BMD is optimally achieved with sustained optimal calcium and vitamin D intakes. Calcium and vitamin D deficiency are recognized for contributing to osteoporosis. Poor nutrition is a common problem leading to calcium and vitamin D insufficiency, particularly in the elderly (Gennari, 2001).

The adverse effects of vitamin D on bone metabolism have been shown. A study conducted on 161 consecutive ambulatory women, healthy except for osteoporosis, indicated that the prevalence of vitamin D insufficiency [25(OH) D < or = 15 mg/ml] in osteoporosis women was 39.1%. The 25 (OH) D levels were lower in the osteoporotic subjects. After controlling for all other variables, lumbar spine (LS) and femoral neck BMD was found to be negatively related to 25(OH) D. Thus, vitamin D insufficiency is a common risk factor for osteoporosis that increased bone remodeling and low bone mass (Mezquita-Raya et al., 2001). However, some diets were reported as cofactors associated with bone health. For example, a diet rich in meat products as well as diets containing high quantities of sodium not only caused low calcium absorption, but also increased urinary excretion of calcium (Heaney, 1999)

Lifestyle factors. Lifestyle behaviors, such as smoking, and alcohol or caffeine consumption affect osteoporosis. Evidence supporting a direct effect of alcohol consumption on bone loss has been demonstrated. Clark and Sowers (1996) found that women with alcohol dependencies had mean bone mineral densities 6.8% lower at the femoral neck and 6.9% lower at the lumbar spine than women in control cases. A 4-year longitudinal survey study conducted to examine risk factors in bone mineral density change in older adults showed that women who had baseline alcohol intake of over 3 ounces to over 7 ounces had greater bone loss at the trochanter site than those women who had minimal alcohol intake (0 to < 1 ounce) (Hannan et al., 2000).

Cigarette smoking has also been linked to a reduction in bone mass and an increase in the risk of osteoporosis. Grainge, Coupland, Cliffe, Chilvers, and Hosking (1998) conducted a study on 580 postmenopausal women (ages ranging from 45-59, no mean ages) on the effects of cigarette smoking, and alcohol or caffeine consumption on bone mineral density. The findings revealed that smokers had significant reduction in bone mineral density when compared with non-smokers. In addition, a study conducted by Hannan et al. (2000) supported that men who were current smokers lost more BMD at the trochanter site than men who had never smoked. Likewise, a survey study on factors associated with appendicular bone mass in older women exhibited that women who smoke had decreased bone mass as compared with nonsmokers. After adjusting for age and weight, current smokers had a 4.3% decrease in distal radius bone mass. Past smokers had a 1.7% decrease in bone mass compared with never smokers (Bauer et al, 1993). Furthermore, findings from a population based cohort study in the Netherlands confirmed that cigarette smoking was associated with increased bone loss in both men and women (Burger et al., 1998).

That lifetime caffeine consumption inversely associated with bone mass was indicated in some studies. A prospective study in 84,484 nurses (aged 35-64 years) indicated that nurses in the highest quintile of caffeine consumption >817 mg per day had an age-adjusted relative risk of hip fracture of 2.96 (95% CI = 1.21-7.24), compared with those in the lowest quintile who consumed <192 mg per day (Hernandez-Avila et al., 1991). A related study by the Framingham Study showed that people consuming 2 or more caffeinated beverages per day had an increased risk of hip fracture (Kiel, Felson, Hannan, Anderson, & Wilson, 1990). Furthermore, a survey study on 9,704 ambulatory older women reported that women with 10,000 grams of caffeine intake, the equivalent of 10 cups of coffee per day for 30 years, had 1.1% decrease in distal radius bone mass (Bauer et al., 1993).

Physical inactivity factors. It is accepted that bones need a certain amount of exercise to stay strong and healthy. People, who are confined to bed or wheelchair or who have particularly inactive lifestyles, have a higher risk of developing osteoporosis. A population-based survey study conducted by Hannan et al. (2000) on older adults (mean age = 74; SD ± 4.5 years) exhibited that men who reported spending most of the day in bed or in a chair had greater bone loss as compared with active men at the femoral neck and at the trochanter site. Another survey study conducted on 352 white women 40 to 54 years of age showed that physical activity is directly and significantly associated with bone density at the spine, distal, and mid radius. In addition, additional 100 kcal/day energy expenditure in physical activity increases bone density at the spine, distal, and mid radius sites (Zhang, Feldblum, & Fortney, 1992).

Bauer et al. (1993) conducted a survey of ambulatory older women (n = 9,704) and found that weight-bearing physical activity was associated with increased bone mass over after adjustment for weight and ages. Approximately 20 minutes of jogging per day (a 2000-kcal/wk increase in vigorous activity) was associated with a 2% increase in distal radius bone mass and a 3.9% increase in calcaneal bone mass. Overall, findings supported the association between physical activity and exercise and bone mineral density.

In summary, evidence from various studies supported that hormone deficiency, genetic, medication use, anthropometrics, dietary, lifestyle, and physical inactivity are factors contribute to osteoporosis. Therefore, early detection as well as screening at risk people for developing osteoporosis is necessary for health promotion.

Quantitative Ultrasound Sonometry and Osteoporosis Assessment

Bone mineral density measurement becomes widely recognized as a method to diagnose osteoporosis as well as to predict risk of osteoporotic fractures (Pavlik, 1991). A number of techniques have been used for measuring bone mass. They are radiographs, single photon absorptiometry, dual photon absorptiometry, dual photon x-ray absorptiometry (DPXA), quantative computed tomography, and quantitative ultrasound sonometry (QUS). However, since QUS has been used in 1991 (Homik & Hailey, 1998), it is growing interest in its use to measure bone mass due to its several potential advantages over traditional densitometry. It is radiation–free, potentially portable, and has low costs. In this section, therefore, theory of QUS, role of QUS on bone mass assessment, and role of QUS on predicting fracture risk are described.

Theory of Quantitative Ultrasound Sonometry

QUS device has focused on measuring the velocity of sound or the relationship between sound attenuation and frequency (broadband attenuation or BUA). Theoretically, a sound wave traveling through a denser and more elastic bone will travel at a higher velocity and will lose more amplitude per frequency of sound wave than one traveling through a weaker bone (Gregg et al., 1997). The velocity is usually expressed in meters per second, termed speed of sound (SOS), while BUA is expressed in units of decibels per megahertz (dB/MHz). Some commercial QUS devices, such as Lunar Achilles, have introduced stiffness index (SI), which is defined as a combination of normalized SOS and BUA, SI = 0.67 X (BUA) + 0.28 X (SOS) – 420 (Lunar Corporation, 1998). In addition, SI results expressed as T-scores are used to diagnose of osteoporosis in the same way as are T-scores obtained by DEXA.

There are several sites of QUS measurements including calcaneus, phalanges, patella, and tibia (Drozdzowska & Pluskiewicz, 2002). However, the calcaneus is the most popular measurement site with regard to some reasons. First, it is 90% cancellous bone that has approximately eight times the metabolic turnover rate compared with cortical bone. Cancellous bones will show noticeable bone metabolic change before cortical bone. Last, calcaneus is easily accessible; therefore, it will reduce repositioning error (Nieh, Boivin, & Langton, 1997).

Role of QUS on Bone Mass Assessment

Some evidences addressed the relationship between QUS parameters and bone mass density (BMD) as well as the ability of QUS identifying osteoporosis. Regarding the correlation between QUS and BMD, Cauley, Danielson, et al. (1997) used QUS and dual energy X-ray absorbptiometry (DEXA) to evaluate BMD in older African-American and Caucasian-American women. BUA and DEXA were correlated with each other in measuring calcaneal and femoral neck BMD; particularly the association was stronger when ultrasound and DEXA was measured in the calcaneus. Similarly, Kung, Tang, Luk, and Chu (1999) used QUS to determine the normative data in healthy Chinese women. They found that BUA was significantly correlated with lumbar spine BMD ($r = 0.326$) and femoral neck BMD ($r = 0.395$) examined by using DEXA. Additional findings were observed that despite the fact that Chinese women participating in the study had significantly lower BMD values than Caucasian women; the mean BUA values for both pre- and postmenopausal Chinese women were nearly the same as those reported for Caucasian women.

In contrast, the differences observed between BMD and QUS variables was reported by Takeda, Miyake, Kita, Tomomitsu, and Fukunaga (1996). They examined bone mass at the calcaneus in normal Japanese subjects, with different sex and ages. Findings showed that QUS variables of calcaneus as well as BMD in normal Japanese men were higher than those in women. Additional findings revealed that age-related change in QUS variables of the calcaneus occurred earlier than BMD values in both men and women. However, the differences observed between BMD and QUS variables might be due to the fact that BMD measures only bone density whereas QUS (SOS and BUA) measure bone structures.

However, QUS used to measure bone mass and/or osteoporosis was indicated in some studies. Hadji et al. (1999) assessed age changes in QUS in 1,333 healthy German women. QUS values, particularly SI for premenopausal German women were similar to those observed in American Achilles reference population. Lin et al. (2001) conducted a prospective study on 16,862 Chinese subjects who did not have any obvious disease. They found that the incidence of osteoporosis in these populations was similar to those in elsewhere, compared with the Rochester study when osteoporosis was defined by using WHO criteria. QUS used to measure bone mass of Thai population has been limited to a few studies. Recently, national survey studies were conducted to investigate prevalence of osteoporosis in Thai people aged 40 years or more. Results showed prevalence of osteoporosis was 13.9% in women (Teinboon & Teinboon, 2002a), and was 22.5% in males (Teinboon & Teinboon, 2002b). Moreover, the prevalence of osteoporosis was higher with advanced age; it was 37.3% in women aged 60 years and over, and was 31.7% in males aged 60 years and over. A related study was conducted by Aree-Ue and Pothiban (2003). They reported that of all participants, 111 elderly living in Chiang Mai, the prevalence of osteoporosis was 71.17%. However, these findings should be interpreted considering the lack of other standard BMD measurements to confirm theses results; thus, the true magnitude of osteoporosis in these studies to be questionable.

Role of QUS on Predicting Fracture Risk

Several studies have described the ability of QUS to predict fracture risk. Hans et al. (1996) examined incident fractures at the hip in 5,662 elderly women (mean age = 80.4 years) by using QUS and dual-photon X-ray absorptiometry, DPXA. Findings revealed that low calcaneal QUS variables were able to predict an increased risk of hip fracture, with similar accuracy to low femoral bone mineral density (BMD) obtained by DPXA. Additionally, the relative risk for hip fracture for a decrease of 1-SD was 2.0 for BUA and 1.7 for SOS, compared with 1.9 for BMD. This reflected that QUS predicted the risk of hip fractures as efficiently as DPXA; therefore, QUS was more useful for assessment in any program aimed at prevention of osteoporotic fractures since it is less costly, compared with other BMD measurements, such as DEXA.

Similarly, Sakata, Kushida, Yamazaki, and Inoue (1997) reported that each ultrasound variable was significantly low in elderly Japanese women with hip fracture. Especially, stiffness index was a good indicator of hip fracture. Likewise, a prospective cohort study conducted by Bauer, Gluer, Cauley, Vogt and Ensrud (1997), who established the utility of calcaneus QUS and bone mineral densitometry for the prediction of fracture in 6,189 postmenopausal women. Results indicated that a low of BUA was associated with an increase incidence of hip fractures. Although the relationship between BUA and hip fractures was not as strong as that observed between femoral neck BMD and fractures, the relationship between BUA and non-spine fractures was the same as that observed for BMD. However, the results suggested that BUA was a useful screening test to predict fracture risk in older women.

Drozdzowska and Pluskiewicz (2002) reported the ability of calcaneal QUS in discriminating patients with hip fractures from healthy individuals of postmenopausal women participating in their studies. Additionally, the SOS was a better discriminator than SI and BUA and estimated the highest odd ratios (ORs) for hip fractures. Obviously, a majority of studies have been focused on women, especially postmenopausal women. However, the ability of QUS to predict the risk of osteoporotic fractures in men was reported by Mulleman, Legroux-Gerot, Duquesnoy, Marchandise, and Cortet (2002). Results revealed that the odd ratios (ORs) for fractures per 1-SD reduction were 2.3 for SOS, 2.1 for SI, and 1.6 for BUA. Although these ORs were lower than results obtained by BMD measurements, QUS provided similar results given by DEXA at the lumbar spine, with a threshold of –2.5 SD for the T-score. The researchers claimed that QUS was as effective as DEXA was in identification of fracture in male osteoporosis.

