

**Women's Actions Related to Health Behaviors after Receiving
Bone Mineral Density Results: An Exploratory Study**

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Abstract

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Women's Actions Related to Health Behaviors after Receiving Bone Mineral Density

Results: An Exploratory Study

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Bone densitometry represents a major advance in the clinical management of osteoporosis. In fact, bone densitometry is the only clinically acceptable and objective method for the accurate measurement of bone mineral density (BMD), bone mass, and the prediction of bone fracture risk. Dual energy X-ray absorptiometry (DXA) is the primary diagnostic bone densitometry tool used in clinical settings. Because the use of bone densitometry is widespread, a growing need exists to determine how health care professionals and women use the information obtained from DXA scans in the management of osteoporosis. Few studies have investigated physicians' recommendations and women's compliance related to detection and treatment of osteoporosis after receiving BMD results by DXA. No studies have investigated actions that women have taken after receiving BMD test results conducted by DXA. This descriptive, exploratory study assessed actions that women took and what they perceived their physicians did after receiving BMD results. Using a telephone survey, actions of 138 women, who participated in a previous study of bone health, were evaluated regarding osteoporosis detection, prevention, and treatment. Many women (62%) shared their BMD test results with health professionals. However, 75% of women with low BMD status and who shared their results with health care professionals reported that they did not receive recommendations for advanced tests. Moreover, these women did not receive recommendations for dietary intake changes (60%), medication use (72%), or other lifestyle changes (60%). Yet 58% of these women self-initiated behavioral changes after receiving their BMD test results. Eighty-five percent of all participants shared their BMD test results with family members, friends, and co-workers, and 70% of all participants encouraged other individuals to have their BMD tested. Of the women who changed their behaviors, 67% of postmenopausal women increased exercise. Ninety-two percent of these women indicated that they would engage in BMD testing again. Many women are interested in their bone health and are willing to share their personal BMD test results with health care professionals and others. Women who may need medical attention for their bone health report a lack of advanced care and few recommendations for impacting bone status.

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Chapter 1: Introduction

While many individuals with osteoporosis are now being properly diagnosed (Laroche and Mazieres, 1998), many patients do not have the underlying cause of their osteoporosis adequately evaluated (Economides, Kaklamani, Karavas, et al., 2000). Further, effective therapies to treat osteoporosis are often not used (Hill, Weiss & LaCroix, 2000; Vestergaard, Hermann, Gram, et al., 1997). Sometimes the attending physician does not appropriately instruct the patient (Laroche & Mazieres, 1998), and sometimes the patient either ignores or never understands the advice (Ryan, Harrison, Blake, et al., 1992). Moreover, studies show that patients with osteoporosis often have a poor understanding of their disease and how to manage it (Ribeiro, Blakeley & Laryea, 2000; Ryan et al., 1992). Osteoporosis diagnosis is easily conducted, but for many reasons, therapy and lifestyle modifications have not been optimally implemented for or by patients.

A surplus of published practical guidelines for the clinical treatment of osteoporosis exists. Agencies such as the National Institutes of Health (NIH) and the American Association of Clinical Endocrinologists (AACE), as well as others, have presented considerable evidence that various treatment measures are effective for osteoporosis (Cauley, Seeley, Ensrud, et al., 1995; Rico, Revilla, Hernandez, et al., 1995; Storm, Thamsborg, Steiniche, et al., 1990). In order to treat osteoporosis, however, a diagnosis must first be made. Until very recently, detection of osteoporosis was extremely difficult. Usually by the time this condition was apparent to a doctor or to a patient, extensive and irreversible bone loss had already occurred (Eiskjaer, Ostgard & Jakobsen, 1992). In the past, x-rays were utilized in an attempt to diagnose osteoporosis. However, about 40% of a woman's bone structure must have been lost from the thoracic or lumbar spine, for example, before this condition could have been observed by standard radiographs or x-rays (Eiskjaer et al., 1992). Unfortunately at this point, the woman would have already had osteoporosis, as well as a very high chance of sustaining bone fractures. In light of this fact, it was imperative that a better method for detecting osteoporosis be developed. Additionally, this method needed to be able to identify osteoporosis whether or not bone fractures were present. Recognizing this latter need to detect osteoporosis in persons who did not have bone fractures, researchers and clinicians argued that bone densitometry, the measurement of bone mineral density (BMD), would be a valuable method to predict the risk of bone fracture by detecting osteoporosis, or

a BMD of 2.5 standard deviations below the young-adult, gender-matched mean (Miller, Bonnick & Rosen, 1996).

Bone densitometry represents a major advance in the clinical management of osteoporosis. Before the advent of bone densitometry, the diagnosis of osteoporosis depended on the presence of a fragility fracture or extreme loss of bone structure. However, with the ability to measure BMD, the diagnosis of osteoporosis can now be made much earlier in the disease process (Compston, Cooper & Kanis, 1995). In fact, bone densitometry is the only direct objective method for the accurate measurement of BMD, bone mass, and the prediction of fracture risk. Similarly, Compston and colleagues (1995) noted that BMD provides the best prediction of fracture risk, and the assessment of bone mass in individuals at risk for osteoporosis enables preventive measures to be instituted before fracture occurs.

Bone densitometry, through dual energy X-ray absorptiometry (DXA), has been established as the “gold standard” for the measurement and assessment of osteoporosis. During the past ten years, several other noninvasive techniques have become available to measure bone mass. For example, bone sonometry, computerized tomography, and peripheral densitometry have been developed for the measurement of BMD (Eastell 1996; Kanis, Melton, Christiansen, et al., 1994). While the choice of the appropriate technique for bone mass measurements in any given clinical circumstance should be based on an understanding of the strengths and limitations of the different techniques, BMD measurement by DXA is currently the most widely used technique for measuring bone mass at the hip, spine, wrist, and for the total skeleton (Seeger 1997; Sturtridge, Lentle & Hanley, 1996).

Measurement of BMD and assessment of results present one aspect of osteoporosis treatment. Because BMD is multifaceted, factors that contribute to low BMD or osteoporosis should be determined. For example, diseases that are associated with a reduced bone mass should be identified (Glaser & Kaplan, 1997; Seeger 1997). Genetic factors, hormonal status, and medication use should be explored, and lifestyle factors that affect BMD must be considered (Fordham 2000). Evaluations of these factors assist clinicians in determining the appropriate course of treatment for an individual with osteoporosis.

Because the use of bone densitometry is widespread, a growing need exists to determine how primary care physicians, gynecologists, and other physician specialists use the information obtained from DXA scans in the treatment of patients. Only a limited

number of studies have addressed how physicians treat osteoporosis following bone density testing (Cole, Paulushock & Haboubi, 1999; Economides et al., 2000; Laroche et al., 1998). Moreover, many individuals have become more involved in self-care and self-efficacy of treatment of health conditions. To date, only one study has investigated physicians' recommendations and women's compliance related to bone health after receiving BMD by DXA results (Cole et al., 1999). No studies have investigated the actions of women who have received BMD test results, conducted by DXA.

Because osteoporosis affects approximately 75 million persons worldwide (Branca 1999), and the healthcare costs related to osteoporosis approach \$15 billion annually in the United States alone (Ray, Chan, Thamer, et al., 1997), evaluation of individuals' and physicians' actions following receipt of BMD results is important. Appropriate treatment and compliance with treatment are both critical aspects of osteoporosis care. Therefore, the objective of this descriptive, exploratory study was to assess actions that women took and to understand what these women perceived their physicians did after receiving their personal BMD test results.

Chapter 2: Literature Review

Bone fractures due to osteoporosis will occur in approximately one of every two women after the age of 50 years (Bellantoni 1996). Moreover, women who suffer one bone fracture due to osteoporosis are significantly more likely to suffer additional fractures (Kotowicz et al., 1994). Osteoporosis is an easily detectable and treatable disease, however. Many women have opted to undergo bone mineral density (BMD) testing to detect for osteoporosis with the intent to prevent or treat this disease as needed. While extensive bodies of literature exist regarding risk factors for osteoporosis, prevention strategies, and effective treatment options, a paucity of data exists for the evaluation of actions by women and their physicians after BMD testing is completed. This chapter addresses osteoporosis—its definition, prevalence, costs, risk factors, and detection—as well as assessment, prevention and treatment of osteoporosis. The few studies that have investigated women’s and physicians’ actions beyond measurement of BMD are also discussed.

Definition of osteoporosis

Osteopenia is a condition of low bone mass that, if not detected and treated, may lead to osteoporosis. Osteoporosis is a progressive disease resulting in low bone mass and bone deterioration of the microarchitecture of bone tissue. This systemic skeletal disease results in increased bone fragility and susceptibility to bone fractures (NIH 2001). Individuals with osteoporosis have weak bones due to the depletion of BMD and bone structure. The combination of low BMD and alteration in bone composition results in weak bones, and numerous persons with osteoporosis will experience bone fractures. The definition of osteoporosis as set by the World Health Organization is a BMD of “ ≥ 2.5 standard deviations below the young-adult, gender-matched mean” (WHO 1994). Four general diagnostic categories for bone mass have been established for adult women (Lane, 1999). These categories include: normal (T score ≥ 1 SD below young-adult average); osteopenia (T score < 1 but > 2.5 SD below young-adult average); osteoporosis (T score ≥ 2.5 SD below young-adult average); and severe osteoporosis (T score ≥ 2.5 SD below young-adult average plus the presence of one or more osteoporotic fractures). The link between low BMD, skeletal fragility, and bone fracture risk is strong; thus, BMD testing provides the best method for detecting osteoporosis (Ross, Davis, Epstein, et al., 1991). Fractures most commonly arise in

the tibia, hip, pelvis, rib, spine, and wrist (Cummings, Black & Nevitt, 1993). Nearly every bone fracture that occurs in an older individual is an osteoporotic fracture as the bone has become demineralized (Nevitt, Johnell & Black, 1994).

Osteoporosis may be separated into two broad categories. The first type of osteoporosis is most commonly observed in postmenopausal women. Type I or postmenopausal osteoporosis is bone loss owing to estrogen deficiency (Consensus Development Conference 1993). Estrogen hinders resorptive action of bone cells and facilitates the maintenance of a standard bone remodeling rate (Canalis 1996). Thus when levels of circulating estrogen decline subsequent to menopause or other causes of estrogen deficiency, women can be subjected to losses of BMD and alterations in bone (Canalis 1996). Low BMD and loss of bone architecture leave the bone thin and fragile, usually resulting in fractures of the hip, pelvis and vertebrae. Women who have experienced any form of ovarian failure are also in danger of losing bone mass because of a deficiency of estrogen (Wasnich 1993). The second type of osteoporosis is age-associated and typically occurs in people older than 70 years. Type II or “senile” osteoporosis is often due to an older person’s diminished capacity to absorb calcium (Cummings & Nevitt, 1997). Parathyroid hormone level increases to maintain serum calcium with the consequence of bone losses. This type of osteoporosis frequently results in fractures of the hip, humerus, rib, pelvis, and vertebrae in both older women and men. Additional causes of osteoporosis involve pathologic conditions such as hyperthyroidism, extended bed rest, or long-term corticosteroid use, for example (Kanis et al., 1994).

Throughout development, bone mass propagates by means of linear growth, cancellous modification, and cortical apposition (Parfitt 1987). These processes are often referred to as modeling. Bone modeling during development and remodeling throughout life are dependent upon factors that regulate the number and activity of both bone-forming osteoblasts and bone-resorbing multinucleated osteoclasts. During the process of continued bone formation, the osteoblasts encase themselves within the bone matrix and become osteocytes. The osteocytes have direct connections to the outer bone surface through microcaniculi (Buckwalter, Glimcher, Cooper, et al., 1995). The osteoclast is believed to degrade bone matrix by releasing hydrolytic enzymes, superoxide radicals and protons into what can best be described as an extracellular phagolysosome (Karsenty 2000). In the adult,

after termination of linear growth, bone formation and resorption are coupled in a process called remodeling. Bone remodeling is the process by which bone mass is maintained at a virtually constant value between the end of skeletal growth and gonadal failure (Hercz 2001). In every remodeling cycle in the young adult, bone formation matches the quantity of bone removed during resorption. However, as aging continues, bone formation lags behind bone resorption, bringing about a net loss of BMD with each remodeling cycle (Kleerekoper 2001). This loss of BMD with aging may be accelerated or progress at a normal pace, depending on medical status, hormonal status, and other lifestyle factors.

Osteoporosis is not always the consequence of normal or rapid bone loss. Bone loss commonly occurs as men and women age, but an individual who does not achieve optimal, or peak BMD during childhood and adolescence may develop osteoporosis without the occurrence of accelerated bone loss (Fordham 2000). Therefore, less than optimal bone development and accumulation of BMD in childhood and adolescence is as significant to the development of osteoporosis as is bone loss in later years (Fordham 2000). Nonetheless, when a BMD that is significantly lower than the mean for a male or female is measured, osteoporosis is diagnosed.

Prevalence

At present, osteoporosis has been diagnosed in 10 million people in the United States, typically women, and is expected to affect millions more (NOF 1998). The pervasiveness of osteoporosis and the frequency of bone fracture vary by gender and race or ethnicity. According to data collected in the third National Health and Nutrition Examination Survey (NHANES III), 20% of women and 5% of men aged 50 years and above in the United States have osteoporosis (Looker, Orwoll, Johnston, et al., 1997). Caucasian, postmenopausal women sustain almost 75% of all hip fractures and have the highest age-adjusted incidence of fracture (Melton & Riggs, 1983). Even though Caucasian women are predominantly affected, African-American, Hispanic, and Asian-American women are also susceptible to osteoporosis (Cummings, Cauley, Palermo, et al., 1994). Moreover, men and children may also suffer from osteoporosis (Fassler & Bonjour, 1996; Vanderschueren, Boonen & Bouillon, 2000), although the frequency of osteoporosis amongst these latter groups is less clear. In fact, recent studies have found that osteoporotic vertebral fractures occur more

often in men than was previously thought. Because the elderly male population is rapidly increasing, future increases in the incidence of osteoporosis in men are expected. More recent data from the first phase of the NHANES III study indicated that the prevalence of osteoporosis of the total hip was 21% among Caucasian women, compared with 16% and 10% among Hispanic-American and African-American women, respectively (Looker et al., 1997). Using the NHANES III data, the National Osteoporosis Foundation (NOF) has estimated that > 10 million Americans currently have osteoporosis, but that an additional 18.5 million have low BMD, placing them at increased risk for osteoporosis (Looker et al., 1997). Thus, the prevalence of osteoporosis is remarkable in the United States with the potential for an even greater need for osteoporosis treatment.

Cost to health care and society

Osteoporosis is a serious health concern throughout the world. In the United States, direct medical care expenses for treatment of osteoporotic fractures are nearly \$15 billion annually, with \$45.2 billion expected just eight years from now (Cooper 2000). Osteoporosis and associated fractures account for the second highest use of hospital inpatient, emergency department, nursing home, and home and hospice care services (Hoerger, Downs, Lakshmanan, et al., 1999). Osteoporosis ranks third in physician office and hospital outpatient visits with subsequent diagnoses (Hoerger et al., 1999). A majority of these estimated costs are related to in-patient care; these costs do not include treatment for individuals without a history of fractures, nor do they include the indirect costs of lost wages or productivity of individuals or caregivers (NIH 2001). Consequently, these figures grossly underestimate the true costs of osteoporosis to health care and to society.

Osteoporosis has physical and psychosocial consequences in addition to financial concerns. These aspects significantly affect individuals, their families, and communities. If allowed to progress without treatment, osteoporosis is one of the leading causes of suffering, disability, and death in individuals (Oleksik, Lips, Dawson, et al., 2000). In 1996, there were approximately 340,000 hospital admissions for hip fractures in the United States (Graves & Owings, 1998). Women and men who sustain hip fractures have high mortality rates, and even individuals fortunate to survive the acute hospitalization are, unfortunately, at increased risk for long-term disability (Scott 1990). Osteoporotic fractures are associated with

increased difficulty with daily activities (Melton & Riggs, 1983). Additionally, fear, anxiety, and depression are frequently reported in women with established osteoporosis (Oleksik et al., 2000). The adverse effects on the quality of life are increasingly recognized. For example, many patients have continual, long-term pain as a consequence of spinal deformity, which may persist long after the acute pain of a vertebral fracture has subsided. Because the direct and indirect costs of osteoporosis to the health care system and society are so great, early detection, prevention, and effective treatment are crucial. Evaluation of risk factors for osteoporosis presents a simple, noninvasive means of establishing an individual's susceptibility to osteoporosis.

Risk factors for osteoporosis

Osteoporosis is a multifactorial disease. Several modifiable and non-modifiable risk factors for osteoporosis exist. In general, older age, female gender, Caucasian ethnicity, low body mass, poor dietary intake, and physical inactivity are all risk factors for osteoporosis (NIH, 2001). Genetic relation to an individual with osteoporosis is also a significant risk factor for this disease (Karasik, Ginsburg, Livshits, et al., 2000). Lifestyle habits, such as tobacco use and alcohol overuse, are related to an increased risk for osteoporosis. Tobacco and heavy alcohol consumption may have direct toxic effects on bone tissue. They may also indirectly affect bone mass through poor dietary intake and compromised nutritional status. Additionally, medical conditions (such as diabetes mellitus, hyperthyroidism, and Crohn's disease), use of medications (such as corticosteroids and laxatives), menopausal status (postmenopause), and lack of exposure to sex-steroid hormones (amenorrhea) are also linked to osteoporosis risk (Schoon, van Nunen, Wooters, et al., 2000). Brief screening of these risk factors may suggest osteoporosis; however, the only way to clinically identify osteoporosis is through the measurement of BMD by bone densitometry.

Osteoporosis detection

Because the best predictor of a future osteoporotic bone fracture is current BMD, bone densitometry is an important diagnostic tool for osteoporosis (Slemenda, Hui, Longcope, et al., 1990). Several methods are available for the measurement of BMD,

including dual energy X-ray absorptiometry (DXA), ultrasonography, and computerized axial tomography (CT).

The most widely used method for BMD measurement is DXA. Relatively inexpensive, with costs ranging from \$150-\$200, DXA can measure BMD of the total skeleton, total proximal femur, forearm, and lumbar spine (Blake & Fogelman, 2001). The hip and spine measurements are especially important because the most serious complications and consequences of fractures occur in these areas (Cummings et al., 1993). Bone sites such as the hip and spine are surrounded by various amounts of soft tissues, including fat, muscle, and abdominal organs. Measurement of these specific sites, therefore, requires a tool that can penetrate through soft tissues; DXA accomplishes this task, thereby allowing for the measurement of both superficial and deep bone mass (Blake & Fogelman, 2001). Using x-ray technology, photons of two (dual energy) energy levels are emitted and absorbed by the body tissues at variable rates. Each pixel of the body is assigned a value for BMD, fat-free soft tissue mass, or fat mass.

For measurements of BMD by DXA, an individual is required to lie on the DXA table. For the lumbar spine, the legs are elevated with a rectangular cushion placed beneath the legs to reduce curvature of the lower back. From a DXA scan, a system computer generates a report of the bone mineral content, BMD, and comparison of this BMD to the age- and gender-matched mean (Z score), as well as comparison to the young-adult, gender-matched mean (T score) (Lane 1999).

The total proximal femur or hip is another commonly measured site (Lane 1999). Bone mass can be measured for the total hip and, thereby, for anatomical parts of the hip. The DXA may also measure total body and forearm bone mineral content and BMD. With a high rate of precision and repeatability in addition to an extremely low dose of radiation, DXA scans are useful and safe for both initial and repeated measures of BMD (Goldmann & Horowitz, 2000). Currently, DXA is the “gold standard” tool for the evaluation and diagnosis of osteoporosis in clinical practice.

Another commonly available testing tool for osteoporosis is quantitative ultrasound (QUS). This method measures the speed of a sound wave traveling through bone. The transit time of the ultrasound wave may be related to the amount of BMD and to the trabecular structure in the interior of the bone (Nelson 1999). This technique is less

expensive than DXA, with costs ranging from \$30-\$100 (Nelson 1999), and does not involve radiation. However, QUS only measures BMD at the heel (calcaneus), finger (metatarsal), tibia, and patella—sites that involve less complications with osteoporosis treatment and fractures (Nelson 1999). Bone density of the hip and spine cannot be measured by the QUS technique.

Of note, however, researchers are currently trying to determine whether the ultrasound measurement gives an indication of bone quality or structure that is superior to the information provided by DXA (Lane 1999). Most studies suggest that QUS measurements give different information about bone mass, but are equal to DXA in predicting future fractures (Frost, Blake & Fogelman, 2001). The results of QUS reflect not only BMD but also properties of collagen in bone. While this information is helpful because QUS results are strongly correlated with fracture risk (Frost et al., 2001), QUS is not a substitute for direct measurement of the hip or spine BMD by DXA. Because DXA measurements display information about the quantity of bone, and QUS measurements provide information about the quality of bone, a combination of these two techniques may likely give better and more useful assessment of an individual's risk of developing an osteoporotic fracture.

Computerized axial tomography (CT or CAT) scans are primarily used for research purposes; however, they can be helpful when other tests are not available or for special situations. A CT scan can create a three-dimensional image of the bone; this is important when an individual appears to be losing trabecular and cortical bone at different rates. In such a case, a CT scan would allow separate examination of the trabecular bone. Specifically, the best method for determining early trabecular bone loss in the spine is with a specially modified quantitative computed tomography (QCT) scanner (Lane 1999). This tool is important because QCT can give an accurate measurement (i.e. 100% trabecular bone mass with 0% cortical bone) that can be used to calculate an individual's risk of vertebral fracture. Bone fractures occur because of the loss of both cortical and trabecular bone, however. Thus, QCT should not be performed in place of DXA testing but as an adjunct to DXA. Additionally, QCT is very expensive and involves a much higher amount of radiation (x-ray source). More recently, a peripheral QCT scanner (pQCT) has been developed that can measure both cortical and trabecular bone of the forearm (Lane 1999). The radiation dose approximates that of a regular X-ray of the arm (Lane 1999)

Assessment of osteoporosis

Evaluation of the presence or absence of risk factors for osteoporosis is helpful when determining whether an individual should undergo DXA testing for measurement of BMD. Several checklists or scoring sheets have been developed to assist individuals with personal assessment of osteoporosis risk (Eastell 1998; http://www.nbgh.org/osteo_risk.htm; http://ourworld.compuserve.com/homepages/Dr_John/calcium.htm). These paper-and-pencil or computer-aided evaluation tools are a helpful first step in osteoporosis awareness, assessment, and referral. As previously stated, however, the only clinically accepted way to accurately assess and diagnose osteoporosis is by measurement of BMD.

A working group of the World Health Organization developed the operational definition of osteoporosis (BMD of ≥ 2.5 standard deviation below the referenced mean; Kanis, Melton, Christiansen, et al., 1994). This definition was adopted, in part, because fracture risk is strongly associated with BMD score; each 10% decrease in a spinal BMD measurement has been linked to a doubling of the vertebral fracture risk (Melton, Atkinson, O'Fallon, et al., 1993). Each 15% decrease in a hip BMD score has been associated with a 2.4-fold increase in hip fracture (Melton et al., 1993). Although low BMD scores best predict risk of fractures at the site of measurement, BMD scores, in general, reasonably predict the risk of osteoporotic fractures at any site of the skeleton (Melton et al., 1993).

Osteoporosis prevention

Osteoporosis prevention is important. Current methods for restoring lost bone are not always safe or effective (Eastell 1998). Prevention should center on three objectives: maximizing peak bone mass, sustaining peak bone mass through adulthood, and minimizing postmenopausal and age-related bone loss. Several preventive measures are especially important for adolescents and young adults who are establishing peak bone mass. These measures include a diet that incorporates sufficient amounts of vitamin D and calcium; habitual, moderate, weight-bearing exercise to encourage and sustain bone formation; and avoidance of activities and substances that limit bone growth and development, such as smoking and steroid use (Fordham 2000). Furthermore, health professionals should ask

women about the regularity of their menstrual cycles to ascertain whether they are exposed to adequate amounts of estrogen.

A well-balanced, calcium- and vitamin D-rich diet will help to promote strong, healthy bones. Adequate calcium intake will help achieve an optimal BMD in young life and will also reduce age-related bone loss later in life. Good food sources of calcium include milk and other dairy products, and green leafy vegetables, such as kale, collards, and mustard greens. Other vegetables high in calcium include broccoli, cabbage, carrots and squash. Calcium supplements are available for people who do not consume or cannot tolerate dairy products, the main source of calcium. A wide range of calcium supplements are available; these supplements contain varying amounts of calcium and are absorbed differently depending on the formulation of calcium in the supplement. Calcium carbonate contains about 40% elemental calcium, which is then absorbed and used to maintain bone density. Calcium citrate only has about 20% elemental calcium, but may cause less constipation than calcium carbonate (Johnston et al., 1992). Calcium phosphate contains about the same percentage of elemental calcium as calcium carbonate, but is more expensive. Because our bodies can absorb only about 500 mg of calcium at one time, it is important to take calcium supplements throughout the day, depending on the amount that is needed (Goldmann & Horowitz, 2000). Calcium carbonate is best absorbed when taken with meals, and calcium citrate or calcium phosphate can be taken at any time (Goldmann & Horowitz, 2000).