Summary

As noted, evidence from some studies supported that QUS was useful in osteoporosis screening and in the prediction of fracture risk. With its low cost, portability, free-ionizing radiation, it may be appropriate to be used as a screening tool, particularly, in economically less affluent countries. Early detection may be the best way to prevent consequent problems resulting from osteoporosis.

Outcome and Impact of Osteoporosis

Osteoporosis is difficult to diagnose until it has progressed and fractures are evident. The common fracture sites are the hip, vertebral spine, and wrist. These fractures frequently occur after apparently minor trauma, such as bending over, lifting, jumping, or falling from the standing position (Leslie, 2000; McClung, 1999). However, osteoporotic fractures lead to subsequent problems including disability, pain, changed quality of life, mortality, and costs.

Disability

The effects of osteoporosis related fractures on disability depend on the sites of fractures. A substantial decline in physical function following hip fracture was reported in the community-living elderly. Marottoli, Beckman, and Cooney (1992) conducted a study on 120 elderly individuals aged 65 and older who sustained a hip fracture from 1982 to 1988 and were treated in the two local hospitals. Among survivors there was a sustained decline in function at 6 weeks after the fracture with little improvement by 6 months. At baseline, 86% could dress independently versus 49% at 6 months; 90% could transfer independently versus 32% at 6 months; 75% could walk across a room independently versus 15% at 6 months; 63% could climb a flight of stairs versus 8% at 6 months; and 41% could walk one-half mile versus 6% at 6 months.

Greendale, Barrett-Connor, et al. (1995) examined functional limitations among 1,010 community-dwelling women aged 55 and older (mean age 72.6), who had previously experienced fractures at the sites. Women having experienced any osteoporotic fracture had a significant 1.7 to 3.0-fold increase in difficulty of bending, lifting, reaching, walking, climbing stairs, and descending stairs. Any fracture was significantly associated with 1.9 to 6.7 times more difficulty in dressing, cooking, shopping, and performing heavy housework. Hip fractures were more strongly associated with difficulty walking and descending stairs than other fracture sites, whereas spine fractures demonstrated a stronger association with difficulty bending, lifting, and descending stairs. Similar findings in a longitudinal study on 368 elderly people aged 70 and older reported that hip fractures increased the number of functional status dependencies including basic activities of daily living, household activities of daily living, advanced activities of daily living, lower-body limitations, and upper-body limitations (Wolinsky, Fitzgeral, & Stump, 1997).

Hip and spinal fractures are an important cause of disability. Hip fractures were associated more strongly with difficulty walking and descending stairs, whereas spinal fractures were associated more strongly with bending, lifting, and climbing or descending stairs.

Pain

Many fractures related to osteoporosis seem to arise without pain. However, several studies conducted on postmenopausal and the elderly reported consistent findings that women with vertebral fractures were several times more likely to experience back pain (Galindo-Ciocon, Ciocon, & Galindo, 1995; Lyles et al., 1993; Ross, Davis, Epstein, & Wasnich, 1994). In addition, a study on 101 postmenopausal women with osteoporosis of the spine and with one or more vertebral fractures reported that 84 (83.2%) had back pain. Constant back pain occurs in more than one fifth (21.4%) of those women, led to physical frailty and increased physical dependence with subsequent decline in basic activity of daily life, or functional status.

In summary, the adverse effects of vertebral fractures induce chronic pain on most activities of daily living that is almost as great as that seen for hip and even wrist fractures.

Quality of Life

Osteoporosis related quality of life has been investigated in a number of studies. Kessenich, Guyatt and Rosen (1998) used the Osteoporosis Quality of Life Questionnaire (OQLQ) to measure quality of life in 105 elderly osteoporotic women; they found that spinal fractures, health perception, and several socio-demographic factors accounted for 63% of the variance in quality of life. A study conducted on 751 European osteoporotic women with or without vertebral fractures revealed that women with vertebral fractures had progressively decreasing quality of life, physical function, social function, general health perception, mental function, and increasing pain (Oleksik et al., 2000).

Longitudinal change in health-related quality of life (HRQOL) following hip fractures was examined. Thirty-two older patients with hip fractures were recruited in the study. At 3 months after fracture, there was a significant reduction in HRQOL in physical function (-51%), vitality (-24%), social function (-26%), and general health (-24%) (Randell et al., 2000). A similar study was conducted to examine health-related quality of life (HRQL) in 652 community-dwelling Canadian men and women 50 years and older with osteoporosis fractures. The SF-36 instrument was used as a tool to measure HRQL. Participants who had experienced a fracture had lower HRQL scores compared with non-fractured participants. The largest differences were observed in the physical functioning and role-physical functioning domains. In women, the physical functioning domain was most influenced by hip and pelvis fractures, whereas the role-physical domain was most affected by hip fractures in men. In addition, participants who experienced vertebral fractures had lower HRQL scores than those without fractures (Adachi et al., 2001). In summary, patients with osteoporosis who have experienced vertebral fractures and hip fractures experience decline in physical function and quality of life.

Mortality

The most severe problem related to osteoporotic fractures is mortality. Several studies reported that hip fractures were a major cause of death in osteoporotic fracture patients. The excess mortality after hip fractures was greatest within the first 6 months of follow-up (Cooper, Atkinson, Jacobsen, O'Fallon, & Melton, 1993). In addition, during the first 12 months following a hip fracture, patients were 2 to 5 times more likely to die compared with people of the same age and sex without hip fractures in the general population (P.D. Ross, 1996). Long-term effects following hip fractures on mortality were demonstrated as well. The 6-year survival rate of community-dwelling female hip fracture patients aged 70 years and over showed that the mortality among hip fracture patients was 9 deaths per 100 women at 5 years post fracture. Those women who had two or fewer impairments had a continuing trend of increased mortality, with an excess of 14 deaths per 100 by 5 years (Magaziner et al., 1997).

Mortality among persons with vertebral fractures was also demonstrated in a number of studies. A population-based study was conducted on 335 residents of Rochester, Minnesota, who had an initial radiological diagnosis of vertebral fracture between 1985 and 1989. The findings showed that seventy-six of those died during 809 person-years of follow-up. At 5 years after diagnosis, the estimated survival was 61% compared with an expected value of 76% (Cooper et al., 1993). Another study was conducted on 907 women aged 55-81 who had experienced a fracture. One hundred and twenty-two women died over the course of the study, which lasted an average of 3.8 years. Twenty-three of those deaths occurred after a clinical fracture (Cauley, Thompson, Ensrud, Scott, & Black, 2000). Hip and vertebral fractures are crucial factors inducing mortality in osteoporosis patients, whereas mortality among women with wrist fractures was similar to women who did not have any fractures (Browner, Pressman, Nevitt, & Cummings, 1996; Cooper et al., 1993; Kelsey, Browner, Seeley, Nevitt, & Cummings, 1992).

Low BMD associated with increased mortality among women and men was also reported. Browner, Seeley, Vogt, and Cummings (1991) found that women with low BMD at the proximal radius, distal radius, or calcaneus had an increased risk of death. After adjusting for age, each SD decreased in BMD was associated with a 20 % increase in mortality. A recent study was confirmed that elderly men (aged 65-76) with low bone mass density have significantly increased mortality rates. An increase of 1 SD in BMD at the hip was significantly associated with an age-adjusted 0.77 relative risk for all-course mortality (Trivedi & Khaw, 2001).

In conclusion, survival rates following fractures related to osteoporosis depend on the types of fractures. However, hip fractures are likely to be the most serious type of osteoporosis related-fractures.

Costs

Fractures, particularly hip fractures, are well recognized as needing hospitalization, surgical intervention, and long-term care which involve economic and health care costs. Although few accurate global estimates are available, the health care and financial cost of osteoporosis are definitely high. Within Australia, the median cost of hospital treated fractures was AUD10,511 per fracture and for fractures treated on an outpatient basis AUD 455 in 1992. Femoral neck fractures were the most expensive fractures (AUD15,984 median cost) (Randell et al., 1995). The economic burden of osteoporosis in New Zealand is also substantial. First-year total direct costs of hospitalization, rehabilitation, and residential care associated with osteoporotic hip fractures- were estimated at USD 27,094,899. Second-year costs of these fractures were USD 16,219,381. The combined total over 2 years post-hip fracture was estimated to be USD 43,314,280. Women aged 45 or older had annual non-hip fracture costs were estimated at USD 2,860,811. In addition, the societal costs of treating the diagnosed condition for men and women were an average USD 2,200,633 per year (Lane, 1996).

Within European countries, in 1992, health care costs related to osteoporosis fractures in Switzerland – which covered 43% of all hospital beds - were calculated by days of hospital stay. The annual costs of acute hospitalizations due to osteoporosis and its complications were approximately 600 million Swiss francs (females: 464, males: 130 million Swiss francs) (Lippuner, Overbeck, Perrelet, Bosshard, & Jaeger, 1997). In the UK health care and social care costs of fractures occurring in women aged 50 years and over were about £12,000 for the cost of a hip fracture, with non-acute hospital costs representing the larger proportion. The other fractures were less expensive, at £468 for wrist, £479 for vertebral, and £1,338 for other fractures. For all fractures, the annual cost in the UK was £727 million (Dolan & Torgerson, 1998). Data reported on osteoporotic fracture costs in Belgium showed that the mean hospital inpatient costs for hip fracture were evaluated at USD 8,977 per case and USD 118,047,194 for the whole country (10 million inhabitants). In addition, patients with a hip fractures experienced an annual USD 752 extra outpatient costs during the year following the fracture event (Reginster et al., 1999). Within some non-European countries, costs of osteoporosis treatments were USD 5.7 trillion in the United States and USD 9.3 trillion in Japan (Delmas & Fraser, 1997).

These figures of osteoporosis costs only present the direct hospital costs-primary care, out-patients, and nursing home care. The accurate estimated costs may be higher since costs resulting from premature mortality as well as quality of life losses have not been addressed.

Conclusion

Osteoporosis related-fractures are frequent and important leading to disability, pain, decrease quality of life, mortality, and medical costs worldwide. Risk reduction prevention of osteoporosis related-fractures might be able to reduce such problems of at-risk individuals worldwide.

Risk Reduction of Osteoporosis in the Elderly

In recent years, much attention has been directed toward the prevention of osteoporosis, since the consequence of fractures related to this disease has become an important cause of morbidity and mortality. Even primary prevention measures to reduce the risk of developing osteoporosis are initiated in adolescence and continue through life, the goals of preserving skeletal integrity should concern the elderly, who are at-risk for osteoporotic fractures. Research has demonstrated that the prevention of osteoporosis and osteoporosis-related fractures may best be achieved by initiating sound health behaviors early in life and continuing them throughout life (Anderson, Rondano, & Holmes, 1996). Based on osteoporosis risk factors and factors contributing to age-related osteoporosis, promoting healthy behaviors (calcium dietary intake and weight-bearing exercise) are important goals.

Effects of Calcium on Bone Mass

Calcium is a key nutrient for bone that should be available in adequate amounts throughout life. During a growing skeletal process, calcium is a threshold nutrient because a maximal amount of calcium is involved in the establishment of peak bone mass. An adequate calcium intake will be utilized to increase bone mass up to a certain point. If young people are below a certain threshold level of dietary calcium intake, they will not be able to reach genetically predetermined peak bone mass (Bilezikian, 1999; Matkovic & Heaney, 1992). It is well accepted that the higher the peak bone mass, the longer it will take for age-related and menopausal bone loss.

After reaching a peak, bone mass is maintained for about the next 10-15 years and then begins to decline.