There is extensive literature on the role of calcium in increasing bone mass, which is important in modifying later risk of fracture, and subsequently osteoporosis. Calcium supplementation trials in children have confirmed a positive but moderate effect of calcium intake on bone mineral accretion. A study by Johnston and colleagues (1992) involved a three-year, double-blind, placebo-controlled trial of the effect of calcium supplementation (1000 mg calcium citrate malate/day) on BMD in 70 pairs of identical twins, aged 6 to 14 years. Researchers found that among the 22 twin pairs who were pre-pubertal during the study, the twin group given calcium supplements had significantly greater increases in BMD after three years compared to the twin group not consuming calcium supplements (Johnston et al., 1992).

An 18-month follow-up study to an 18-month controlled calcium supplementation trial attempted to study if calcium supplementation effects on BMD could be maintained

after the supplement had been withdrawn (Lee, Leung, Leung, et al., 1996). Researchers found that the difference in percentage gains in lumbar spine BMD ($12.1 \pm 8.2\%$ vs. $14.9 \pm 10.05\%$) between the study and control groups disappeared after 18-months of calcium supplementation withdrawal. These investigators concluded that gains in BMD from calcium supplementation for 18 months in childhood was reversible after an equal amount of time of calcium supplementation withdrawal.

Interest in dietary calcium intake has also been related to the achievement of peak bone mass in adolescence, as well as to the reduction of osteoporosis risk by increasing the gain in BMD through calcium supplementation (Ott & Chesnut, 1989; Sandler, Slemenda, LaPorte, et al., 1985). Maggiolini and colleagues carried out a cross-sectional study to investigate the association between forearm BMD and dietary calcium, anthropometric characteristics, puberty, and physical activity in 200 girls, aged 11 to 15 years, and 100 women, aged 20 to 23 years (Maggiolini, Bonofiglio, Giorno, et al., 1999). This study found that different calcium intakes did not appear to play a crucial role in forearm BMD.

In contrast, a study by Chan and colleagues (1995) found more promising results. They studied the effects of calcium supplementation with dairy products on the bone and body composition of pubertal girls. They carried out a randomized, controlled study (with 12-month follow-up) on 48 Caucasian girls whose mean age was 11 years. The intervention included supplementing one group's diet with dairy products to the recommended allowance of 1200 mg calcium daily. The other group ate their usual diet. Bone mineral content and BMD were measured by DXA for the radius, femoral neck, lumbar spine, and total body. Results indicated that the dairy group had significantly greater increases in BMD at the lumbar spine ($22.8 \pm 6.9\%$ vs. $12.9 \pm 8.5\%$) compared to controls (Chan, Hoffman & McMurry, 1995). The authors concluded that adolescent girls whose dietary calcium intake was provided by dairy products at or above the recommended dietary allowances had an increased rate of bone mineralization.

The effect of dietary calcium on vertebral bone mass has also been studied in both pre- and post-menopausal women. Sorensen and colleagues (1990) investigated the effect of dietary modification with dairy products on vertebral bone mass in 37 premenopausal women, aged 30 to 42 years. Twenty of the women increased their dietary calcium intake by an average of 610 mg/day for three years, while the other 17 women served as controls.

Researchers found that the vertebral bone density in women consuming increased calcium did not change significantly over the three-year period. However, the vertebral bone density in the control women declined ($-2.9 \pm -0.8\%$, $P < 0.001$) and was significantly lower than that in the supplemental group (Sorensen, Baran, Grimes, et al., 1990). Therefore, the study suggested that dietary modification in the form of dairy products retards vertebral bone loss in premenopausal women.

In addition to calcium, vitamin D intake is also important. Vitamin D deficiency is common among elderly people and can cause bone loss, so it is important to ensure adequate vitamin D intake. Elderly women and men who are homebound, in nursing homes, or rarely go outside for any variety of reasons are especially at risk. Lower-than-normal levels of vitamin D have also been found in postmenopausal African-American women. Researchers have found that daily supplementation with vitamin D corrects these lower levels (Kyriakidou-Himonas, et al., 1999). Supplementation also decreases bone turnover, suggesting that vitamin D may prevent osteoporosis in this population. Some common food sources of vitamin D include fish, such as salmon and sardines. Fortified dairy products serve as the primary source of vitamin D, and many cereals are fortified with vitamin D.

The rationale for vitamin D supplementation is that postmenopausal women are more likely to develop vitamin D deficiency due to a decreased ability of the skin to initiate the pathway for the synthesis of active vitamin D (MacLaughlin & Holick, 1985). Moreover, vitamin D is less readily absorbed in the intestine of older individuals (Ebeling, Sandgren, DiMagno, et al., 1992). A few studies have examined the effect of vitamin D supplementation on BMD. In a randomized, factorial study of hormone replacement therapy (HRT) and vitamin D in 370 women with a mean age of 53 years, Komulainen and colleagues (1999) showed no benefit to the femoral neck or the lumbar spine BMD after 4 years of supplementation with 300 IU of vitamin D compared to a placebo (Komulainen, Kroger, Tuppurainen, et al., 1999). In a separate study, a vitamin D supplement of 400 IU daily was given for two years to 177 elderly Dutch women with a mean age of 80 years (Ooms, Roos, Bezemer, et al., 1995). Supplementation led to a 2% increase in femoral neck bone density compared with placebo. However, no effect was found at the trochanter or at the distal radius.

Randomized studies of vitamin D in combination with calcium have shown significant results. Dawson-Hughes and colleagues (1995) showed that in 247 healthy postmenopausal women, a vitamin D supplement of 700 IU/day plus calcium reduced femoral neck bone loss by 1.5% in comparison with a vitamin D supplement of 100 IU/day alone (Dawson-Hughes, Harris, Krall, et al., 1995). Additionally, Chapuy and colleagues (1992) randomized 3,270 elderly women, with a mean age of 54 years to 800 IU of vitamin D plus 1200 mg of supplemental calcium or placebo. The women exhibited a 43% reduction in hip fracture and a 32% reduction in all non-vertebral fractures in the treatment group (Chapuy, Arlot, Dufoeuf, et al., 1992). Studies such as these demonstrate the importance of utilizing food sources of calcium and vitamin D, as well as supplements containing both of these nutrients for the prevention of osteoporosis.

Exercise is beneficial to bones as well as for many other aspects of health. Complete immobilization leads to rapid bone loss, whereas exercise can increase BMD, particularly during childhood and adolescence. In order to benefit bones, exercise must be weight-bearing and novel. Research has shown that jumping or skipping increases bone mass of the hips in young women (Fuchs, Bauer & Snow, 2001). However, over-exercising should be avoided, as very intense exercise can actually be harmful to bones, especially in young women in certain circumstances. For example, some long-distance runners, ballet dancers, and other athletes have become amenorrheic as a result of excessive exercise and consequently suffer bone loss and fractures due to amenorrhea (Hirschberg & Hagenfeldt, 1998; Lauder, Williams, Campbell, et al., 1999). Because exercise is an essential element in building and maintaining bone mass, it is important for preventing osteoporosis. In fact, there is considerable evidence that exercise, especially weight-bearing exercise, can increase bone density and help prevent bone loss.

Davee, Rosen, and Adler (1990) conducted a cross-sectional study to assess the effects of physical activity on trabecular bone density in 27 college women (mean age of 24.5 years). They studied three groups of nine, non-smoking, eumenorrheic women with different exercise regimens. Group 1 consisted of sedentary women who exercised less than 1hr/week; group 2 women performed aerobic exercise greater than 2.5hr/week; and group 3 women supplemented aerobics with muscle-building activities for more than 1hr/week. Lumbar BMD for groups 1 and 2 were comparable; however, women in group 3 had

significantly greater spinal bone density ($P < 0.007$ vs. groups 1 and 2). Findings from the study suggest that chronic muscle-building exercises may augment lumbar bone mass.

Snow-Harter and colleagues (1992) conducted an 8-month controlled exercise trial in a group of 31 healthy college women (mean age of 19.9 years), who were randomly assigned to a control group or to progressive training in jogging or weight lifting. Lumbar spinal and right hip BMD were measured. Lumbar BMD increased in both runners and weight trainers ($1.3 \pm 1.6\%$ and $1.2 \pm 1.8\%$, respectively; $P < 0.05$). Although results between these two groups did not differ, they were both significantly greater than results in control subjects, in whom bone mineral did not change (Snow-Harter, Bouzsein, Lewis, et al., 1992).

Friedlander and colleagues (1995) carried out a two-year, randomized intervention trial to investigate the efficacy of exercise and calcium supplementation on increasing peak bone mass in young women. One-hundred and twenty-seven subjects, aged 20 to 35 years, were randomly assigned to either an exercise program that contained both aerobics and weight training, or to a stretching program. Calcium supplementation of up to 1500 mg/day or placebo was given in a double-blinded manner to all subjects. There were significant positive differences in BMD between the exercise and stretching groups for spinal trabecular (2.5%), femoral neck (2.4%), femoral trochanteric (2.3%), and calcaneal (6.4%) BMD measurements. The calcium intervention had no positive effect on any of the bone parameters. This study indicated that over a two-year period, a combined regimen of aerobics and weight training has beneficial effects on BMD in young women (Friedlander, Genant, Sadowsky, et al., 1995).

Another study, designed to assess the effects of 18 months of resistance training on regional and total BMD, was carried out with 56 inactive, premenopausal women, aged 28 to 39 years (Lohman, Going, Pamentier, et al., 1995). Subjects were randomized into either an exercise or a control group. Bone mineral density increased significantly above baseline at the lumbar spine for the exercise group at 5 months (2.8%), 12 months (2.3%), and 18 months (1.9%), as compared with controls. Additionally, femur trochanter BMD increased significantly ($P < 0.05$) in the exercise group at 12 months (1.8%) and 18 months (2.0%), compared with controls. Results from this study support the use of strength training for increasing BMD in premenopausal women.

Similar exercise studies have been conducted on older women. Kerr and colleagues (2001) examined the effect of a two-year exercise intervention and calcium supplementation (600 mg) program on BMD in 126 postmenopausal women (mean age of 60 years). Subjects were randomized into one of three groups: strength, fitness, or non-exercise control. The two exercise groups completed three sets of the same nine exercises, three times a week, with the strength group increasing load, and the fitness group increasing duration of activity. Researchers observed a significant effect of the strength program on BMD at the total hip ($0.9 \pm 2.6\%$; $p < 0.05$) and intertrochanter hip ($1.1 \pm 3.0\%$; $P < 0.01$). This study demonstrated the effectiveness of a progressive strength program in increasing bone density at the hip compared to an increase in duration of activity or to inactivity (Kerr, Ackland, Maslen, et al., 2001).

A randomized, controlled study by Heinonen and colleagues (1998) evaluated the effects of 18 months of calisthenics and endurance training regimens on BMD in perimenopausal women. One hundred and five healthy, sedentary females, aged 52 to 53 years, were randomly assigned to a calisthenics, endurance, or control group. Bone mineral density of the lumbar spine, right femoral neck, calcaneus and distal radius was measured by DXA at 0, 4, 8, 10, 14 and 18 months. Results showed that the training effect in the calisthenics group was not significant. However, the distal radius BMD of the endurance group showed a significant negative trend ($P = 0.006$). Investigators concluded that multi-exercise endurance training maintains the BMD in the femoral neck of perimenopausal women (Heinonen, Oja, Sievanen, et al., 1998).

Pruitt and colleagues (1992) also tested the hypothesis that weight training would be an effective modality in maintaining or increasing BMD at the lumbar spine, femoral neck, and bone mineral content at the distal wrist in early postmenopausal women. Seventeen women completed a 9-month, weight-training program, and nine women served as the control group. Resistance training occurred three times per week. Results showed that mean change in lumbar spine BMD in the weight-training group was significantly different from the change in the control group ($1.6 \pm 1.2\%$ vs. $-3.6 \pm 1.5\%$; $P < 0.01$), indicating that weight-training may be a useful exercise modality for maintaining lumbar spine BMD in early postmenopausal women (Pruitt, Jackson, Bartels, et al., 1992).