Calcium requirements established by the National Institutes of Health (NIH) are different among various ages. Both male and female elderly are recommended to take 1,500 mg daily (NIH Consensus Development Panel on Optimal Calcium Intake, 1994). It is well recognized that the best source of calcium is food. Milk and dairy products contain high levels of calcium. Persons, who have lactose intolerance, particularly in the elderly, are recommended to consume smaller but more frequent amounts (6 ounces or less) of calcium with other foods (Lane, 1997). Some dark green and leafy vegetables, another source of dietary calcium, also provide moderate amounts of calcium contents (Marchigiano, 1999). The different levels of element calcium are addressed in many types of Thai food as well. Recently, calcium-fortified foods have become essential contributors to calcium intake. A number of calcium-fortified food products include fruit drinks, breads, margarine, soy milk, or cereals. In addition, calcium supplements in the form of pills have become key calcium sources, and come in a wide variety of forms. Since calcium carbonate - either in the form of natural product (oyster shell) or as a chemically refined salt - contains the highest percentage of element calcium (40%), it has become a popular form of calcium. However, a disadvantage of calcium carbonate is that for some people, calcium carbonate may cause bloating and constipation. In addition, an acid medium is needed for calcium carbonate absorption. Another popular form of calcium supplement is calcium citrate. Although it contains only 20% calcium, it is more soluble and easy to absorb. In addition, it can be taken at any time without regard to food (Bilezikian, 1999; Marchigiano, 1999). Calcium plays a role as an important factor not only to increase peak bone mass, but also to maintain/prevent bone loss. Therefore, several studies have been conducted to examine the effects of calcium on health either on increasing peak bone mass or maintaining bone mass.

Calcium and peak bone mass. A number of studies indicated the effects of calcium intake on peak bone mass. Johnston et al. (1992) conducted a randomized controlled trial study to examine the effects of calcium supplementation on BMD in identical twin girls. In a three-year study, the findings showed that supplementation of dietary intake of approximately 900 mg with an additional 700 mg led to a significant increase in bone mass at the radius and spine, and with remarkable increase in the hip region as well. This finding is consistent with the study conducted by Lloyd et al. (1993), who found that bone mass increased among adolescent girls whose calcium intakes was increased from 80% to 110% of the recommended dietary allowance (RDA). From the findings, it can be concluded that adequate calcium intake at or above a certain threshold level are required for bone health during skeletal growth. And also, a study conducted by Bonjour et al. (2001), who follow-up 3.5 years after the end of calcium supplement (milk-extracted calcium phosphate) in 62 girls aged 8 years revealed that the overall mean bone mineral density of the six skeletal sites was highly significant increase from baseline (calcium-supplemented group 179 mg/cm^2 versus placebo group 151 mg/cm^2). Thus, milk-extracted calcium phosphate taken during the prepubertal period can modify the trajectory of bone mass growth and cause a long-standing increase in bone mass accumulation, which lasts beyond the end of supplementation.

Additionally, Hu, Zhao, Jia, Parpia, and Campbell (1993) conducted a study to investigate the association between dietary calcium and bone density among middle-aged and elderly women. Eight hundred and forty-three Chinese women (aged between 35 and 95) participated in the study. Findings indicated that bone mineral content (BMC) and BMD at the radius were significantly higher in participants with high calcium intake in the past than those with low calcium intake. Additionally, BMC and BMD were positively correlated with total calcium intake ($r = 0.27$- 0.38, $p < .0001$), daily calcium ($r = 0.34 - 4.0$, $p < .0001$), and a lesser extent with nondairy calcium ($r = 0.06 - 0.12$, $p < .001$), even after age and low body weight were adjusted for. This can be concluded that dietary calcium, especially from daily sources, increases bone mass in middle-aged and elderly women.

Calcium and bone mass maintenance. The effect of calcium on maintaining bone mass was also examined in many studies. A two year experimental study was conducted on 122 normal women (mean age = 58; SD ± 5 years) who had reached menopause at least three years before, and had a mean dietary calcium intake of 750 mg per day. Results from two year study showed that the mean rate total body BMD loss was reduced by 43% in women receiving calcium supplement 1,000 mg per day. Moreover, of those women the rate of BMD loss was reduced 35% in the legs and 67% in the ward's triangle (Reid et al., 1993). Similarly, a randomized controlled trial was conducted on 84 elderly women (54-74 years), who were more than 10 years past the menopause to determine the long-term effect of calcium supplementation on bone density. Over the 4 years the calcium supplement group (mean calcium intake 1,988 ± 90 mg/day) did not lose bone at the hip and ankle sites. The control group (mean calcium intake 952 ± 109 mg/day) lost significantly more bone than the calcium supplement group at all sites of the hip and ankle (Devine et al., 1997).

Calcium status of Thai people. In Thailand, studies regarding either calcium status or calcium associated with BMD have been limited. Only few published studies are addressed in this study. Komindr et al. (1994) conducted a survey study to examine calcium status in 466 healthy Thai women (age ranging from 46 to 90 years) living in Bangkok. The findings showed that participants in the study consumed lower dietary calcium intake than the recommended amount. The average daily calcium intake among those participants was 361 mg per day. Similar findings reported by Asian Osteoporotic Study Group, which indicated average dietary calcium consumption among Thai people were 300-400 mg per day (Rajatanavin, 2000).

A survey study conducted in northeastern Thai confirmed the amount of habitual calcium intake was markedly lower than the recommended amount of 800 mg per day adults. The average daily calcium intake among men and women was 378.6 and 265.6 mg, respectively. Furthermore, more than 79% of the subjects consumed dietary calcium less than half of the recommended values, whereas only 6% of men and 3% of women had their dietary calcium intake levels of more than 800 mg per day. The findings were also reported that the dietary calcium food sources of those people came from three major sources. Nearly 40% of dietary calcium intake was provided by glutinous rice. The second calcium food source was locally available fish, including fermented, which provided 27% of total calcium intake. The third major source was small animals with bones, such as frogs and small toads, which contributed to 18% of calcium intake. Dairy products and vegetables contribute to only 4% - 7% of dietary calcium intake (Kosulwat et al., 2000). The data also illustrated that subjects who consumed higher amounts of dietary calcium tended to have higher values of BMD at all sites.

Calcium intake is an important nutrient element in bone health, and particularly adequate amounts of calcium intake maximize peak adult bone mass, maintains bone mass and minimize bone loss in later life. Unfortunately, even though calcium is provided by various sources, the average daily calcium intake, particularly in Thai population, was lower than the recommended daily amounts. Therefore, increasing dietary calcium intake should be the aim of a public health campaign in all age groups to prevent osteoporosis and its consequent problems.

Effects of Exercise on Bone Mass

Exercise is a subset of physical activity defined as planned, structured, and repetitive body movement done to improve or maintain one or more components of physical fitness. Physical activity has been defined as any bodily movement produced by skeletal muscles that result in energy expenditure (Pate et al., 1995). Physical activity is an important determinant of bone mass, and it is widely accepted that certain forms of exercise can increase bone density at specific sites in the body (Lindsay, 1992; Sharkey, Willian, & Guerin, 2000). Physical stress on bone, particularly exercise that exerts moderate stress on bone, is thought to promote bone deposition with lower cytokine levels which in turn could result in reduced osteoclast stimulation and less bone loss (Kvernmo, Olsen, & Osterud, 1992; Urrows, Freston, & Pryor, 1991). Although the best exercises and their frequency, duration, and intensity for maintaining or increasing bone mass have not yet been precisely determined, weight- bearing exercise such as walking, jogging, dancing, and skiing appears to be significant (Lindsay, 1992; Sharkey et al., 2000).

Since bone loss associated with immobilization or weightlessness has been associated with an increase in bone resorbtion, a number of studies addressed the effects of brisk walking exercise as well as walking leisure-time walking activity on bone mass. A study conducted on 239 postmenopausal women revealed that women who walked more than 7.5 miles per week had higher mean bone density of the whole body and of the legs and trunk regions of the body than those who walked less than 1 mile per week. In addition, the number of miles walked was significantly correlated with a longitudinal rate of change in bone density at the legs (Krall & Dawson-Hughes, 1994). Brooke-Wavell, Jone, and Hardman (1997) found that in a study conducted on 84 healthy postmenopausal women aged between 60 and 70 years, the participants participating in walking exercise group with duration of 20-50 minutes for each walk decreased bone loss in the calcaneous and in the lumbar spine. In contrast, BMD in the lumbar spine and the calcaneous fell in control group. This study was consistent with another study conducted by Puntila et al. (2001), who found that the participants (1,873 peri-and postmenopausal women) who engaged in at least one hour of regular leisure-time weight-bearing exercise, particularly walking exercise per week during the 12 month of follow-up had their annual loss of lumbar BMD and lumbar bone mass content (BMC) smaller than in sedentary women. Interestingly, another study revealed the benefits of walking exercise on reducing risk of fracture in postmenopausal women. Feskanich , Willett, and Colditz (2002) reported that among 61,200 postmenopausal women (aged 40-70 years and 98%

white), walking for 4 hour per week there was a 41% lower risk of hip fracture (RR, 0.59; 95% CI, 0.37-0.94), compared with walking less than one hour per week.

Despite walking exercise, the effects of other types of weight-bearing exercises on bone mass were also indicated in some studies. A randomized controlled trial of 1-year duration was conducted on women, 50 to 70 years of age. Women who participated in strength-training exercise increased in femoral neck and lumbar spine BMD, whereas those who participated in a control group decreased in femoral neck and lumbar BMD. In addition, women in an exercise group improved muscle strength, and dynamic balance (Nelson et al., 1994). A consistent study was conducted by Kerr, Morton, Dick, and Prince (1996), who examined the effect of a 1 year progressive resistance training program on the bone mass of 56 postmenopausal women. Bone mineral density (BMD) was measured every 3 months at the radial forearm and four hip sites using the Hologic QDR 2000 bone densitometer. Participants in the strength regimen group (mean ages = 58.40; SD ± 3.7 years) had a significantly greater bone mass increase at the trochanteric hip site (control -0.6 ± 2.2%, exercise 1.7 ± 4.1%), at the intertrochanteric hip site (control -0.1 ± 2.1%, exercise 1.5 ± 3.0%), Ward's triangle (control 0.8 ± 5.2%, exercise 2.3 ± 4.0%), and at the ultradistal radial site (control -1.4 ± 2.3%, exercise 2.4 ± 4.3%). There was no significant increase in BMD with the endurance regimen group (mean ages = 55.7; SD ± 4.7 years) except at the radius midsite (control -1.0 ± 2.3%, exercise 0.1 ± 1.4%). These results support the notion of a site-specific response of bone to maximal loading from resistance exercise. Similarly, Kohrt, Ehsani and Birge (1997) compared the effects of two exercise training programs at 11 months in duration on bone mineral density (BMD) in older, sedentary women. Thirty-nine women (aged

60-74 years) were assigned to the following groups: (a) the skeleton through ground-reaction forces exercise (GRF) (i.e., walking, jogging, stairs); (b) the skeleton through joint-reaction forces exercise (JRF) (i.e., weight lifting, rowing); or (c) no-exercise control groups. The GRF and JRF exercise programs showed similarly significant increases in BMD of the whole body, lumbar spine, and Ward's triangle region of the proximal femur. Only participants in the GRF exercise program showed significantly increased femoral neck BMD. There were no significant changes in BMD in control subjects.

Maddalozzo and Snow (2000) investigated the effects of high intensity free weight training in older men or women. Twenty-eight men (mean ages = 54.6; SD ± 3. 2 years) and 26 non estrogen-replaced women (mean ages = 52.8; SD ± 3.3 years) were recruited in the study, then were randomly assigned to a moderate or high intensity training group and trained three times/week for 24 weeks. The results showed that high intensity training resulted in an increase in spine BMD in men, but not in women, whereas moderate intensity training produced no changes in either gender at this site. Additionally, increased greater trochanter BMD was observed in men regardless of training intensity, but not in women at any hip site. Another study was conducted to evaluate the effects of a 16-week progressive high-intensity strength training (HIST) program on peripheral markers of bone turnover (bone Gla protein, BGP; bone alkaline phosphatase, B-AP; N-terminal propeptide of type I procollagen, PINP; C-terminal cross-linked telopeptide of type I collagen, ICTP) in healthy, elderly men over 65 year of age. Thirty healthy men (aged 65-81 years) who performed light to moderate daily physical activity were randomly divided into two groups. The participants in exercise group (followed a supervised 16-week progressive HIST program) received 6 different sets of exercise. The results indicated that the HIST program did not significantly change BGP and PINP levels. On the contrary, serum B-AP level was significantly increased and serum ICTP was slightly reduced. Bone turnover - the ratio between bone formations to bone resorption (B-AP/ICTP ratio) – showed significant improvement in all participants of group 1, while no significant changes were observed in Group 2 during the 16 weeks of observation. Although the positive effects of a progressive HIST program on B-AP levels and B-AP-ICTP ratio seem promising, the support of bone mass measurement and the determination of other bone markers are requested to better identify exercise protocol (duration, intensity) for elderly people (Sartorio et al., 2001).

The effects of weight-bearing exercise on bone mass in participants with low bone mass or with osteoporosis were also addressed. Kudlacek, Pietschmann, Bernecker, Resch and Wilvonseder (1997) performed a prospective study over a 12-month period on bone density at a spinal and peripheral measuring site on 28 female senior members (mean age = 67; SD ± 2 years) of a dancing group in Vienna. The mean training time per week was 3.2 ± 0.8 hr. The participants with osteoporosis (group I) showed a significant increase in lumbar bone density, whereas in the participants without signs of osteoporosis (group II) showed no change of the BMD. Additionally, radial bone density did not show any changes in either group. However, group I also showed a significant correlation between basal spinal BMD and the percentage change of BMD during the observation period. Changes of the biochemical parameters were observed in the bone-specific isoenzyme of alkaline phosphates - a marker of osteoblastic activity - in group I supporting evidence of increased bone formation.

Another study conducted by Kronhed and Moller (1998), who evaluated the effects of weight-bearing exercise on BMD in community people (aged ranging from 40 to 70 years) with low bone mass at the distal radius. The training program was carried out for 60 min twice a week during one year. After the training period, participants in the exercise group had significant increase in BMD at the greater trochanter, while participants in the control group had significant increase in BMD at the lumbar spine. The researchers recommended that the results should be judged with caution because several participants were over the age of 60, and at that age degenerative changes in the lumbar spine may increase to a greater or lesser extent. However, regular weight-bearing exercises during one year seemed to influence BMD at the greater trochanter in a training group of both women and men.

Continuing and detaining of weight-bearing affected bone mass were presented in some studies. Iwamoto, Takeda and Ichimura (2001) examined the effect of exercise training and detraining on bone mineral density (BMD) in postmenopausal women with osteoporosis. Thirty-five postmenopausal women with osteoporosis (aged ranging from 53 to 77 years) were randomly assigned to three groups: a control group (n = 20), a 2-year exercise training group (n = 8), and a 1-year exercise training plus 1-year detraining group (n = 7). Exercise training includes daily brisk walking and gymnastic training. The findings indicated that exercise training program led to a significant increase in lumbar BMD in postmenopausal women with osteoporosis compared with the control. The BMD reverted toward a level that was not significantly different from the control with detraining. Therefore, continued exercise training is needed to maintain the bone mass gained through exercise training. Similarly, Brooke-Wavell, Jones, Hardman, Tsuritani, and Yamada (2001) found that fifteen postmenopausal women who had been walking regularly for one year and then returned to their former sedentary lifestyle significantly decreased calcaneous BMD, while changes in participants with continuing walking exercise over two years were not observed.

However, although weight-bearing exercises showed the positive effects on bone mass, the findings from some studies were controversial. A study was conducted to evaluate the effects of a weight-bearing (water based) exercise program on bone mass at the spinal or femoral sites. Seventy-seven community-dwelling postmenopausal women, 50 to 70 years of age with low bone mass were recruited in the study. Participants exercised in a pool with waist-high water for 60 minutes, 3 days a week, over a 12-month period. The findings revealed that spinal BMD decreased significantly, whereas there was no change in femoral neck BMD. Water exercises were not enough stress on the bones to initiate a bone response (Bravo, Gauthier, Roy, Payette, & Gaulin, 1997).

A consistent finding was found by Shaw and Snow (1998). They determined weight-bearing exercises plus resistance from weighted vests on improving dynamic balance, muscle strength and power, and bone mass in 36 postmenopausal women (aged 50-75 years). A 9-month regimen of weight-bearing exercises, performed three times a week, was emphasized on lower-body muscle strength and power development. Resistance was added progressively and individually by the use of a weighted vest. Although significant improvements were observed for indices of lateral stability, lower-body muscular strength, muscular power, and leg lean mass in exercisers, there was no significant change for femoral neck bone mass either in the exercisers or the controls at the end of the study. Thus, lower body exercise, using a weighted vest for resistance, provided only an effective means of improving key indices of falls in postmenopausal women, but not improved femoral bone mass. These findings were supported by Adami, Gatti, Braga, Bianchini and Rossini (1999), who conducted a study on 250 postmenopausal women, aged 52-72 years. After participating in a 6-month exercise program, there was no difference of BMD at the femoral neck, lumbar spine, ultradistal and proximal radius between the exercise and the control groups. Similar findings were addressed in a study conducted by Ebrahim et al. (1997). They evaluated the effects of brisk walking exercise on bone mineral density in women with upper limb fractures. Results revealed that at 2 year follow-up, bone mineral density at the femoral neck had fallen in both groups, while lumbar spine BMD had increased to a similar extent in both groups.

In Thailand, there are limited published studies regarding exercise and bone mass conducted in Thai people. However, a study with Thai women aged 46-90 years showed the correlation between exercise (average 2.4-2.8 hr/wk) and BMD (Piaseu, Komindr et al., 2001). A related finding was reported in another study conducted by Aree-Ue and Pothiban (2003). Results from logistic analysis indicated that self – reported weight-bearing exercise was a predictor of bone mass at the calcaneous (odds ratios, 3.0; CI 95%, .65-9.8); an increase of 1 SD weight-bearing exercise was associated with a 3-fold increase bone mass at the calcaneous in older adults living in Chiang Mai. Promoting exercise aimed at increasing and maintaining bone mass for Thai people is needed.

As noted, evidence from these studies concluded that weight-bearing exercises positively affected bone mass, although inconclusive findings were reported in some studies. Importantly, weight-bearing exercise longer than one year increases bone mass, and exercise regularly might be beneficial on bone mass. Also, the response of bone mass at a specific-site depends on different types of exercise. However, exercise duration and gender influencing bone mass conditions need to be examined in further study.

Conclusion

Numerous studies have examined exercise as a means to increase bone mineral density. Many of which reported positive results not only for participants without osteoporosis disease, but also the participants with osteoporosis or low bone mass even though there are differences in duration, frequency, and types of exercise. Continuous exercise, particularly over 1 year duration, is good for bone health. Evidence from previous studies showed less attention to investigate the effects of exercise on bone mass in male groups. To shed light on the benefits of exercise on healthy bones, male population should be included in the study. Additionally, adequate consumption of several nutrients with specific roles in calcium and bone metabolism can better maintain bone mass later in life.

Research on Educational Osteoporosis Prevention Programs

Osteoporosis has been described as a silent epidemic. Previous studies addressed many potential strategies available to prevent and treat osteoporosis. Risk factors such as low calcium dietary intake and sedentary lifestyle behaviors have been subjects of osteoporosis prevention research. An osteoporosis prevention program has been one means of increasing awareness of osteoporosis that may persuade at risk people to initiate healthy behaviors. The purpose of this section is to review the literature of published articles focusing on educational osteoporosis prevention programs.

Osteoporosis Knowledge and Healthy Behaviors

Previous studies have demonstrated the effectiveness of healthy behaviors such as exercise and calcium intake in osteoporosis prevention and maintenance of bone mass. At risk populations need to be provided with accurate and beneficial information so that they can consider and modify their lifestyles. A number of studies developed osteoporosis educational programs to improve osteoporosis knowledge levels and facilitate behavior change. Klohn and Rogers (1991) examined the effects of osteoporosis information about different aspects of the severity on a patient's intention to prevent osteoporosis. Two hundred and thirty African-American female students (mean ages = 18.6, no SD provided) were randomly assigned to 1 of 10 conditions (8 experimental conditions, 2 control conditions) of the 2×2×2×2 factorial design. Participants receiving high-visibility osteoporosis messages rated osteoporosis more severe than participants in other groups. The participants receiving the sudden-onset of osteoporosis messages had stronger belief in severity than the no-information control group. Participants receiving the high-visibility message and the near-future/high-visibility messages had a stronger intention to prevent osteoporosis than did the no- message control group. The authors suggested that people may evaluate the severity of the health threat in terms of the outcomes of the particular threat. Thus, they may be most concerned with such outcomes as pertain to an alteration in ability to function. The temporal aspects of the health threat may be of only secondary importance. Therefore, health care providers should emphasize the visible effects of an illness and the immediate onset of the health threat to promote preventive behaviors. However, the use of an undergraduate sample may limit the generalizability of the results to other age groups.

Edwards (1998) conducted an osteoporosis prevention educational program on young girls (age 11 to 16 years). The program consisted of three phases: phase one identified the eating and exercise habits; phase two was a multi-disciplinary health promotion campaign based on response to phase one; and phase three assessed the effectiveness of the health promotion strategies focusing on exercise and calcium intake. The findings showed that about 60% of the girls exercised at least once a day, which did not meet the objectives of the campaign (80% of girls), although exercise levels appeared to have increased slightly. In addition, increased osteoporosis knowledge did not affect eating behavior in this population. However, two factors might affect the results in the study. First, the psychometrics of self-reporting questionnaire was not provided that may result in inaccurate data leading to limited validity of this study. Second, a young girl might not perceive the risk of osteoporosis, which is a disease that may only affect them later in life. Therefore, even though they knew what they had learned about osteoporosis, their intention to prevent such a disease did not change. A challenge for further osteoporosis prevention programs is to develop appropriate strategies to encourage at risk people to engage in healthy, preventive behaviors.

A related study was conducted by Ribeiro and Blakeley (2001), who found that Canadian women (aged 45-69, no mean age provided) who participated in an osteoporosis workshop had an increase in osteoporosis knowledge, and such knowledge was still evident 6 months following the workshop. A slight increase in the use of hormone replacement therapy (HRT) and calcium intake was found in women who had increased osteoporosis knowledge, while other health practice changes were not supported. Evidence from the study indicated that whether knowledge encouraged people to make informed decisions about their health practice was not clear. However, osteoporosis knowledge associated with calcium intake behavior was supported by Peterson et al. (2000), who evaluated the effects of a brief dietary intervention on the calcium intake of young women. Eighty premenopausal women (mean age = 21.3; SD ± 3.4 years) with low baseline calcium intake (<700 mg/d) participated in the study. Women in the intervention group took part in three in-person meetings held at weekly intervals. Six months following, they found that women in the intervention group had increased calcium intake.

Another study focused on osteoporosis knowledge of nurses. Berarducci, Lengacher, and Keller (2002) assessed the effectiveness of an educational program on nurses' osteoporosis knowledge. The participants were 81 nurses who attended a continuing education symposium on women's health issues in southwest Florida, with a mean aged of 50.7 years (SD ± 10.84). The participants were exposed to an educational program which included a 1-hour lecture and slide presentation. Following the lecture and slide presentation, 20 minutes were allowed for questions and answers. Findings indicated that the educational program significantly increased osteoporosis knowledge of the participants ($\rho = .000$). Additionally, a majority of the participants (71%) indicated they were more likely to engage in osteoporosis preventive behavior. However, it should be noted that the results were interpreted by measuring effects of the program immediately following completion of the educational program; the behavioral changes actually occurring over a 6-month to 12-month period were not warranted. In addition, a lack of a control group made the results questionable.