Overall, these studies provide supporting evidence that exercise is effective at increasing and/or maintaining BMD in women of various ages and menopausal status. As such, physical activity, especially weight-bearing exercises, can be recommended as a positive lifestyle approach to osteoporosis prevention.

Generally, individuals at risk for osteoporotic fractures should consider use of dietary supplements of essential vitamins and minerals, particularly calcium and vitamin D, if dietary intakes are inadequate. Susceptible individuals should take precautions to prevent falls and fractures, including eye examinations to measure depth perception (Tinetti & Speechley, 1989); exercising on a regular basis to make muscles stronger and improve balance (Judge, Lindsey & Underwood, 1993); and utilizing assistive equipment, if necessary, to aid in walking. Additionally, physicians should evaluate medications used by their patients to confirm that such drugs do not have side effects that are likely to increase the risk of a fall (Ray & Griffin, 1990). If osteoporosis has not been prevented, several treatment options are available.

Treatment of osteoporosis

Treatment of osteoporosis involves relieving pain, improving mobility, and preventing further bone loss so that fracture risks are reduced. Most treatments currently tested and developed for osteoporosis act by preventing bone loss. While treatments reduce the risk of fractures, they cannot “cure” osteoporosis once it has developed. In other words, treatments cannot fully restore bone to its previous, healthier state. Many of the agents recommended for prevention of osteoporosis, such as calcium, vitamin D, exercise, and estrogen, are also used in the treatment of osteoporosis. Additionally, there are a number of pharmaceutical agents that are often necessary to prevent further loss of BMD.

Calcium and vitamin D

While calcium is used as a means of osteoporosis prevention, calcium supplementation is one route for osteoporosis treatment. Though often used with other therapeutic agents to maximize their benefits, calcium supplementation alone is primarily effective in preventing further bone loss, especially in older women and women with low calcium intakes. In a four-year study of 86 postmenopausal women treated with 1,000 mg of

calcium per day or placebo, there was a sustained reduction in the loss of total body BMD in the calcium group (Devine et al., 1997). Calcium supplementation in excess of 1 g per day can slow the loss of bone mass in women after menopause, regardless of whether they have had an osteoporotic fracture (Heaney 1993). Until recently, it was unknown whether calcium treatment affected osteoporotic fractures. A few studies have now shown that in postmenopausal women who already have osteoporosis and vertebral fractures, and who were treated with calcium supplements and dietary calcium of over 1,500 mg per day for two years, new vertebral fractures decreased (Recker, Hinders & Davies, 1996; Reid, Ames & Evans, 1990). Calcium also decreases the risk of hip fracture in women who start taking it even in their late 70s, which is important because hip fractures are common among this age group (Cummings, Nevitt & Browner, 1995). Vitamin D may be as important in the treatment of osteoporosis as calcium because it increases the absorption of calcium from the intestine into the body. In fact, in studies of fracture and calcium supplementation, the only research showing reductions in fractures are studies where calcium was combined with vitamin D (Dawson-Hughes et al., 2000).

Vitamin D not only helps with calcium absorption, but it also has a direct effect on bone, by stimulating osteoblasts, the cells responsible for bone formation. In a study of 622 postmenopausal women with at least one vertebral fracture, half received calcitriol, the active form of vitamin D, and the other half were given calcium alone. During the three years of follow-up there were 24 additional fractures in the calcium group, but only 11 fractures in the group that took vitamin D, a 60% reduction (Tilyard et al., 1992). Although calcitriol has been shown to prevent bone loss and reduce the risk of spinal fractures, it is not recommended as a sole treatment for osteoporosis, but rather, should be used in combination with calcium supplementation.

Exercise

According to a review by the National Osteoporosis Foundation (NOF), there is no direct evidence that exercise decreases fractures (NOF 1998). However, because exercise has other advantages, the evidence on BMD (as discussed earlier in this paper) is deemed adequate to propose exercise as a general public health intervention for osteoporosis. Nonetheless, exercise should not be considered a sufficient treatment for osteoporosis in

high-risk women who would otherwise be candidates for more effective treatments (NOF 1998).

Hormonal treatment

Hormone replacement therapy is the treatment option most frequently prescribed for osteoporosis. Clinical studies have shown that HRT prevents bone loss during and after menopause and reduces the risk of hip, spine, and wrist fractures (Christiansen et al., 1981; Kiel et al., 1987; Maxim, Ettinger & Spitalny, 1995). Although used mostly in perimenopausal women, HRT is also effective in older women in their 60s and 70s (Keating, Cleary, Rossi, et al., 1999). For HRT, estrogen, either alone or in combination with progesterone, is prescribed. Estrogen indirectly affects bone by stimulating production of vitamin D, promoting the conservation or reabsorption of calcium by the kidneys, and triggering the release of calcitonin by the thyroid, which decreases the bone-dissolving activity of osteoclasts (Keating et al., 1999). Additionally, estrogen causes a release of growth hormone by the pituitary gland, which stimulates bone formation and increases absorption of calcium in the intestines. Estrogen receptors are also located on bone cells, so there is a direct effect of estrogen on osteoblasts and osteoclasts.

Although estrogen replacement alone is effective in treating osteoporosis, it may cause an increased risk of endometrial and uterine cancer in women who are sensitive to estrogen (Beresford, Weiss, Voigt, et al., 1995; Col, Eckman, Karis, et al., 1997). Consequently, progestins have been used in combination with estrogen to reduce the risk of developing estrogen-sensitive cancers (Beresford et al., 1995). The use of both of these hormones is referred to as combined HRT. A woman whose uterus has been removed, and therefore cannot develop either uterine or endometrial cancer, is usually given simply estrogen replacement therapy (ERT).

When taken for a long period of time, HRT has both benefits and risks. Women who take HRT or ERT for three to five years can expect a 50% reduction in their risk of vertebral fractures and a 25% reduction in their risk of other bone fractures (Gorsky, Koplan, Peterson, et al., 1994). One study of women aged 65 years and older found that their BMD increased by an average of 5% after using ERT for three years (Felson, Zhang, Hannan, et al., 1993). Longer use of hormones, of ten or more years, may lower the risk as much as 75% (Gorsky et

al., 1994). Hormone replacement therapy and ERT have other important health benefits, including the easing of menopausal symptoms such as hot flashes, vaginal dryness, and memory loss (Gorsky et al., 1994).

It is controversial as to how long women should continue HRT. In a study of women who were treated for 4 years and then stopped taking HRT for six years, bone mass was found to decrease by only 10% (Lindsay, Hart, Aitkin, et al., 1976). Although more studies need to be conducted, it appears that benefits of HRT on the skeleton wane after cessation of treatment. In fact, if a woman stops HRT, she can expect the same rapid bone loss that would have occurred after menopause (Knight & Eden, 1996). Moreover, five to seven years later, her bone density and risk of fractures are about the same as those of a woman who had never used HRT (Knight & Eden, 1996).

There are a few situations in which HRT should not be used. Such examples include women with endometrial or breast cancer, pregnant women, and postmenopausal women who have undiagnosed vaginal bleeding (Col et al., 1997). Hormone replacement therapy always involves risks as well as benefits, and the balance is different for each individual. It is therefore crucial that a discussion occur between physician and patient regarding both a woman's family history and personal medical history in order to weigh the advantages and disadvantages of HRT (Col et al., 1997).

Calcitonin

Calcitonin is a hormone produced by the thyroid gland that, when used to treat osteoporosis, acts by decreasing osteoclastic bone resorption. The result is stronger bones and a reduction in the risk of fracture. Calcitonin is also used to decrease the pain associated with a new vertebral fracture. The Preventive Recurrence of Osteoporotic Fracture (PROOF) study showed that calcitonin nasal spray reduced the risk of new vertebral fractures by 36% in patients who had previously had one to five fractures (Silverman, Chesnut & Andriano, 1998). Similarly, in a two-year, randomized, placebo-controlled, double-blind dose-ranging study of inhaled salmon calcitonin in 208 osteoporotic women, researchers found a three-fold reduction in appendicular fractures and a somewhat greater reduction in vertebral fractures (Overgaard, Hansen, Jensen, et al., 1992).

Bisphosphonates

Bisphosphonates are a group of synthetic drugs that are increasingly being used in the treatment of osteoporosis. Their main effect is to deactivate the bone-destroying cells, or osteoclasts, thereby preventing bone loss (Fleisch 1991). Bisphosphonates decrease bone resorption but allow normal bone formation, so they produce an increase in bone mass at each remodeling site. Such a decrease in bone resorption protects against loss of trabecular bone and maintains or improves bone quality, thereby reducing the risk of osteoporotic fracture (Fleisch 1991). The three most common forms of bisphosphonates are etidronate, alendronate, and risedronate, of which alendronate and risedronate are the only Food and Drug Administration (FDA) approved bisphosphonates for managing osteoporosis (Siris 2000).

Etidronate has been approved for use in Paget's disease, a condition that results in bone pain because of excessive remodeling (Fairney et al., 1998). It works by slowing the bone remodeling process. Etidronate was evaluated in women with osteoporosis (Fairney et al., 1998), but significant long-term improvements in bone mass were not observed. Therefore, etidronate has not been approved by the FDA as a treatment of osteoporosis in the United States.

Similarly, Risedronate has been proven effective in the treatment of Paget's disease (Siris, Chines, Altman, et al., 1998). In a double-blind, placebo-controlled, multi-center study, 290 osteoporotic men and women on high-dose oral corticosteroid therapy were randomized to receive placebo, .25 mg/day risedronate, or 5 mg/day risedronate for 12 months (Reid, Hughes, Laan, et al., 2000). A 70% reduction in the incidence of vertebral fractures in the combined risedronate treatment groups (relative to placebo) was observed. Although researchers concluded that risedronate increases BMD and potentially reduces the incidence of vertebral fractures in patients with corticosteroid-induced osteoporosis, the study was not powered to show fracture efficacy. Therefore, risedronate as a treatment for osteoporosis, is still under investigation.

Alendronate is approved for osteoporosis treatment in the United States. Unlike etidronate, alendronate inhibits bone resorption but has no effect on bone formation. Numerous studies have demonstrated that alendronate can lead to successful outcomes in the treatment of osteoporosis. In the large scale Fracture Intervention Trial (FIT), 2,027 women

aged 55 to 80 years and with established osteoporosis were randomized to receive either alendronate or a placebo. After three years, the alendronate group had 47% fewer fractures in their spine, and 51% and 41% fewer hip and wrist fractures, respectively (Cummings, Black & Thompson, 1998). In a separate study, women with osteoporosis were treated with alendronate for three years and had a 6% increase in lumbar spine bone mass and a 2 to 4% increase in hip bone mass compared to women who were taking a placebo (Liberman, Weiss & Broll, 1995). In yet another study, effects of two intermittent alendronate regimens in the treatment of osteoporosis were assessed. One-hundred twenty-four postmenopausal women, aged 52 to 75 years, with either a femoral neck or lumbar spine BMD of 2 standard deviation below the mean values of young, healthy adults, were randomized into three treatment groups: calcium/vitamin D supplement alone; calcium/vitamin D plus 20 mg alendronate weekly; or calcium/vitamin D plus 10 mg alendronate daily. After one year, a significant increase in BMD at both the spine and femoral neck were observed in both groups given the alendronate (Rossini et al., 2000). Results from studies such as these have clearly established alendronate as effective therapy for the treatment of osteoporosis. Side effects of alendronate are rare, but include diarrhea, bloating, and upper gastrointestinal irritation.

Trials of up to seven years duration have demonstrated that spine BMD continues to increase progressively and that BMD gains at other sites are maintained (Tonino, Meunier & Emkey, 2000). Furthermore, discontinuation of alendronate does not lead to accelerated bone loss, as has been reported for women who stop taking estrogen (Greenspan, Bell & Bone, 1999; Stock, Bell & Chesnut, 1997). Within one to two years after discontinuing alendronate, rapid or progressive decreases in BMD or a slow resumption of bone loss and a mild increase in biochemical markers of bone turnover were not found (Greenspan, Bell & Bone, 1999; Tonino et al., 2000).