Brecher et al. (2002) evaluated the effectiveness of a multidisciplinary primary osteoporosis prevention program on increasing osteoporosis knowledge, calcium intake, and exercise among participants who participated in the program, compared with a control group. The community-dwelling women aged between 25 and 75 years were eligible. The experimental group attended a 3- hour educational program including a medical presentation, an experiential presentation of dietary issues, and an interactive exercise presentation. Results indicated that there was a significant difference in knowledge over time ($F = 38.37$; $df = 2, 168$; $\rho < .001$), and between groups ($F = 8.30$; $df = 1, 84$; $\rho = .05$). Although there were not significant group differences for other variables such as current exercise and weekly dietary calcium intake, participants in the treatment group reported increasing calcium intake at 3-month follow-up more than those in a control group (83% vs 58%, respectively). The lack of significant findings for exercise and intention to exercise outcome was explained by the fact that the participants were active before participating in the study, with 73% having exercise at least 1 hour per week. However, the authors claimed that the program provided several strengths, which were identified through anecdotal remarks, including program usefulness, well-organized program, and the use of multiple learning formats.

Also, a study conducted on older population was noted. Davis and White (2000) tested the effect of an osteoporosis educational program on osteoporosis knowledge in older adults. Ten older adults living in a residential setting were recruited. The program was 4 weeks long with 1-hour session associated with osteoporosis information. The findings showed that the participants increased osteoporosis knowledge after attending the osteoporosis educational program. Unfortunately, whether osteoporosis knowledge can promote health practice behaviors, an important goal of osteoporosis prevention was not investigated. However, findings from the program provided information for planning the education programs in the future. Firstly, a one-hour program session was the appropriate length for adult learning. Secondly, use of a game for reinforcing content helps maintain participants' attention. Lastly, a group size of 10 or fewer people was appropriate to assess learning needs and individual attention. In addition, cognitive ability of older adults was more important than age in retaining subjects in the study.

A related study was presented by Curry, Hogstel, Davis, and Frable (2002). They assessed whether a community-based program increased osteoporosis knowledge and whether it contributed to osteoporosis preventive behavior of older adults. A community-based sample, women aged between 60 and 90 years, was recruited in the study. Participants attended a 30-minute presentation provided by one of two co-researchers. Additionally, a handout including major points related to each topic was given to each participant. Findings indicated that the older participants demonstrated a significant increase in knowledge about osteoporosis from pre-test to post-test assessment. Moreover, of all, 85.5% reported the intention to increase calcium intake, 90.8% planned to discuss osteoporosis with their physician, 97.9% planned to evaluate home for fall risk, and 95.6% planned to share information with others.

In brief, evidence from many studies demonstrated that educational intervention programs increase osteoporosis knowledge. However, whether knowledge by itself is enough to encourage a person to engage in preventing behavior was questionable since few studies supported the intention of planning to engage in osteoporosis preventive behavior. Also, the actual change in osteoporosis preventive behavior was not clearly addressed.

Osteoporosis Knowledge, Health Beliefs, Self-Efficacy, and Osteoporosis Preventive Behaviors

Several studies demonstrated the mixed findings regarding the role of osteoporosis knowledge, health beliefs, and self-efficacy as factors in osteoporosis preventive behaviors. A number of studies have used a variety of educational strategies to investigate the association among these variables. Sedlak et al. (1998) employed the Health Belief Model (HBM) and Self-Efficacy (SE) as a framework to assess the effectiveness of an osteoporosis prevention program for 131 nursing college women. Osteoporosis knowledge, health beliefs, and confidence in health practice were measured. The findings indicated that osteoporosis knowledge and health beliefs were significantly increased in the intervention group, whereas the confidence in health practice, exercise and calcium intake was found to increase more in the control group. The findings also showed the effectiveness of the program in increasing awareness of osteoporosis prevention in young women, but this awareness did not necessarily lead to change in health practices. The researchers suggested that two factors might affect the findings: 1) the theoretical framework based on the

Health Belief Model and Self-Efficacy might not be appropriate in promoting actual behaviors; and 2) there was a high attrition rate (50.79%) presented in the study.

The effects of brief written educational materials on osteoporosis knowledge, beliefs, and behaviors were examined by Blalock et al. (2000). Three hundred and seven women (mean age = 38.6, no SD provided) were randomly assigned to one of four groups. One group received an information packet containing general information about osteoporosis. Another received an action plan packet containing instruction on how to increase one's level of exercise and calcium intake. One group received both packets. The final group did not have any packets. Although participants receiving the information packets demonstrated increase in knowledge and health beliefs, participants in the experimental and control groups did not differ from one another with respect to change in calcium intake or exercise. The researchers claimed that this may be because the participants were in different stages of behavior change in each group, but they received the same educational materials. In addition, the participants were not evaluated for their perceptions of severity, threat, barriers, and benefits that are crucial factors in promoting preventive behavior (Rosenstock, 1974b).

To extend the effects of appropriate education strategies to different stages of change, a related study was conducted. Blalock et al. (2002) evaluated the effects of an osteoporosis prevention program (a tailored vs. non-tailored educational intervention and a community-based intervention) on calcium intake and exercise in 547 women (mean age = 47.0; SD ± 4.40). The Precaution Adoption Process Model (PAPM) (Weinstein, 1988) was employed as a theoretical framework to guide the study; individuals in different stages of change need different types of intervention to move them forward in the behavior change process. Women in the "engage stage" of change who received tailored education increased their calcium intake more than those receiving nontailored education, particularly in the community intervention group. Women who either received tailored or nontailored education in the action stages of change did not have observable behavior change. The authors claimed that nontailored education may provide sufficient information regarding osteoporosis prevention, so changes in behavior between intervention and control groups were not observable. However, limitations of the study were reported. First, the offer of a free bone density assessment attracted a less educated group. Second, there was increased success in recruiting the sample in the community intervention group than in the control group (n = 328 and 219, respectively). Third, the community intervention was given to only a few participants (32 of 328 participants). It was unknown how many people visited the Osteoporosis Resource Centers in their communities. Last, the telephone counseling session made it be difficult to determine whether the differences observed were the results of education tailoring or the telephone counseling.

A study conducted by Sedlak, Doheny, and Jones (2000) assessed the outcomes of three different educational osteoporosis prevention programs in women of different ages and education levels. The intense educational program recruited young college women whose ages were under 25, and who received three educational sessions over a 3-week period. Participants in the intermediate program who were a heterogeneous community sample of college educated women (ages ranging from 22 to 83) met with the program developers and a panel of health professionals for a 3-hour session. In the brief program group, participants who were nurses whose ages ranged from 35 to 59 received only a 45-minute session. Increased osteoporosis knowledge in all groups was observed, but a change in health beliefs or behaviors related to osteoporosis prevention was limited. The difference in ages and education levels may affect the health perception and stage of change in health practice; therefore, an educational osteoporosis prevention program should be matched to the individual need.

Another study was conducted to assess the impact of an osteoporosis educational program on female nursing college students (mean age 18.48; SD ± 0.6) (Piaseu, Belza, & Mitchell, 2001). Participants were randomly assigned to either experimental or control groups. The experimental group received osteoporosis information via instructional materials and a 3-hour slide presentation. Participants in the control group, however, were offered the opportunity to attend the osteoporosis intervention program after completing the posttest. Participants in the experimental group had significant increase in knowledge, health beliefs, and confidence in exercise and calcium intake compared to the control group. The Health Belief and Self-Efficacy Model were useful in examining the results. Once strength of the study was the investigators prevented cross-contamination between the experiment and the control groups by giving the pretest for the experimental group after the posttest for the control group was completed. Participants were female nursing college students; the generalizability of study findings to men or other age groups is limited.

In summary, several educational strategies were used in the studies. All osteoporosis education prevention programs increased osteoporosis knowledge. However, the evidence for whether osteoporosis knowledge facilitated health beliefs and health behavior changes was limited.

Osteoporosis Knowledge, Bone Mineral Content Testing, and Osteoporosis Preventive Behaviors

Strategies for prevention and treatment of osteoporosis are widely recommended, but how best to communicate this information to at-risk people is unclear. The results of several studies have been mixed with regard to which components should be included in osteoporosis educational programs. Bone mineral content testing was added in a number of studies.

Cook, Noteloviz, Rector, and Krischer (1991) conducted a study on 771 white women (aged 30- 80, no mean age provided) from an urban medical practice (6%), a group family practice (30%), and two gynecologists' private practices (64%). Results revealed that women who received an educational booklet, a one-hour workshop reinforcing the booklet, and a bone mineral content (BMC) screening had increased osteoporosis knowledge and increased lifestyle changes by 60%. In addition, women with below average BMC levels were more likely (86%) to report positive lifestyle changes than those with average or above average BMC (69%). Findings included increased awareness of osteoporosis and promoted behavior change, which was done by written materials, talking to at risk persons, and providing BMC testing. A similar study conducted by Waller et al. (1997) evaluated the effects of osteoporosis knowledge on preventing osteoporosis within the community. Participants aged 20-79 (no mean age provided) were recruited. Findings showed that walking groups, special balance training groups, and public meetings discussing health behaviors related to osteoporosis occurred in the intervention community, where people participated in osteoporosis educational program and received BMC testing. And also, a related study was conducted by Jamal et al. (1999). They evaluated the effects of written materials, brief in-person counseling, and bone density testing on a variety of health preventive behaviors in 669 healthy Caucasian women (mean age = 27.5; SD ± .5 years). They found that at a 1-year follow up, participants were less likely to smoke, consume alcohol, and caffeinated beverages, and more likely to use calcium supplements, vitamin D supplements, and drink at least one glass of milk a day.

Rolnick et al. (2001) assessed the impact of osteoporosis education, with and without BMD, on the initiation of lifestyles and drugs for preventing osteoporosis in premenopausal women aged between 54 and 65. Women who participated in a 2-hour osteoporosis educational session plus BMD testing were three times more likely than those in a 2-hour osteoporosis educational session to report starting HRT. Women in the intervention groups who attended both a 2-hour osteoporosis educational session plus BMD testing were significantly more likely to report modifying their diet, calcium, and vitamin D intake than those in the control group. However, a limitation is that women who were willing to participate in the study were more interested in considering changes in lifestyle.

In brief, a variety of strategies were adopted in order to increase osteoporosis knowledge. Goals were to encourage at-risk people to modify their health behaviors or engage in health preventive behavior. Bone mineral testing played a significant factor to encourage a person to practice preventive behavior when it was incorporated in a part of an osteoporosis educational intervention program.

Conclusion

The evidence from these reviewed studies addressed two major issues as follows. First, either educational materials (booklet and brief written) or slide presentation increased participants' knowledge of osteoporosis, but some studies, however, failed to find the relationship between osteoporosis knowledge and health practice behavior such as calcium intake and exercise, which are crucial factors to increase/maintain bone mass. Although some studies indicated that offering BMD testing does prompt women to change some lifestyles to health behaviors, BMD testing is accepted as costly. However, the possible explanations for the mixed findings regarding the association between osteoporosis knowledge and health practice behavior is that the age of the participants varied greatly although most studies limited their sample to young women. Young women may perceive the severity and subsequent problem of osteoporosis differently than middle age adults or older adults, and they may have less intention to alter their lifestyle behaviors. Moreover, some studies failed to report psychometrics of questionnaires that might result in the finding validity. Last, although health behavior theories such as the HBM, SE, and the PAPM were employed as a theoretical framework, results from some studies were inconsistent support participants' health practice.

However, almost all studies indicated that using health behavior theories is useful when the intervention designs fit to the principles of theories. For example, when the PAPM was used, the assessment of the individual's readiness for changing behaviors is essential. Any education prevention program should be adapted to the specific stage of change, and programs should be founded on the application of theoretical principles that are matched to the specific stage of change, rather than merely developing an educational program based on the assumption that participants are ready to take action.

Review of Theories Related to Health Behavior

The importance of theories is to help the understanding of the nature of targeted health behaviors. And also, theories provide the most suitable targets for programs, the methods for accomplishing, and outcomes for evaluations that are the ways to achieve behavior changes. Contemporary theories of health behavior include individual and interpersonal levels known as cognitive theories that suggest two key important concepts: 1) behavior is considered to be mediated through cognitions; and 2) knowledge which is necessary but not sufficient to produce behavior changes (Glanz & Rimer, 1997).

Since the individual is the most basic level of health promotion practice, there are several theories addressed at the individual levels such as the Stage of Changes Model (Prochaska, Redding, & Evers, 1997), the HBM (Rosenstock, 1974a), and Theory of Reasoned Action (Fishbien & Azjen, 1975). According to the Stage of Changes Model, the key concept focuses on individuals' readiness to change or attempt to change toward healthy behavior. The HBM addresses a person's perception of the threat of a health problem and the accompanying appraisal of a recommended behavior for preventing or managing the problems, while the Theory of Reasoned Action focuses on the intention to perform a behavior as the most important factor to actually engage in future behavior.

Within theories of health behavior at the interpersonal levels, these theories are not limited to developing an understanding of interactions though the dynamic of relationship is always at the core of these theoretical frameworks. The theories include factors associated with individuals' experience and perceptions of their environments in combination with their personal characteristics (Glanz & Rimer, 1997). Although theories at this level include several theories such as the Social Power, the Social Support, and the Social Learning Theory (SLT), the SLT is more concentrated because it includes many concepts that are useful in health promotion, especially the Self-Efficacy (Bandura, 1977).

As it is widely accepted that osteoporosis is a silent disease, awareness and perception of seriousness of this disease is important to encourage at-risk people to engage in preventive behavior. Since published study regarding awareness and perception of seriousness of osteoporosis in Thai older adults was limited, the HBM is selected for describing and applying in this study. Additionally, because the nature of the HBM does not provide specific strategies to increase health behavior, the SE will be added to be a theoretical framework of this study since the SE clearly addresses both the psychosocial factors that determine health behavior and strategies to promote behavior change (Glanz & Rimer, 1997). Therefore, these two theories are presented in this section.

The Health Belief Model

One of the recent trends in health care is to encourage health promotion and disease prevention. The trend was catalyzed by recognition that death and disability can be eliminated or reduced by behavioral change. The Health Belief Model (HBM) was developed to explain health-related behavior at the level of individual decision-making. Since the 1950s, it has been used both to explain change and maintenance of health behavior and as a guiding framework for health behavior interaction (Strecher & Rosenstock, 1997). This section includes an overview of the components of the HBM, review and critique research using the HBM, and implications for the discipline of nursing.

Overview of the Components of the HBM

The HBM was developed in the 1950s in an effort to explain the widespread failure of people to participate in programs to prevent or to detect disease such as screening for tuberculosis (Strecher & Rosenstock, 1997). The HBM was derived from the social-psychological theory of Kurt Lewin. Therefore, it is important to consider some aspects of Lewin's theory from which the model variables were drawn and adopted. According to Maiman and Becker (1974), Lewin's theory concept focuses on goal setting in the "level of aspiration." Level of aspiration was defined as "the level of future performance in a familiar task which an individual, knowing his level of past performance in that task, explicitly undertakes to reach" (Maiman & Becker, 1974, p.10). A person stating his level of aspiration is in a "choice" situation that is different level of difficulty. The choice is made on the basis of the relative valences (positive or negative attractions) of levels of success or failure and the subjective probability of being able to attain the probable level. Thus, Lewin's theory is concerned with: (1) the value of an outcome to an individual and (2) the individual's estimate of the probability that a given action will result in that outcome.

The HBM extended the use of Lewin's theory to explain preventive health behavior. The HBM has a phenomenological orientation. It is concerned with the subjective world of the acting individual. It proposes that the likelihood that a person will take action relative to a health condition is determined by both the individual's psychological state of readiness to take that action and the perceived benefits of the action weighed against the perceived cost or barriers involved. The individual's psychological condition of readiness to take action is determined by both the person's perceived susceptibility to the particular condition and the perceived severity of the consequences of contracting the condition (Becker et al., 1977).

A perceived benefit of taking action is the individual evaluation of advocated health action in terms of its feasibility and efficaciousness in reducing perceived susceptibility and severity, weighed against psychological and other barriers or costs of taking action. The perceived likelihood of successfully achieving the goal is a function of the perceived benefits of taking action and less the barriers or cost of that action.

Furthermore, the HBM proposed that "cue to action" is a stimulus occurring to trigger appropriate behaviors. It may be either internal (perception of bodily states) or external (interpersonal interaction, mass media communications, and personal knowledge). The required intensity of a cue to action varies with differences in levels of perceived susceptibility and severity. If the levels of perceived susceptibility to or severity of a disease is high, readiness to take action will require only slight stimuli. On the other hand, with relatively little perception of susceptibility to or severity of a disease, intense stimuli would be needed to instigate a response. A group of "modifying variables" is the last component of the HBM and includes demographic, sociopsychological, and structural variables that may affect an individual's perceptions of susceptibility, severity, and/or benefits of taking action. The HBM components and their linkages are summarized in Figure 1.

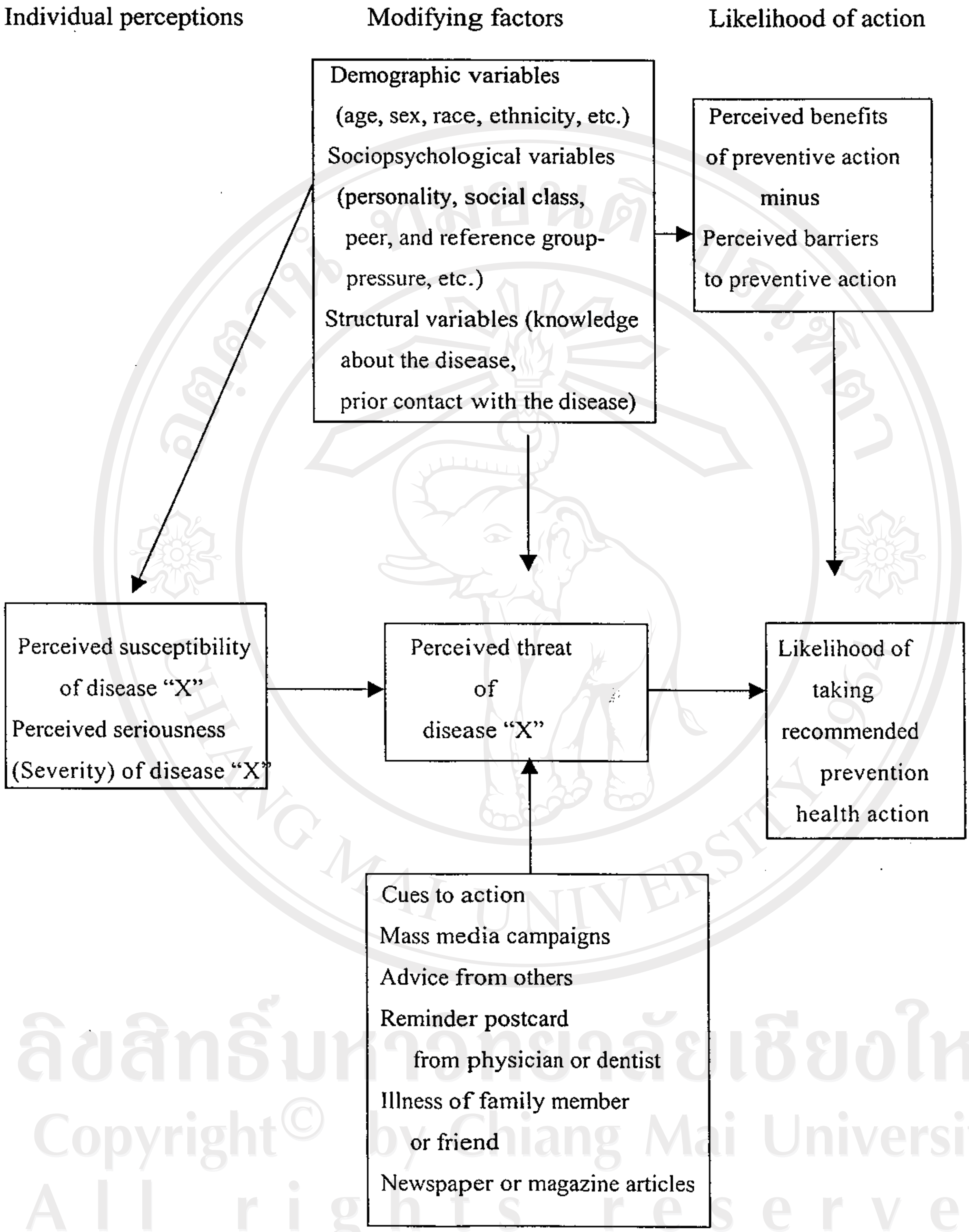

Figure 1. The Health Belief Model (Rosenstock, 1974 a, p.7).

Although the HBM was formulated originally to explain preventive health behavior, several researchers have expanded it to explain other health-related behaviors, such as illness behavior and sick-role behavior (Kirscht, 1974; Becker, 1974). Thus, other variables (health motivation and self-efficacy) were added into the original HBM. Health motivation was introduced into the model on the assumption that motives selectively determine an individual's perception of the environment. Health motivation was defined as an individual's degree of interest in and concern about health matters. To maintain or attain a positive state of health and to avoid a state of illness, health motivation is needed (Becker, Drachman, & Kirscht, 1974).

The concept of self-efficacy was added into the HBM in order to increase its explanatory power (Rosenstock, Strecher, & Becker, 1988). With chronic illness, people require long-term behavior changes, so they need to have an incentive to take action and feel self-efficacious to implement that change. Therefore, "making self-efficacy explicit in the HBM has two values; it delimits the barriers dimension; and, more importantly, suggests new and more productive lines for research and practice" (Rosenstock et al., 1988, p.179).

Review and Critique Research Using the HBM

Over the past 50 years, the HBM has been applied to screening behaviors. It also has been extended to both illness behavior and compliance with medical regimens in sick-role or chronic illness behavior. Medline and the Cumulative Index of Nursing and Allied Health Links (CINAHL), and selected studies cited in other references, were searched only for studies that used the HBM to understand health preventive behaviors. Search terms used were "health belief model, health belief model and preventive behaviors, and health behavior and older adults." The search was limited to studies published from 1991 through 2002, published in English, full articles, and studies presenting the key words of "the health belief model" in the title or abstract. Thirty articles that meet these criteria are reviewed and critiqued in this section. Empirical adequacy, design and instrumentation, and external validity are used to guide this review and critique.

Empirical adequacy. Perceived barriers were the most consistent variable across study populations and outcome behaviors. That is consistent with the findings reported by Jan and Becker (1984), who found that perceived barriers were the most powerful HBM variable, followed by perceived susceptibility. On the other hand, instances of perceived susceptibility found in this review are less supported than instances of perceived severity, although the individual's perception of susceptibility to a disease has been found to be positively related to a screening for health problems such as tuberculosis (Poss, 2000), HIV and AIDS (Lux & Petosa, 1994; Maguen, Armistead, & Kalichman, 2000; M.A. Ross, 1996; Petosa & Jackson, 1991), and cancer (Fung, 1998). Holm, Frank, and Curtin (1999) mentioned that the HBM construction of perceived susceptibility is more appropriate to measure the primary preventive behavior than the secondary preventive behavior.

Perceived severity/seriousness of a health condition has received more support from research studies on a variety of disease conditions than perceived susceptibility. A relatively high degree of perceived seriousness was found in HIV and AIDS groups (Jemmott, Maula, & Bush, 1999; Petosa & Jackson, 1991). In recent years, HIV and

AIDS are increasing. Perceived seriousness is now more frequently considered in screening for health problems than perceived susceptibility.

Studies using multivariate methods have empirically examined the utility of the HBM with regard to predicting HIV risk behaviors or behavior intentions. The findings indicated benefits and barriers were most consistently associated with outcomes (Lux & Petosa, 1994; Petosa & Jackson, 1991) that were similar to the findings of the earlier review (Janz & Becker, 1984). Perceived benefits have been revealed as an important factor that people are more likely to comply with health behavior in both preventive behavior and illness/sick role behavior.