Selective estrogen receptor modulators

Selective estrogen receptor modulators (SERMs) are a family of drugs that attach to estrogen receptors in tissues and produce similar effects to that of estrogen, but without some of the negative side effects. One of these compounds, tamoxifen, with estrogen-like properties, was evaluated for the treatment of osteoporosis and was found to prevent bone loss in the hip and spine in postmenopausal women (Avioli 1999). In 1999, a second SERM,

raloxifene, was approved by the FDA for the treatment of osteoporosis. It has been found to increase BMD, as well as lower cholesterol and reduce the risk of breast cancer (Plouffe 2001; Zanchetta & Bogado, 2001). In the Multiple Outcomes of Raloxifene Evaluation (MORE) study, 7,705 postmenopausal women with osteoporosis were divided into three groups: 1 raloxifene tablet/day, 2 raloxifene tablets/day, or placebo. The groups were studied for three years and results indicated that the vertebral fracture rates were 10.1%, 6.6%, and 5.4%, respectively (Ettinger et al., 1999). These fracture rates represented a 30 to 50% reduction in fracture rate among the two groups taking raloxifene (Ettinger et al., 1999).

Soy and ipriflavone

Some new and exciting nutritional research regarding bone involves soy. Soybeans are a great source of protein, but unlike animal products, they are free of cholesterol and relatively low in fat. A specific characteristic of soy that is beneficial to bone is that it is rich in isoflavones—compounds that act like weak estrogens in the body. As of date, there has only been one well-designed scientific report on the effects of soy-based nutritional supplements on bone density. A six-month study followed 66 postmenopausal women to determine whether soy protein that contained various amounts of isoflavone would improve BMD (Potter, Baum, Teng, et al., 1998). One-third of the women received a high dose of isoflavone, one-third received a medium dose, and a control group was given a placebo. Results showed that the control group had a 0.5% decline in bone density; those who took the medium dose of isoflavone had neither a gain nor a loss of bone. Women who consumed the high dose of isoflavone showed no improvement in bone density at the hip, but lumbar spine BMD increased by an average of 2.25% (Potter et al., 1998).

Ipriflavone, a synthetic isoflavone, has been widely tested in humans. Many studies outside the United States have found that ipriflavone improves bone density in the spine and hip of postmenopausal women by 1 to 2% over a 1- to 3-year period (Arjmandi, Birnbaum, Juma, et al., 2000; Alexandersen, Toussaint, Christiansen, et al., 2001; Ohta, Komukai, Makita, et al., 1999). Although ipriflavone appears to produce few side effects (Potter et al., 1998), it interacts with estrogen receptors, so its effects on the uterus, breasts, heart, and other organs requires further assessment. As such, ipriflavone has not been approved by the

FDA as a medication; however, it is available in many health food and drug stores as a supplement.

Several nutrient and drug options, either alone or in combination, have been studied and proven to minimize or retard bone loss and relieve painful symptoms. Although drug treatment is usually necessary to prevent further bone loss, there are a number of self-help measures that an individual can take that will slow the progression of the disease. Knowing that there are measures that can be taken to improve an individual's condition, such as changes in diet and exercise, may help those who are affected feel that they have some control over this disease. An important source of information for all aspects of osteoporosis should be health care professionals involved in the management of osteoporosis. However, the transmission of that knowledge from physician to patient has often been less than successful.

Physicians' and women's actions after bone mineral density testing

Laroche and Mazieres (1992) conducted a study that used two surveys to investigate whether diagnosis and treatment of osteoporosis were correctly carried out by general practitioners in the Midi-Pyrenees region of France. The first survey included 85 patients, aged 36 to 83 years, who had been diagnosed with osteoporosis by their general practitioners. Patients in this study were seen by a rheumatologist in a hospital or private practice setting. This specialist then completed a questionnaire based on the history taken from the patient and records in the patient's possession. Of those 85 patients, 29.5% had vertebral osteoporosis with fractures, 34% had osteoporosis without fractures, 20% had osteopenia, and 16.5% did not have osteoporosis. Therefore, out of the 85 patients diagnosed with osteoporosis (by their general practitioners), 16.5% were given an incorrect diagnosis. These findings suggest that general practitioners are diagnosing osteoporosis simply on the basis of accepted risk factors or without further DXA testing to confirm the presence of osteoporosis.

For the second survey, 200 general practitioners who had referred patients to the rheumatology department were sent a questionnaire on their management of osteoporosis. Fifty-two physicians completed and returned questionnaires. Medical follow-up investigations were carried out correctly by only 6% of physicians and for only 4% of patients. Equally alarming was the finding that initial treatment was correctly prescribed in

only 34% of cases of osteoporosis with fractures and 50% of cases of osteoporosis without fractures (Laroche and Mazieres, 1992).

Studies within the United States have also displayed some discouraging findings. A group of researchers conducted a retrospective review of cases from physicians affiliated with a community teaching hospital (Economides et al., 2000). The study sample consisted of 142 female patients with abnormal BMD who had been referred by 50 physicians, either internists or gynecologists. A questionnaire was completed for each patient, providing data about further investigations, treatment interventions, and frequency of referral to a specialist in bone diseases. Results showed that 30% of the 142 study patients with abnormal BMD findings did not receive further medical intervention to identify the cause of bone loss. Additionally, the percentage of all referrals for metabolic bone diseases was low — 11.3% in the patients of internists and 14.5% in the patients of gynecologists.

A separate study attempted to examine both physicians' recommendations and women's compliance following osteoporosis testing (Cole et al., 1999). This study evaluated data provided by 222 Caucasian women between the ages of 23 and 83 years. A total of 84 primary care physicians referred all subjects for testing to rule out osteoporosis because patients had presented risk factors for osteoporosis. A short, multiple choice/short answer instrument was designed to assess a physician's response to his or her patient's bone scan, and to assess the patient's short-term compliance with the recommendation of her physician (1 to 9 months following osteoporosis testing). Overall, 80.2% of the total sample reported that their physicians had recommended a change in medication use (including nutritional supplements) following BMD treatment (Cole et al., 1999). Of those who received a recommendation to change medication use in response to their bone scan results, 68.5% reported a recommendation of calcium, 43.8% reported a recommendation of alendronate, 24.7% reported a recommendation of vitamin D, and 22.5% reported a recommendation of calcitonin. Additionally, 7.9% reported a recommendation of HRT (Cole et al., 1999).

The aforementioned studies attempted to assess how the results of bone densitometry were used by physicians for actual intervention, either investigative or therapeutic. Their purposes were to determine whether the information obtained from a BMD test affected patient management. These studies primarily focused on physicians' practices concerning osteoporosis prescriptions, which is of great importance. It is essential that recognized

specialists and international experts clarify the definitions of osteoporosis, establish a list of efficacious agents and their indications, and ensure that scientific information reaches the primary care physician. However, of equal importance, is the need to study women's actions regarding the prevention and treatment of osteoporosis after receiving BMD testing results, a subject that has received very little attention to date.

Ribiero, Blakely, and Laryea (2000) attempted to assess women's knowledge and practices regarding the prevention and treatment of osteoporosis. A descriptive hand-delivered questionnaire was designed to survey 185 women. Measures of knowledge and practices were obtained with a mixture of open-ended and structured questions. Results showed that 94% of the women in the study had read or heard something about osteoporosis; however, only 55% reported that they found the information useful (Ribiero et al., 2000). Most women in this study (96%) knew that women's bones thin and become more brittle as they age, but only 12% realized that, for women, the process of bone demineralization starts well before the onset of menopause. Equally limiting was the knowledge regarding risk factors for osteoporosis in women. Thirty-three percent of these women were able to identify only one risk factor correctly. Additionally, the most commonly identified risk factors were those that were unable to be controlled or changed: small body frame (22%); and menopausal status (11%). In fact, the two most significant behavioral risk factors, low calcium intake and sedentary lifestyle, were identified by only 10% and 15% of the women, respectively (Ribiero et al., 2000).

Practices regarding the prevention and treatment of osteoporosis were less than adequate among respondents. Only 20% stated that they used high calcium foods as a preventive measure against osteoporosis (Ribiero et al., 2000). The majority recognized that exercise was important to maintain general health and prevent heart disease, but only 29% knowingly used exercise to prevent osteoporosis. Sixteen percent did not exercise at all. Regarding the use of HRT, only 29% of these women listed any benefits associated with taking HRT, and only 19% identified any of the potential side effects (Ribiero et al., 2000). Overall, results from this study indicated that women received inadequate information about osteoporosis, possessed limited knowledge about osteoporosis, and were not taking sufficient measures to prevent or treat osteoporosis as they aged.

With the recent surge of public education and other health promotion efforts designed to improve women's knowledge about osteoporosis, many women are taking the initiative to find out more about their own bone health. They are no longer just passively listening to news reports, or reading magazine articles, but are more actively seeking out measures to determine their current health status in regards to osteoporosis. One particular measure that women are increasingly taking is to undergo BMD testing—even in the absence of a referral by their doctor. But what do these women do after they receive results from these tests? Can they make informed choices about the available prevention strategies and treatment options for osteoporosis? And where, or from whom, do they obtain further information about osteoporosis? Questions such as these have not been addressed in previous studies. They are, however, relevant to this descriptive, exploratory study.

Summary

A review of the aforementioned studies clearly demonstrates that there is a considerable lack of knowledge about the diagnosis and treatment of osteoporosis among various health care professionals. Laboratory tests are often incorrectly prescribed by the general practitioner, errors in the indications for bone density measurements are common, and errors in the treatment prescription reflect the uncertainty of specialists as to the definition of osteoporosis, as well as the efficacy of various treatments for this disease.

Similarly, women's knowledge about their own level of risk for osteoporosis is discouraging. They are unaware of the various diagnostic tools available to them to assess their individual risk. Furthermore, they have limited knowledge of the many treatment options that are now available for this disease.

There is a paucity of published data regarding the actions of women who have undergone BMD tests and subsequently received their results. The objective of the present study, therefore, was to describe and explore the actions related to receipt of BMD test results in women who participated in a previous study of bone health.

Chapter 3: Materials and Methods

A telephone survey was conducted to investigate actions that women took after participating in a study related to bone health. Women in the primary study received personal bone mineral density (BMD) results and advice for increasing BMD through dietary intake and exercise, when necessary. Steps that these women took after acquiring their BMD results were evaluated. Questions were formulated based on anticipated actions of women and established standards of care for osteoporosis prevention and treatment.

Development of survey questions

The survey was designed by an Assistant Professor of Human Nutrition, Foods and Exercise at Virginia Polytechnic Institute and State University (VPI&SU) who was also a Registered Dietitian (RD). Questions were developed from previous literature (Economides et al., 2000) that reported physicians' actions regarding abnormal BMD test results and from the National Institutes of Health guidelines for standards of care for osteoporosis prevention and treatment (NIH 2001). Additional questions were created based on the RD's experience with women's inquiries, reactions, and other cares associated with osteoporosis detection, prevention, and treatment.

Survey questions focused on six themes. These themes included: (1) reaction to BMD test results; (2) sharing of BMD test results with a health care professional and subsequent medical care; (3) self-imposed behavioral changes based on BMD test results; (4) self-directed learning about osteoporosis after receipt of BMD test results; (5) sharing of BMD test results with others, and (6) reaction to body composition results.

Section one (theme 1) of the questionnaire included two questions regarding the woman's reaction to her BMD test results. The first question was close-ended while the second question was partially close-ended unordered.

Section two (theme 2) contained 10 questions focused on the woman's action of furnishing a health care professional with her BMD test results. Questions in section two consisted of listings of health care professionals and treatment modalities including dietary intake alterations, pharmacological agents, exercise, and other health behaviors pertinent to the range of care for identified health care professionals. These questions were close-ended and partially close-ended unordered.

The third section (theme 3) of the questionnaire included three questions regarding self-imposed behavioral changes. The first question was close-ended, the second question was partially close-ended unordered, and the third question was open-ended.

Section four (theme 4) contained questions regarding the woman's self-directed exploration of information regarding osteoporosis. One close-ended and one partially close-ended unordered question were included to uncover primary sources of osteoporosis information gathering.

The fifth section of the questionnaire (theme 5) focused on the woman's actions of sharing her BMD test results with others and of encouraging other women to have BMD tests conducted. Two close-ended and two partially close-ended unordered questions were included.

Section six (theme 6) included questions to examine women's reactions to their overall body composition (i.e., body fat mass, muscle mass, and BMD) results. Four questions were included – two close-ended and two partially close-ended – regarding concerns of and behavioral changes related to body fat mass, muscle mass, and BMD test results.

Six final general questions were included. These questions involved interest in repeated testing or follow-up testing of BMD status, recent broken bones, and benefits to participation in the primary study. Three of these six questions were close-ended while the remaining three were open-ended.

Questionnaire refinement

One graduate student in human nutrition at VPI&SU carried out a review of the original questionnaire. This doctoral student had extensive experience working with BMD testing and conducting of research related to osteoporosis epidemiology and prevention in women. The graduate student was instructed to read the questionnaire for content and comprehension as well as to answer questions so that a correct interpretation of each question and the overall intent of the full questionnaire could be ascertained. The questionnaire review was completed within two days of the request.

Based on this review, one question was refined, and section six (theme 6) of the questionnaire was added. An introductory statement and legally implied consent statement were also reviewed and found to be acceptable.

Selection of survey administration method

A telephone survey was selected for the method of questionnaire administration. Two primary advantages to a telephone survey included an anticipated usable questionnaire response rate of > 78% (Dillman 1978) and rapid responses. Because the catchment communities for this telephone survey were local to the VPI&SU campus area, the telephone survey was also cost-effective. Additionally, respondents were able to elaborate on their responses, thoughts, and messages as well as ask questions of the interviewer for clarification, if needed.

Use of a mail survey was considered; however, the advantages of a mail survey for respondents, including longer time to consider questions, more response time, and greater detail for instructions compared to telephone survey (Dillman 1978), did not outweigh the disadvantages. Mail surveys have the disadvantages of indirect communication between respondent and researcher and lack of immediate follow-up for clarification of questions (Godwin et al., 1982). Additionally, the usable questionnaire response rate was anticipated to be > 60% with a mail survey compared to > 78% with a telephone survey (Dillman 1978).

Administration of telephone survey

The telephone survey included an "Introductory Statement and Legally Implied Consent Statement" (Appendix 1) along with the "Study Questionnaire" (Appendix 2). Purposes of the "Introductory Statement and Legally Implied Consent Statement" were to introduce the interviewer to the interviewee, inform the participants of the survey's intent, secure participation, and record willingness to participate. The "Study Questionnaire" consisted of four pages. The 31 questions were grouped into the six themes as previously described.

Three interviewers, all graduate students in human nutrition at VPI&SU, were enlisted to conduct the telephone surveys. Interviewers were provided with directions for completion of surveys. Each "Introductory Statement and Legally Implied Consent

Statement" and "Study Questionnaire" contained a script for the telephone survey (Appendix B and Appendix C, respectively). Interviewers were directed to follow this script as closely as possible but to also allow for respondents' comments and questions as needed. Names and telephone numbers of potential respondents were provided to the interviewers by an investigator.

Participants

A sample of 186 women who had previously participated in a primary study related to osteoporosis and bone health conducted in the Bone metabolism Osteoporosis and Nutrition Evaluation (BONE) Laboratory between December 1999 and February 2001, were pooled as potential participants for the present study. Inclusion criteria for the original study consisted of an age requirement only. All participants were at least 25 years of age. Other exclusion criteria for participation in the primary study did not exist. All participants in the original study were volunteers and self-initiated their participation in the primary study.

Due to the exploratory nature of the present study, all original participants from the primary study were included. Thus, random sampling to obtain a representative sample of original participants was not performed. Additionally, a power analysis to determine the minimum effective sample size was not conducted, as there was a lack of data from which to adequately estimate statistical power.

Data collection

Prior to data collection, the survey questionnaire, study methodology, and research protocol were approved by the Institutional Review Board for research involving human subjects at VPI&SU. Subsequently, this project was conducted in accordance with the guidelines established for research involving human subjects at VPI&SU.

Telephone calls were operated from a centralized location in the BONE Laboratory, Room 229 Wallace Hall, on the VPI&SU campus. Telephone interviews were completed between April 16, 2001, and June 7, 2001. Initial telephone calls were placed between 0800 and 1700 hours each day for completion of surveys; however, if requested by a respondent, subsequent telephone re-calls were made at the convenience of the respondent. If a

telephone call was unanswered, no more than three attempts were made to reach an individual participant.

Anthropometric and bone mineral density data

For each participant that completed a telephone survey, age, body height and weight, menopausal status, hormone replacement therapy or oral contraceptive use, and use of pharmaceutical agents for osteoporosis were obtained from records collected during the individual's participation in the primary study. Body mass index (BMI) was calculated from body height and weight for each participant by an investigator. Number of years since menopause for a participant was calculated by an investigator, when applicable, based on data collected during the original study. Pre- and post-menopausal groups of women were established based on menstrual status data.

Percents of the young-adult average for BMD of the whole body (WB), lumbar spine (LS), total proximal femur (TPF), and total forearm (FA) for participants were recorded from BMD test results obtained from the primary study. Normal BMD and low BMD categories were established by an investigator. Participants who had T-scores of $> 90\%$ for all bone sites were classified as normal BMD participants. Because a 10% decrease in BMD increases fracture risk by 50% (Reid 1996), participants with at least one BMD site at $\leq 90\%$ of the young-adult, gender-matched mean were categorized as low BMD participants.

Treatment of data and statistical analyses

For facilitation of data entry into a computerized data set, each question of the survey was coded (Appendix 3). Response patterns and corresponding codes were established, after which, an investigator used the coding system for all completed surveys. One researcher coded all data to eliminate inter-investigator error.

Statistical analyses were conducted to explore these data. Descriptive statistics including means, standard deviations (SD), ranges, and frequency analyses, were used to describe participants and their anthropometric characteristics and survey responses.

Participants were divided into pre- or post-menopausal groups, after which, chi-square analyses were conducted to explore differences in responses to questions based on menopausal status. Participants were also categorized into normal or low BMD groups, after

which, chi-square analyses were performed to identify differences in questionnaire responses based on BMD test results.

Lastly, *t*-tests were conducted to distinguish differences in anthropometric variables and BMD results between pre- and post-menopausal women as well as between women with normal or low BMD. The Statistical Analysis System (SAS) software for PC was used to perform all statistical analyses (version 8.0, SAS, Cary, NC). A p-value of < 0.05 was used to determine statistical significance.

Chapter 4: Results

One hundred thirty-eight women or 74.2% of the prospective individuals participated in this study. Two women declined to participate, while 46 women were unavailable or unreachable by telephone.

Descriptive statistics

Participants ranged in age from 26.8 to 84.5 years with a mean \pm SD age of 48.1 ± 10.4 years. On average, participants were 164.16 ± 6.20 cm tall (range = 149.30 to 179.78 cm) and weighed 70.8 ± 16.4 kg (range = 43.2 to 130.0 kg). The BMI for participants ranged from 17.0 to 50.8 with an average BMI of 26.3 ± 6.0 . Table 1 displays bone density data for the WB, LS, TPF, and FA. The WB BMD of participants ranged from 76 to 126% of the young-adult reference mean with an average of $100 \pm 8\%$. Bone mineral density of the LS ranged from 51 to 127% with an average of $96 \pm 14\%$. The TPF BMD averaged $94 \pm 12\%$ of the young-adult reference mean and ranged from 57 to 122% of this reference average. Ranging from 73 to 119%, the average FA BMD of participants was $99 \pm 9\%$ of the young-adult reference mean.

Of the 138 participants, 62% ($n = 85$) were not surprised by their BMD results, while 38% ($n = 53$) were surprised by results of their BMD tests. Of the 38% that were surprised, 57% ($n = 30$) thought that their BMD results would have been better, while 37% ($n = 20$) thought that their BMD results would have been worse than they actually were. Only 3 participants (6%) were surprised by their BMD results but did not have pre-set expectations for their BMD results. Thirty-one of the 53 women explained their surprise with their BMD results. The two primary reasons for being surprised with BMD results included a current, high intake of dietary and/or supplemental calcium (19% or $n = 6$) and a young age or premenopausal status (13% or $n = 4$).

Of the 138 participants, 62% ($n = 85$) shared their BMD results with at least one health care professional, while 38% ($n = 53$) did not. Table 2 identifies the health care professionals with whom participants shared their results. Of these 85 individuals, the vast majority (80%) shared their BMD results with their primary care physicians. Seven individuals shared their BMD results with "other" health care professionals including a

homeopath (n = 1), immunologist (n = 1), internist (n = 1), a massage therapist (n = 1), neurologist (n = 1), nutritionist (n = 1), and an oncologist (n = 1; see tables 1 and 2).

For the 68 participants who shared their BMD results with their primary care physicians, 13% (n = 11) indicated that their primary care physicians recommended further medical treatment, laboratory tests, or other tests based on these women's BMD test results. Of these 11 individuals, their primary care physicians recommended blood work (18% or n = 2), serum chemistries (9% or n = 1), vitamin D concentration in blood (9% or n = 1), parathyroid hormone concentration (27% or n = 3), estrogen concentration (9% or n = 1), progesterone concentration (9% or n = 1), thyroid hormone concentrations (18% or n = 2), urinalysis (9% or n = 1), mammography (9% or n = 1), additional BMD scans, tests, or studies (64% or n = 7), and other tests (9% or n = 1). (The survey allowed participants to identify any and all recommendations for further medical treatment, laboratory tests, and other tests that their primary care physicians recommended.)

Of the 62% (n = 85) of participants that shared their BMD results with a health care professional, 28% (n = 24) of participants indicated that these health care professionals prescribed dietary changes, while 72% (n = 61) of participants indicated that these health care professionals did not prescribe dietary changes. Dietary changes that were prescribed by participants' health care professionals included: (1) "take a calcium supplement" (75% or n = 18); (2) "increase dietary calcium" (42% or n = 10); (3) "take a vitamin D supplement" (13% or n = 3); (4) "decrease dietary protein intake" (4% or n = 1); (5) "take a soy supplement" (4% or n = 10), and (6) "other" recommendation (specifically, space calcium supplement intake throughout the day) for diet (4% or n = 1). None of these women's practitioners recommended increasing dietary intake of vitamin D, decreasing caffeine consumption, decreasing salt intake, decreasing alcohol intake, or increasing soy foods in the diet.

Of the 62% (n = 85) of participants that shared their BMD results with a health care professional, 15% (n = 13) indicated that these health care professionals prescribed pharmaceutical agents (i.e., medications), while 85% (n = 72) of participants responded that these health care professionals did not prescribe medications. Medications that these participants' health care professionals prescribed included: (1) bisphosphonates (38% or n = 5); (2) ERT or HRT (23% or n = 3); (3) raloxifene (23% or n = 3); (4) calcitonin (15% or n = 2), and (5) "other" (Celebrex; 15% or n = 2).

Other lifestyle changes were recommended for 29% (n = 25) of the 62% (n = 85) of participants that shared their BMD results with a health care professional; however, other lifestyle changes were not recommended for 71% (n = 60) of these 85 women. Recommendations for other lifestyle changes included: (1) increase exercise, in general (52% or n = 13); (2) increase weight-bearing exercise, in general (44% or n = 11); (3) lift weights or weight lifting (24% or n = 6); (4) increase walking (24% or n = 6); (5) engage in stretching exercises (4% or n = 1), and (6) "other" (lose weight; 4% or n = 1). Participants reported that none of the health care professionals recommended the use of meditation, Tai Chi, or stair climbing. Further, none of the health care professionals recommended that these women increase jogging or running, exercise on a rowing machine, engage in balance exercises or quit smoking.

Of all 138 participants, 49% (n = 67) reported that they did change their behaviors based on results of their BMD tests, while 51% (n = 70) indicated that they did not change their behaviors based on results of their BMD tests. One participant declined to respond to this question. For the 49% who did change their behaviors, 57% (n = 39) of these 67 women indicated that they changed their dietary intakes. Forty-nine percent (n = 33) of these 67 women increased their exercises, and 34% (n = 23) began consuming vitamin and/or mineral supplements. Of these 67 women who changed their behaviors, 6% (n = 4) began the use of bone-related medications, and 3% (n = 2) stopped smoking. Additionally, 14 women engaged in "other" behaviors including increasing their calcium supplement dose (33% or n = 4).

Table 3 identifies sources of information from which participants investigated osteoporosis further after receipt of their BMD test results. Of the 138 participants in this study, 28% (n = 39) investigated osteoporosis further while 72% (n = 99) did not investigate osteoporosis further after receiving their BMD results.

A vast majority (85% or n = 116) of participants shared their BMD test results with other individuals. These other individuals (for the 116 women) included family members (76% or n = 89), friends (48% or n = 56), and "others" (16% or n = 19). Seventy-nine percent of "others" included coworkers. Only 15% (n = 21) of participants did not share their BMD results with other individuals.

Many participants (70% or $n = 96$) encouraged other individuals to have their BMD tested, while 30% ($n = 41$) of the 138 participants did not encourage other individuals to have their BMD tested. Of the 96 women who did encourage others to have BMD tested, 71% ($n = 68$) encouraged their friends, 35% ($n = 34$) encouraged family members, and 25% ($n = 24$) encouraged "others" (71% of which were coworkers) to have their BMD tested.