However, almost all of the studies tested four major variables of the HBM - perceived susceptibility, perceived seriousness, perceived barriers, and perceived benefits. Only four studies focused on modifying factors (cues to action and demographic variables) in their studies. The original HBM mentioned this factor as having mediated effects on outcomes. It may be difficult to test the HBM as a whole with all of the modifying variables taken into consideration. Three of the study findings showed age and education were significantly associated with health behavior (Lux & Petosa, 1994; Neff & Crawford, 1998; Petosa & Jackson, 1991), whereas the researcher in another study (Petro-Nustas, 2001) argued that demographic variables did not influence the health beliefs of young women in mammography screening. Thus, a modifying factor may be needed to verify the outcome of studies using the HBM.

Design and instrumentation. The HBM was employed in this review as a framework both in a quantitative design (descriptive and experimental designs) and in a qualitative design (a focus group). In addition, it was used in both prospective and retrospective studies. Although almost of the researchers who conducted those studies agreed with the usefulness of the HBM in predicting health behaviors, some recommended merging the HBM with other psychological theories.

A number of studies (Fung, 1998; Lux & Petosa, 1994; Petosa & Jackson, 1991) used multivariate analysis to test the HBM as independent predictors of preventive behavior. This approach considered only direct effects of HBM variables upon preventive behaviors, and thus had a low predictive power, because the HBM was originally used to explain health related behaviors with limited predictive power. A number of researchers, therefore, have included intention (a concept that is part of the Theory of Reason Action), general health motivation, and self-efficacy as variables in their studies (Adih & Alexander, 1998; Norman, 1995; Piaseu, Belza et al., 2001; Poss, 2000; Sedlak, Doheny & Estok, 2000; Sedlak et al., 1998), and have shown that they are good predictors of behaviors.

From the review, the researcher found that the HBM concepts were measured using the instruments which varied from study to study. With the exception, the Health Belief Model Scales developed for breast cancer screening were used as the instrument in almost all of the studies (Clarke, Lovegrove, Williams, & Machperson, 2000; Foxall, Barron, & Houfek, 1998; Fung, 1998; Holm et al., 1999; Petro-Nustas, 2001). Validity and reliability of revised Health Belief Model Scale were reported, and most reliability scores reported with Chronbach Alpha scores between .66 and .91 of both subscale and total scale.

External validity. Random selection was used in only two of the studies (Piaseu, Belza et al., 2001; Sedlak et al., 1998). In most of the studies, the sample were younger adults; only five studies reported on older adults (Meana, Bunston, George, Wells, & Rosser, 2001; Nexoe, Kragstrup, & Sogaard, 1998; Sedlak, Doheny, & Estok, 2000; Taggard & Connor, 1995; Thomas, Fox, Leake, & Roetzheim, 1996). Because the majority of the studies reflect health beliefs in younger adults who perceived barriers as the most important variable related to health behavior, followed by perceived seriousness — they do not reflect the health beliefs in older adults whose perceptions may be different. Older adults perceive benefits as the most important component, followed by perceived barriers. A number of the studies were conducted in diverse populations. However, small sample size and non-random assignment results in limiting generalizability to other populations.

Implications for Nursing

Understanding the factors associated with health related behavior is important if we are to obtain the cooperation and participation of clients in their own care. As the HBM is individual level theory, personal judgment and knowledge are variables that affect health related behaviors. Moreover, the HBM was developed for the purpose of understanding health related behavior, and fits nicely with the discipline of nursing that is mainly interested in theories that will guide and improve practice. Findings from these reviews provide evidence for implications for nursing practice as well as further research. As found from the review, older adults demonstrated perceived benefits and perceived barriers as the most important factors related to health behaviors, nurses, therefore, should provide this population with information regarding the benefits of various health actions and help them select the action with the highest probability of success as well as help them eliminate obstacle factors to achievement their goals. In addition, a study finding from this review showed older adults with osteoporosis (Sedlak, Doheny, & Estok, 2000) perceived less susceptibility to such a disease, less osteoporosis knowledge, and less performance in preventive behavior. In this case, nurses should provide information regarding an individual's susceptibility to certain health problems and increase this person's realistic perception of the efficacy of the preventive health behavior. Further, in a study aimed to promote actual behavior as well as changes in behavior, incorporation of the HBM with other health behavior theories may be needed since the HBM is a descriptive theory, originally used to explain health related behavior.

Social Learning Theory

Overview of the Social Learning Theory

The Social Learning Theory (SLT) was developed by Bandura and his colleagues in the 1970s to explain human health behavior. This theory was relabeled as Social Cognitive Theory (SCT) in the following year. The SCT is based on a process of reciprocal determinism, behavior, other personal factors, and environmental factors all operating actively as determinants of each other (Bandura, 1977).

According to the SCT, individual motivation and action are regulated by the mechanism of foresightful behavior. These are two types of expectations that exert powerful influence on behavior: outcome expectations and efficacy expectations or perceived self-efficacy. An outcome expectation is defined as a person's estimate that a given behavior will lead to certain outcome, while an efficacy expectation is the conviction that one can successfully execute the behavior required to produce the outcome (Badura, 1977). The difference between outcome and efficacy expectation is presented in Figure 2.

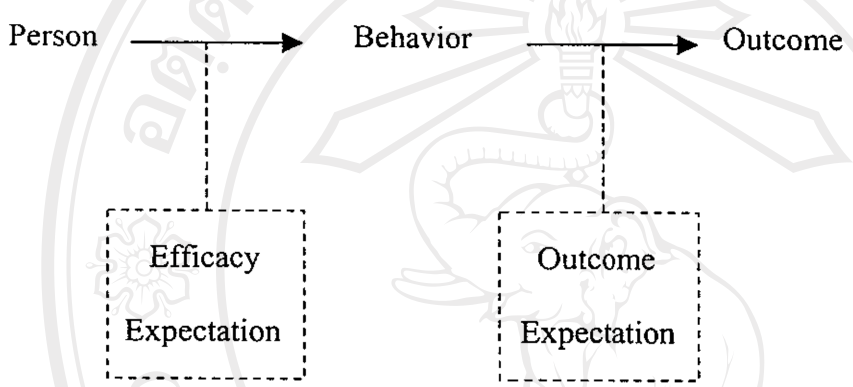

Figure 2. Diagram of the relationship between outcome expectations and efficacy expectations (Bandura, 1977)

Self-efficacy expectation is a central concept of the SCT. An individual expectation varies across behaviors and contexts. People tend to take action that they judge themselves capable of handling successfully, while they avoid threatening situations that they believe themselves unable to handle. Self-efficacy influences how much effort people will expend on a task and how long they will persist in the face of obstacles; the stronger the efficacy, the more active the efforts (Bandura, 1977). Thus, successful changes in health behaviors should increase efficacy expectation or self-efficacy. However, outcome expectations are important in health promotion because if health behavior has uncertain perceived consequences, the initial motivation and decision to change the behavior may rest mainly on outcome expectations (Gecas, 1989; Grembowski et al., 1993).

Self-efficacy is based on four sources of beliefs. These are performance accomplishments, vicarious experience, verbal persuasion, and emotional arousal. Performance accomplishment is based on one's own personal experiences. Mastery experiences are the important source of establishing a strong sense of efficacy. Thus, successes foster a robust belief in one's personal efficacy, while failures demoralize it, particularly if failures occur before a sense of efficacy is firmly established. A resilient sense of efficacy requires experience in overcoming obstacles through sustained effort (Bandura, 1995). Vicarious experience is another source of creating efficacy belief that is provided by social models. Role modeling affects mastery expectation. If people see others who similarly succeed by sustained effort, they will raise their perceived capabilities of accomplishing such activities. Verbal persuasion is the third source of establishing people's self-efficacy belief. Persons who are persuaded verbally that they can successfully manage in given activities are likely to mobilize their efforts and sustain them. Although verbal persuasion is widely used because of its ease and ready availability, self-efficacy created by this source is likely to be weak and short-lived. Therefore, situations that bring success and avoid placing persons in situations prematurely where they are likely to fail should be established (Bandura, 1977, 1995). The final promoter of self-efficacy is emotional arousal. Emotional arousal affects self-efficacy in threatening situations. Physical and emotional states influence a person's perception of his/her capabilities because he/she will interpret his/her stress reaction and tension as signs of vulnerability to poor performance (Bandura, 1995). Thus, individuals are more likely to expect their successes when they are not overwhelmed by aversive arousal than when they are tense, trembling, and viscerally nervous (Bandura, 1977).

Efficacy expectations (self-efficacy) also vary on three dimensions: magnitude, generality, and strength. Magnitude refers to levels of difficult tasks. Individuals may be limited by the different tasks. For example, people may variously be limited to simpler tasks, extend to moderately difficult ones, or include even the most demanding ones. The difference in generality is that some experiences create only limited mastery expectation, whereas others may extend beyond the specific situations. In terms of different strengths, individuals who possess strong expectations of personal mastery will persevere in their coping efforts despite dissuading experiences, while weak expectations are easily extinguishable by disconfirming experiences (Bandura, 1977).

Because the SCT is based on the combination of the concept that cognitive processes are central to acquiring behavior with the notion that performance-based procedures are powerful in changing behavior, it is widely used in various disciplines for understanding health behavior.

Review and Critique Research Using Self-efficacy among Older Adults

Medline and the Cumulative Index of Nursing and Allied Health Links (CINAHL) were searched for studies using self-efficacy to understand health behavior among older adults. Search terms used were "self-efficacy, self-efficacy and older adults, social learning theory, social cognitive theory, Bandura's theory, and self-efficacy and health behavior." The search was limited to studies published from 1991 to 2002, published in English, full articles, and presented key words of "self-efficacy and older adults" in the title or abstract. Fifteen articles that fit these criteria are presented and critiqued. Empirical adequacy, study design and instrumentation, and external validity were used to guide the critique.

Empirical adequacy. The findings from these reviewed studies support evidence that self-efficacy and outcome expectation exert an influence on the health behavior of older adults, particularly exercise behavior (Clark & Nothwehr, 1999; Conn, 1998; Jette et al., 1998; McAuley, Lox, & Duncan, 1993; Resnick, 2001a; Resnick, 2001b; Resnick, Palmer et al, 2000; Resnick & Spellbring, 2000). Most studies theoretically supported the concept that self-efficacy expectations have a greater influence on behavior than outcome expectation (Clark & Nothwehr, 1999; Conn, 1998; Grembowski et al., 1993; Resnick, 2001a; Resnick, 2001b; Resnick, Palmer et al., 2000; Resnick & Spellbring, 2000). In contrast to other works, a finding from one study found no evidence that older adults' self-efficacy related to exercise behavior (Jette et al, 1998), while another study showed outcome expectations have a stronger influence on exercise behavior than self-efficacy (Resnick, 2001a). Although perceived self-efficacy has been shown to be a major determinant of health-preventive behavior (Bandura, 1995), engagement in exercise has varied (Conn, 1998; Resnick, Palmer et al., 2000; Resnick & Spellbring, 2000). In addition, findings from a mixed qualitative with quantitative study supported the important influence of outcome expectations on adherence to walking (Resnick & Spellbring, 2000).

Theoretically, the notion of reciprocal determinism describes the interaction among the person, environment, and behavior. Findings indicated that demographic variables have little impact on the efficacy beliefs of older adults (Grembowski et al., 1993; Resnick, 1998). The other studies found that socio-demographic variables were strongly related to self-efficacy expectation (Clark & Nothwetr, 1999; Seeman, Rodin, & Albert, 1993), but only in men (Resnick, Palmer et al, 2000; Seeman et al, 1993). Age was found to be as an important negative direct and indirect predictor of self-efficacy (Conn, 1998; Resnick, Palmer et al., 2000). However, these findings relied on specific sample and behaviors.