Of the 138 participants, 40% ($n = 55$) responded that their body fat and muscle mass results were of concern, while 60% ($n = 82$) indicated that their body fat and muscle mass results were not of concern to them. One participant declined to respond to this question. Of the 55 respondents that were concerned with soft tissue mass results, 70% ($n = 38$) of these women indicated that their body fat was too high. Additionally, 19% ($n = 10$) of these women responded that their weight was too high, while 4% ($n = 2$) indicated that they would like more muscle or were dissatisfied overall (4% or $n = 2$). Two percent each indicated that their body fat and lean mass results gave concern for health ($n = 1$) and that these results did not match fat and lean mass results from other types of tests ($n = 1$). When asked if receipt of body fat and muscle mass test values resulted in changes in lifestyle behaviors, 68% ($n = 36$) of the 55 participants responded "yes", while 32% ($n = 17$) responded "no". Behavioral changes for these 36 women included an increase in exercise (75%), a change in dietary intake (58%), and an increase in general weight loss tactics (8%).

Greater than 90% of these women indicated that they would engage in follow-up tests for evaluation of BMD (92% or $n = 124$). Only 8% ($n = 11$) would not complete BMD tests again. Three individuals did not respond to this question.

Only 2% of participants ($n = 3$) suffered broken bones since completion of their BMD tests. Broken bones included a rib ($n = 1$), hip ($n = 1$), and fibula ($n = 1$). Conversely, 98% of participants ($n = 134$) did not sustain a bone fracture after completion of their BMD tests. One participant declined to answer this question.

Finally, women were asked to indicate if they found that their participation in the original study and receipt of BMD test results was beneficial. Ninety-nine percent ($n = 136$) of women responded "yes", while 0.5% ($n = 1$) and 0.5% ($n = 1$) responded "no" and "yes and no", respectively. The primary benefit identified by participants was an increased knowledge and awareness of personal BMD status (51% or $n = 70$). Other benefits included: (1) receipt of baseline BMD so that changes may be monitored (22% or $n = 31$); (2) peace of

mind that BMD test results were positive (15% or n = 20); (3) reassurance that current behaviors were positive for bone health (9% or n = 12); (4) results led to more positive behavior changes (9% or n = 12); (5) receipt of comprehensive results (8% or n = 11); (6) only way to have tests completed (7% or n = 10); (7) results led to diagnosis and treatment from health care professional (3% or n = 4), and (8) awareness of risk factors for osteoporosis increased (3% or n = 4).

Chi-square analyses for pre- and post-menopausal participants

Responses of pre- and post-menopausal women to questions were examined for differences. (Perimenopausal women, n = 14, were excluded from these analyses). Statistically significant differences in responses to questions by premenopausal compared to postmenopausal women were observed for only three questions.

Postmenopausal women (n = 58) were significantly less likely to be surprised by their BMD results compared to premenopausal women (n = 66). Premenopausal women were nearly equal in response (52% or n = 34 indicated “yes”, 48% or n = 32 indicated “no”); however, 71% (n = 41) of postmenopausal women indicated that they were not surprised but only 29% (n = 17) indicated that they were surprised by their BMD test results ($\chi^2 = 4.75$, DF = 1, P-value = 0.03).

Of the subset of pre- (n = 32) and post-menopausal (n = 17) women who were surprised by their BMD test results, significantly more postmenopausal women thought that their BMD results would have been worse than their results actually were compared to premenopausal women ($\chi^2 = 5.47$, DF = 1, P-value = 0.02). Twenty-five percent (n = 8) of premenopausal women thought that their BMD test results would have been lower or worse than their results actually were, while 75% (n = 24) of premenopausal women did not think that their BMD test results would have been worse than they actually were. In comparison, 59% (n = 10) of postmenopausal women thought that their BMD results would have been worse than their results actually were, while 41% (n = 7) of postmenopausal women did not think that their BMD test results would have been worse than they actually were.

Of the subset of pre- (n = 34) and post-menopausal (n = 18) women who changed their behaviors based on their BMD test results, significantly more postmenopausal women increased exercise after receipt of their BMD test results compared to premenopausal women

($\chi^2 = 4.17$, DF = 1, P-value = 0.04). Thirty-eight percent (n = 13) of premenopausal women increased exercise, while 62% (n = 21) of premenopausal women did not increase exercise after receiving their BMD results. In contrast, 67% (n = 18) of postmenopausal women did increase exercise, while 37% (n = 10) of postmenopausal women did not increase exercise after receipt of their BMD test results.

Statistically significant differences in responses to questions regarding sharing of BMD test results with health care professionals and recommendations for further medical care and for all treatments by health care professionals (including diet, medication, and lifestyle changes) were not observed between pre- and post-menopausal women. Furthermore, self-imposed behavior changes, types of behaviors (except exercise as noted above), investigation of osteoporosis, sharing of BMD test results, advocacy for BMD test results to other individuals, as well as responses to body composition results and follow-up testing of BMD questions were not observed between pre- and post-menopausal participants in this study. Data were insufficient to test differences in broken bones, and statistically significant differences regarding benefits of participation were not observed between pre- and post-menopausal women.

A statistically significant difference was found in the number of pre- (n = 66) and post-menopausal (n = 58) women categorized as having normal or low BMD. Postmenopausal women were significantly more likely to have low BMD compared to premenopausal women ($\chi^2 = 13.81$, DF = 1, P-value = 0.008). Fifty-nine percent (n = 39) of premenopausal women did not have any BMD sites below 90% of the young-adult, gender-matched mean, while 41% (n = 27) of premenopausal women did have at least one BMD site below 90% of the young-adult, gender-matched mean. In comparison, 33% (n = 19) of postmenopausal women did not have any BMD sites below the 90% criterion for BMD, while 67% (n = 39) did have at least one BMD site below 90% of the young-adult, gender-matched reference mean.

In terms of use of hormone therapies (either ERT or HRT for postmenopausal women or oral contraceptives for premenopausal women), a statistically significant difference was observed in the number of women receiving exogenous hormones. Significantly more postmenopausal women used ERT or HRT compared to the use of oral contraceptives among premenopausal women ($\chi^2 = 9.98$, DF = 1, P-value = 0.002). Among premenopausal

women, 26% (n = 17) did use oral contraceptives, while 74% (n = 49) of premenopausal women did not use oral contraceptives. Among postmenopausal women, 53% (n = 31) did use ERT or HRT, while 47% (n = 27) did not use ERT or HRT.

Chi-square analyses for normal and low bone mineral density groups

Responses to questions by women with normal (n = 69) and low (n = 69) BMD test results were examined for differences. (Perimenopausal women, n = 14, were included in these analyses). Statistically significant differences in responses to questions by normal compared to low BMD status were observed for several questions.

Women with low BMD status were significantly more likely to be surprised by their BMD test results compared to women with normal BMD status ($\chi^2 = 8.85$, DF = 1, P-value = 0.003). Twenty-six percent (n = 18) of women with normal BMD status were surprised by their BMD results, while 74% (n = 51) were not surprised by their BMD results. In contrast, 51% (n = 35) of women with low BMD status were surprised by their BMD results, while 49% (n = 34) were not surprised by their results.

Of those participants who were surprised by their results (n = 53), participants with low BMD status were significantly more likely to respond that they expected their BMD test results to have been higher (or better) than their results actually were compared to participants with normal BMD status ($\chi^2 = 9.22$, DF = 1, P-value = 0.002). Twenty-eight percent (n = 5) of women with normal BMD status expected their results to have been higher, while 72% (n = 13) of women with normal BMD status did not expect their BMD results to have been higher. Conversely, 71% (n = 25) of women with low BMD status expected their results to have been higher, while 29% (n = 10) of women with low BMD status did not expect their BMD test results to have been higher.

Of those participants who were surprised by their results, participants with low BMD status were significantly less likely to respond that they expected their BMD test results to have been lower (or worse) than their results actually were compared to participants with normal BMD status ($\chi^2 = 9.71$, DF = 1, P-value = 0.002). Sixty-seven percent (n = 12) of women with normal BMD status expected their results to have been lower, while 33% (n = 6) of women with normal BMD status did not expect their BMD results to have been lower. In contrast, 23% (n = 8) of women with low BMD status expected their results to have been

lower, while 77% (n = 27) of women with low BMD status did not expect their BMD test results to have been lower.

For women who shared their BMD test results with a health care professional (n = 85), women with low BMD status were significantly more likely to report receiving recommendations for follow-up testing by these health care professionals compared to women with normal BMD status ($\chi^2 = 11.77$, DF = 1, P-value = 0.0006). There were no women with normal BMD status and who shared their BMD results with a health care professional who received recommendations for follow-up tests (0% or n = 0); all of these women reported that their health care professionals did not recommend any further tests (100% or n = 41). However, of the women with low BMD status and who provided their BMD results to health care professionals, 25% (n = 11) reported that follow-up tests were recommended. Yet, 75% (n = 33) of women with low BMD status and who provided their BMD results to a health care professional did not report receiving a recommendation for follow-up tests from their health care professionals.

Of women who shared their BMD test results with a health care professional, women with normal BMD status were significantly less likely to report that they received recommendations for changes in dietary intake from their health care professionals compared to women with low BMD status ($\chi^2 = 5.48$, DF = 1, P-value = 0.02). Seventeen percent (n = 7) of women with normal BMD status reported that they were instructed to change dietary intake, while 83% (n = 35) reported that they were not. In contrast, 40% (n = 17) of women with low BMD status indicated that they were instructed to change dietary intake, while 60% (n = 26) indicated that they were not instructed to change dietary intake.

Of women who shared their BMD test results with a health care professional, women with normal BMD status were significantly less likely to report that they received recommendations for medication use from their health care professionals compared to women with low BMD status ($\chi^2 = 10.69$, DF = 1, P-value = 0.001). Two percent (n = 1) of women with normal BMD status reported that they were prescribed a medication, while 98% (n = 41) reported that they were not. In contrast, 28% (n = 12) of women with low BMD status indicated that they were prescribed a medication, while 72% (n = 31) indicated that they were not prescribed a medication.

Of women who shared their BMD test results with a health care professional, women with normal BMD status were significantly less likely to indicate that they received recommendations for other lifestyle changes from their health care professionals compared to women with low BMD status ($\chi^2 = 4.30$, DF = 1, P-value = 0.04). Nineteen percent (n = 8) of women with normal BMD status indicated that they received recommendations to change lifestyle behaviors, while 81% (n = 34) indicated that they did not. Forty percent (n = 17) of women with low BMD status reported that they received recommendations to change lifestyle behaviors, while 60% (n = 26) reported that they did not receive these recommendations from their health care professionals.

Women with low BMD status were significantly more likely to self-initiate changes in behavior based on their BMD results compared to women with normal BMD status ($\chi^2 = 4.57$, DF = 1, P-value = 0.03). Forty percent (n = 27) of women with normal BMD status initiated behavior changes, while 60% (n = 41) of women with normal BMD status did not self-initiate behavior changes based on personal BMD results. Conversely, 58% (n = 40) of women with low BMD status did self-initiate changes in behavior based on results of their BMD tests, while 42% (n = 29) of women with low BMD status did not.

Women with low BMD status were significantly more likely to report investigating osteoporosis after receiving personal BMD results compared to women with normal BMD status ($\chi^2 = 10.33$, DF = 1, P-value = 0.001). Sixteen percent (n = 11) of women with normal BMD status reported that they further investigated osteoporosis after receipt of their BMD results, while 84% (n = 58) did not. In contrast, 41% (n = 28) of women with low BMD status indicated that they did, while 59% (n = 41) of women with low BMD status indicated that they did not further investigate osteoporosis after receipt of their BMD test results.

Statistically significant differences in responses to all other questions were not found between women with normal or low BMD status. Additionally, statistically significant differences were not observed for use of ERT or HRT or oral contraceptives among women with normal or low BMD status. Approximately 32% (n = 22) of women with normal BMD status and 41% (n = 28) of women with low BMD reported using ERT, HRT, or oral contraceptives ($\chi^2 = 1.13$, DF = 1, P-value = 0.29; Note: two of these women were perimenopausal). Too few women reported use of bone-specific medications to allow statistical evaluation.