Design and instrumentation. A descriptive design and a cross-sectional intervention study were employed in most studies. There are only a few studies available using longitudinal studies (Kurlowicz, 1998; Mancuso, Rincon, McCulloch, & Charlson, 2001). Path analysis (Conn, 1998; Kurlowicz, 1998; Resnick, 2001a; Resnick, 2001b; Resnick, Palmer et al., 2000) as well as multiple regressions (Clark & Rodge, 1999; Grembowski et al., 1993; Seeman et al., 1993) was used in a number of studies. Data obtained from these studies were not available on a range of factors that might predict behavior such as education levels. It may be that other variables not tested would have a more insightful effect on health behavior. In addition, the cross-sectional nature of these data precluded any conclusions regarding causality in the observed relationship between efficacy beliefs and behavior changes. The complexity and reciprocity of these relations or various constructs, however, is suggested by the mixed findings from longitudinal and intervention studies (Clark & Nothwehr, 1999; Seeman et al., 1993).

Exercise behavior was used for studying health behavior changes in almost all of the studies. Even though measures used varied from study to study, reliability and validity were adequately reported in all studies. For instance, the Self-Efficacy Expectation Scale (SES) was reported to have high internal consistency reliability (.88-.90) (Kurlowicz, 1998). The Self-Efficacy for Exercise Scale (SEES) was confirmed for its reliability which internal consistency reliability was .93 (Resnick, 2001a). The Outcome Expectations for Exercise Scale (OEES) had internal consistency with alpha coefficient ranging between .72 and .93. Confirmatory factor analysis provided evidence for validity of measures with the path coefficients ranged from .65 to .85 (Resnick, 2001b; Resnick, Palmer et al., 2000). However, all instruments were self-reported. The use of subjective reporting might influence the validity of the findings. Therefore, the Step Activity Monitor or a motion sensor might provide additional confirmation of the subjective report.

External validity. The sample size in the reviewed studies varied from 76 (Kurlowicz, 1998) to 2,524 (Grembowski et al., 1993). Random selection was reported in only three studies (Cameron et al., 2000; Clark & Nothwehr, 1999; Resnick, 1998). Participants in a number of studies were well educated and participated in health care centers, such as a continuing care retirement community. In addition, studies using path analysis (Conn, 1998; Kurlowicz, 1998; Resnick, Palmer et al., 2000; Resnick, 2001a) were reported with a small sample size that was smaller than the 200 participants generally recommended when doing structural equation modeling, and were also too small to test reciprocal pathways (Bollen, 1989). Due to small sample size and selective sampling, the findings cannot be generalized to all older adults.

Implications for Nursing

Evidence clearly supports that self-efficacy expectations are important factors associated with health behavior in the older population. This finding has important implications. First, at-risk individuals who have low self-efficacy should try to raise self-efficacy in order to change health behavior. Second, although patients need skills and information for practicing the recommended health behavior building confidence in performing behaviors appears to be an important part of any educational program for them. Third, self-efficacy expectations should be assessed prior to initiating an intervention program and then followed over time to better understand the relationship between self-efficacy and health behavior. Fourth, it is quite possible that individuals who are older and/or have preconceived notions regarding deteriorating physical condition might believe they can no longer get benefit from healthy behaviors, such as exercise. Therefore, self-monitoring of physical function and conditioning and providing some feedback about their progress, will raise their self-efficacy thereby increasing health behavior. Fifth, because older adults are individually different, the factors that motivate them to participate in health behaviors should vary. The intervention aimed at improving physical and functional health should include a focus on psychological variables, such as beliefs about health behaviors and self-efficacy related to specific health behaviors. Finally, intervention with self-efficacy and barriers-management education for older adults, a vulnerable population, could result in important health behavior changes.

Summary

Osteoporosis is a major health concern affecting a large and growing population, particularly the elderly. The consequent problems include disability, pain, deterioration of quality of life, morbidity, mortality, and economic health care cost. These problems affect both the individuals and the society. However, even though age–related decline is a factor contributing to osteoporosis in the elderly, modification of lifestyles and reduction of risk factors as well as early detection are important to maintain and promote good bone health.

Several studies support the idea that calcium is an important factor contributing to peak bone mass and maintenance of bone health. The best source of calcium is found in foods. Supplements are a valuable alternative when necessary. Unfortunately, many research results show that people consume less calcium than is recommended, both in Thailand and in other western countries. Vitamin D is also a major factor promoting bone health by helping calcium absorption. Even though only 15 minutes of daily exposure to sunshine during the summer season produces sufficient vitamin D intake, the results from many studies show insufficient vitamin D intake. However, the findings reported that Thai people had enough vitamin D levels in their serums. Lifestyle factors, particularly exercise, are crucial in preventing osteoporosis. It is widely accepted that weight–bearing exercise is the most important to promote bone health although there has not been absolute agreement on duration and frequency of weight-bearing exercise that would promote and maintain bone mineral density. Many studies have suggested 30 minutes of brisk walking three to four times weekly as an excellent way for people to incorporate exercise into their daily lives.

Since knowledge has been a factor in motivating people to engage in preventive behaviors, several studies focus on developing educational programs specific to osteoporosis knowledge. The researchers attempt to develop a comprehensive program and test for their effectiveness. Psychological theories, such as the HBM and the SE were employed as the theoretical base of several studies and demonstrated their effectiveness on healthy behavior. Additionally, any educational osteoporosis prevention program incorporating with bone mass testing was substantial effects on behavior changes. However, there has been limited of a comprehensive educational osteoporosis prevention program for older adults.

Considering the enormous costs and the morbidity and mortality associated with osteoporosis, prevention is the best and most cost-effective approach. Effective programs on motivating at-risk individuals to healthy behavior such as having a well-balanced diet containing adequate amounts of calcium, and exercising by walking and remaining as active as possible must be developed in order to stop accelerating bone loss and maintain bone health to promote quality of life in the elderly.

Conceptual/Theoretical Framework

The Health Belief Model (HBM) and Self-efficacy Expectations (SE), derived from SCT, have been synthesized as a model to promote and understand osteoporosis preventive behaviors. According to HBM, a person who has certain beliefs will be more likely to engage in preventive behaviors (Rosenstock, 1974b). The health beliefs associated with osteoporosis might be perceived susceptibility to osteoporosis, perceived seriousness of osteoporosis, perceived benefits of preventive behaviors such as calcium intake and weight-bearing exercises and few perceived barriers to osteoporosis prevention (e.g. inconvenience, cost, and difficulty). Logically, the more benefits the at-risk patient receives from the recommendations, the more likely it is that he/she will take action; the more barriers, the more likely it is that he/she will not participate.

This educational program, the "Join the Movement to Have Healthy Bones Project: JHBP", provided knowledge of osteoporosis aimed at: 1) increased perceived susceptibility to osteoporosis, perceived seriousness of osteoporosis, perceived benefits of calcium intake and weight-bearing exercise, and perceived motivation; and 2) decreased perceived barriers to consume calcium and weight-bearing exercise. Since lifelong habits of eating or exercising are obviously difficult to surmount, modifying them requires a good deal of confidence that one can in fact alter such behaviors. Therefore, to succeed in behavioral changes, persons must have an incentive to take action, feel threatened by their current behavioral styles, and believe that change of a specific behavior will be beneficial by resulting in a valued outcome at acceptable costs. They must also feel self-efficacious to participate in that change (Rosenstock et al., 1988). These support the need to combine self-efficacy to the original components of the HBM to better understand osteoporosis preventive behavior, and to promote behavior changes. Additionally, the HBM does not suggest a specific approach for intervention to be used by the investigator, while self-efficacy addresses strategies to promote behavior changes. Self-efficacy can be increased by putting a person in a situation where he/she can practice and master a behavior, learn from a role model, and receive verbal persuasion led through suggestions into believing he/she can perform a given activity. This educational program, the "Join Movement to Have Healthy Bones Project: JHBP", provided specific approaches for promoting preventive behavior and behavior changes.

The hypothesized explanatory model combining concepts from the HBM and the SE model guiding this study is addressed in Figure 3. A person who participated in the education intervention program could obtain osteoporosis knowledge, and then increased health beliefs and self–efficacy to practice osteoporosis preventive behaviors. Increasing calcium intake and brisk walking exercise were the major goals of this study. However, the effects of two these behaviors on healthy bones (increasing bone mass or maintaining bone mass) were not assessed since they are results of long-term behavior changes, over years rather than months.

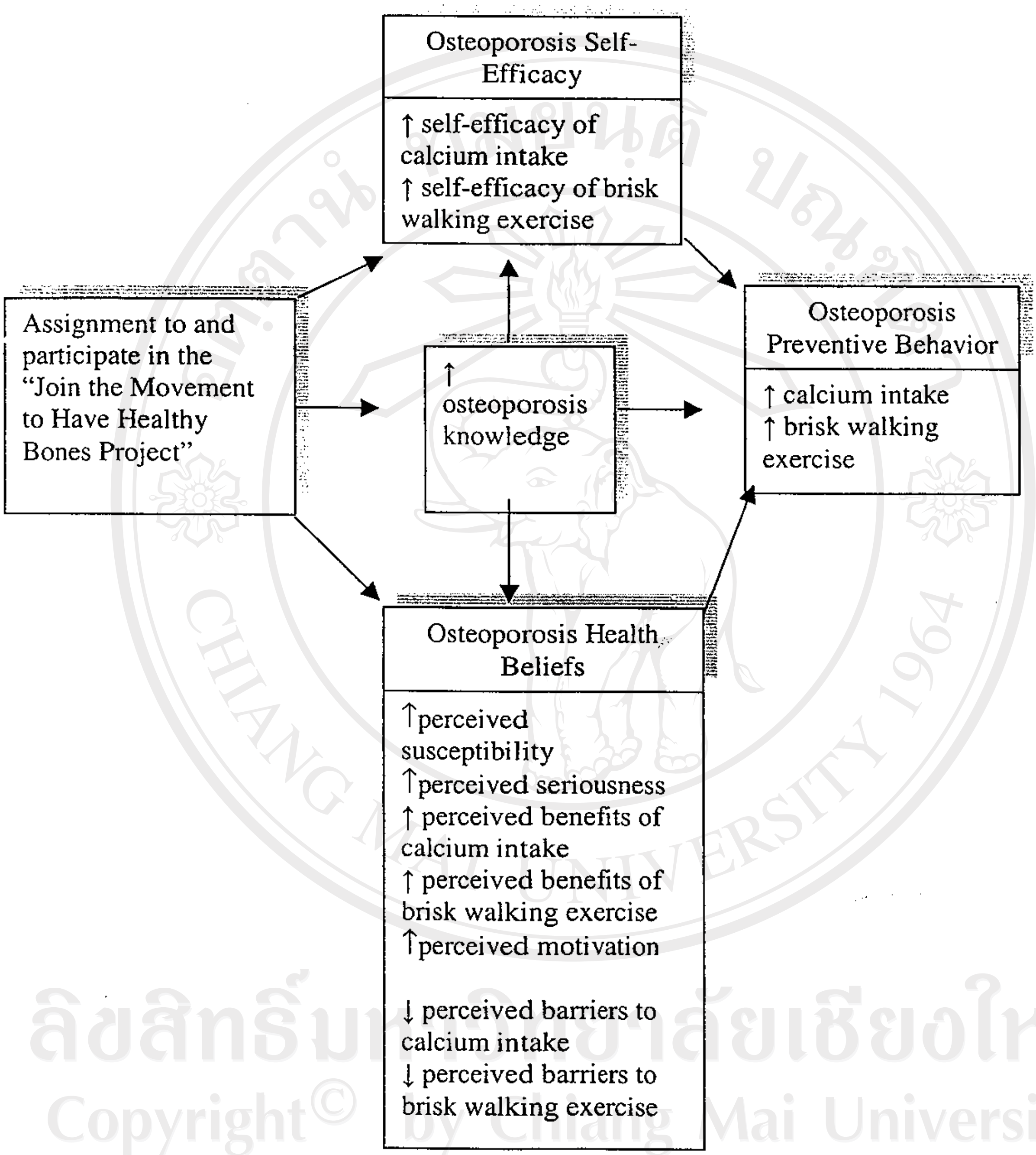

Figure 3. Hypothesized Model of the Study