T-test comparisons between pre- and post-menopausal women

Table 4 displays comparisons by *t*-tests for age, body height and weight, BMI, WB, LS, TPF, and FA BMD measurements between groups of pre- and post-menopausal women. Postmenopausal women were significantly older compared to premenopausal women (56.0 ± 8.8 vs. 40.8 ± 6.9 years, respectively, $P < 0.0001$) and weighed significantly more (73.4 ± 16.3 vs. 66.0 ± 14.1 kg, respectively, $P = 0.007$). The difference in body weight between these two groups was not statistically significant ($P = 0.18$). The calculated BMI of postmenopausal women (27.7 ± 6.4) was significantly higher ($P = 0.002$) compared to the BMI of premenopausal women (24.3 ± 5.1). Postmenopausal women possessed significantly lower BMD (according to % of the young-adult, gender-matched reference means) at the WB (97 ± 7 vs. 102 ± 8 %, respectively, $P = 0.004$), TPF (89 ± 12 vs. 96 ± 12 %, respectively, $P = 0.002$), and FA (95 ± 10 vs. 100 ± 7 %, respectively, $P = 0.001$), but not at the LS (93 ± 14 vs. 98 ± 14 %, respectively, $P = 0.09$). Postmenopausal women were, on average, 10.7 ± 9.1 years post menopause.

T-test comparisons between women with normal and low bone mineral density status

Table 5 contains comparisons by *t*-tests for age, body height and weight, BMI, WB, LS, TPF, and FA BMD measurements between groups of participants based on BMD status. Women with normal BMD weighed significantly more ($P = 0.0008$) compared to women with low BMD status (75.4 ± 17.8 vs. 66.2 ± 13.6 kg, respectively). Additionally, the calculated BMI of women with normal BMD (27.8 ± 6.6) was significantly higher ($P = 0.004$) compared to BMI of women with low BMD status (24.8 ± 5.0). As expected, women with normal BMD status possessed significantly higher BMD at the WB (105 ± 6 vs. 95 ± 6 %, respectively, $P < 0.0001$), LS (105 ± 9 vs. 87 ± 13 %, respectively, $P < 0.0001$), TPF (102 ± 8 vs. 85 ± 19 %, respectively, $P < 0.0001$), and FA (103 ± 7 vs. 95 ± 8 %, respectively, $P < 0.0001$) compared to women with low BMD status based on % of the young-adult, gender-matched reference means. Statistically significant differences were not observed for age ($P = 0.08$) and height ($P = 0.10$) between groups of women with normal BMD status and low BMD status.

Chapter 5: Discussion

In the current study, actions that women took after receiving their personal BMD test results were examined. More specifically, women's reactions to BMD tests results, sharing of BMD test results with health care professionals, and subsequent medical care, self-imposed behavioral changes based on BMD test results, self-directed learning about osteoporosis after receipt of BMD test results, sharing of BMD test results with others, and reactions to body composition results were investigated.

Results of this study must be interpreted with caution for two main reasons. First, the sample was not representative of the general population of women in the United States. Participants were selected due to their previous participation in an original study related to osteoporosis and bone health conducted in the BONE Laboratory at VPI&SU. Thus, random sampling to obtain a representative sample of original participants was not performed, and women included in the original study constituted a convenience sample. Of the 138 women included in this present study, 137 were Caucasian and one participant was African-American. As a whole, these participants were well-educated. Forty-two participants had received high school diplomas, while 67 obtained Bachelor's degrees (college), and 29 held advanced degrees (Masters or Doctoral). Secondly, open-ended questions in this survey did not always allow for obtainment of complete and explicit responses.

Despite these limitations, results underscore several important findings. It is noteworthy that of the 85 participants who shared their BMD test results with a health care professional, a vast majority (80%) shared their results with their primary care physician. These findings are consistent with those of a previous study related to women's knowledge and practices regarding osteoporosis (Ribeiro et al., 2000).

A notable finding was that women with greater body weight had higher BMD compared to women with lower body weight (Table 5). A high body weight has been shown to stimulate bone mineralization and strength due to the mechanical loads placed on bone from additional body mass. This finding suggests that weight maintenance, but not necessarily weight gain, is important for preserving BMD status in women. Moreover, for women with risk factors for diseases associated with high body weight, care must be taken to preserve bone mass if weight loss is recommended to manage other diseases.

Also interesting are the practices of health care professionals (as reported by study participants) concerning subsequent medical care of women with low BMD status. Of the women with low BMD status and who provided their BMD results to health care professionals, only 25% reported that follow-up tests were recommended. Similarly, only 28% of these women indicated that they were prescribed a medication. Such findings may reflect the uncertainty of health care professionals as to the efficacy of follow-up laboratory testing for osteoporosis risk or bone health status, as well as for treatment indications and implications from bone densitometry measurement.

Findings regarding dietary and lifestyle changes are also interesting. A moderate percentage (40%) of women with low BMD test results who reported their results to at least one health care professional indicated that these practitioners recommended dietary changes. Similarly, a moderate percentage (40%) of women reported that they received recommendations to change lifestyle behaviors. Of all these women who shared their BMD test results with at least one health care professional (n = 85), only 28% of these participants indicated that these health care professionals prescribed dietary changes. None of these women's practitioners recommended increasing dietary intake of vitamin D — a standard preventive measure for osteoporosis. None of these women's practitioners recommended decreasing alcohol consumption or salt intake. Additionally, the recommendation to increase soy foods in the diet was not suggested by these health care professionals. These findings suggest that dietitians should partner with other health care professionals, namely physicians, to increase the awareness and importance of dietary modifications in prevention and treatment of osteoporosis. In fact, dietitians should make their services for physician and patient education more accessible. Additionally, computer-assisted instruction may serve as an aid in the education of physicians regarding osteoporosis prevention, detection, and treatment. This type of instruction may offer advantages of accessibility, consistency, and self-paced study that may encourage physicians to become more knowledgeable about this disease or to participate in more continuing education activities.

Regarding self-initiated changes in behavior and investigation of osteoporosis, 40% of women with low BMD self-initiated changes in behavior based on results of their BMD tests. Additionally, 41% of women with low BMD status indicated that they further investigated osteoporosis after receiving personal BMD results. Although these findings are

promising, a need to encourage more women to change their lifestyle behaviors and become more knowledgeable about osteoporosis still remains, particularly among women with low BMD status.

There are many self-care strategies that women can implement for the management of osteoporosis. First, it is important that women comply with physician recommendations with respect to diet and exercise. Women should also strive to reduce risk factors for osteoporosis that are modifiable. For example, smoking cessation and alcohol consumption reduction may help preserve BMD. Additionally, women should have a thorough understanding of both the risks and benefits of medications necessary for osteoporosis treatment. Lastly, because even minor falls may lead to bone fractures in persons with weakened bones, objects in the environment that may lead to falls should be removed.

Overall, the vast majority (85%) of all participants in this study shared their BMD test results with family members, friends, co-workers, and other individuals. Also noteworthy, was the finding that many of the participants (70%) encouraged other individuals to have their BMD tested. This type of information sharing may greatly increase osteoporosis awareness, thereby bridging much of the gap that physician-to-patient knowledge transfer may leave. Physicians may consider organizing health advocates from among their patients to facilitate dissemination of health information regarding osteoporosis to their clients.

Future research

Results of this study demonstrate a new source of public information and health promotion efforts. Self-advocating women provide an excellent means of getting the message of osteoporosis prevention, detection, and treatment to other individuals in the community who may be at risk. At the same time, there is a need for further research on how to increase self-care among women regarding osteoporosis.

Because patients' reporting of their own or their physicians' behaviors may not directly coincide with behaviors in question, future studies of physicians' behaviors or women's compliance with physician recommendations may better examine the congruence between patient and physician reports. Moreover, investigations involving lesser-educated and more diverse individuals, compared to women in the present study, may provide a more

complete picture of women's actions and perceptions regarding osteoporosis self-care and physician-directed care.

Additionally, there is a need to ensure proper education of health professionals regarding BMD testing, and its implications. Clinical nutrition is concerned with the diagnosis and treatment of diseases that affect the intake, absorption, and metabolism of dietary components. Adult diseases affected by nutrition include the most prevalent causes of poor health in the United States, including osteoporosis. Despite the predominance of nutritional ailments in clinical medicine and heightening scientific documentation regarding the importance of dietary adjustment to disease prevention, contemporary medical practitioners are commonly inexperienced in the association of diet to health and disease. New efforts must be initiated to disseminate essential information for osteoporosis detection and treatment in clinical practice.

Medical students represent another population that would benefit from more extensive education on osteoporosis. Although diet plays a significant role in the onset and progression of many of the leading causes of death in the United States, nutrition courses have not always been included in medical school curriculum. The need to incorporate nutrition into the catalog of required medical skills and competencies is becoming recognized. The Association of American Medical Colleges (AAMC) reported that during the 1997-1998 school year, 26% of schools had a required nutrition course, whereas 25% of schools still did not require or could not quantify nutrition education in their programs (Cooksey, Kohlmeier, Plaisted, et al., 2000). While there have been some improvements in recent years, far more work remains to be done.

Osteoporosis is a widespread public health problem. The costs to national healthcare systems from osteoporosis-related hospitalizations are alarming. As more people are diagnosed with osteoporosis, more people will become dependent and will require medical care. This leads to an increased burden on our public health care systems. As such, future efforts to spread the message that more needs to be done by governmental organizations and health insurers to promote early detection of osteoporosis should be undertaken.

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APPENDIX A

Tables

Table 1. Bone mineral density data for participants as compared to the young-adult reference mean.

Bone mineral density site	N	Mean \pm SD ^a	Range
Whole body (%) ^b	138	100 \pm 8	76 — 126
Lumbar spine (%)	138	96 \pm 14	51 — 127
Total proximal femur (%)	138	94 \pm 12	57 — 122
Total forearm (%)	138	99 \pm 9	73 — 119

^aSD = standard deviation.

^bRepresents % of young-adult, gender-matched reference mean for bone mineral density at that bone site.

Table 2. Health care professionals with whom participants (n = 85) shared their bone mineral density results.

Health care professional	Percent ^a (number) of participants
Primary care physician	80 (68)
Obstetrician/gynecologist	15 (13)
Endocrinologist	1 (1)
Rheumatologist	2 (2)
Orthopedist	1 (1)
Registered nurse or nurse practitioner	2 (2)
Chiropractor	3 (3)
Dietitian	1 (1)
Gerontologist	0 (0)
Physician's Assistant	0 (0)
Pharmacist	0 (0)
Other	9 (7)

^aPercent does not add to 100 as participants identified as many health care professionals as applicable.

Table 3. Sources of information used by participants (n = 39) to further investigate osteoporosis after receipt of bone mineral density test results.

Source of information	Percent ^a (number) of participants
Internet or websites	69 (27)
Pamphlets	28 (11)
Health newsletters	15 (6)
Books (general)	15 (6)
Friend	13 (5)
Health magazine	13 (5)
Women's magazine	13 (5)
Radio program or advertisement	10 (4)
Scientific journal article	10 (4)
Newspaper	10 (4)
Relative	8 (3)
Television program or advertisement	5 (2)
Textbook	5 (2)
Nutritional supplement store	5 (2)
Other newsletters	5 (2)
Other sources	13 (5)

^aPercent does not add to 100 as participants identified as many sources of information as applicable.

Table 4. Comparisons of age, body height and weight, body mass index, whole body, lumbar spine, total proximal femur, and total forearm bone mineral density (BMD) measurements between groups of pre- and post-menopausal women.

Variable	Premenopausal Women (n = 66)	Postmenopausal women (n = 58)	P-value ^a
Age (years)	40.8 ± 6.9	56.0 ± 8.8	< 0.0001
Height (cm)	164.61 ± 6.10	163.13 ± 5.98	0.18
Weight (kg)	66.0 ± 14.1	73.4 ± 16.3	0.007
Body mass index	24.3 ± 5.1	27.7 ± 6.4	0.002
Whole body BMD (%)	102 ± 8	97 ± 7	0.004
Lumbar spine BMD (%)	98 ± 14	93 ± 14	0.09
Total proximal femur BMD (%)	96 ± 12	89 ± 12	0.002
Total forearm BMD (%)	100 ± 7	95 ± 10	0.001

^aP-values from *t*-test comparisons between groups.

Table 5. Comparisons of age, body height and weight, body mass index, whole body, lumbar spine, total proximal femur, and total forearm bone mineral density (BMD) measurements between groups of women with normal and low BMD status.

Variable	Normal BMD status (n = 69)	Low BMD status (n = 69)	P-value ^a
Age (years)	46.5 ± 8.3	49.7 ± 12.1	0.08
Height (cm)	165.03 ± 6.35	163.29 ± 5.96	0.10
Weight (kg)	75.4 ± 17.8	66.2 ± 13.6	0.0008
Body mass index	27.8 ± 6.6	24.8 ± 5.0	0.004
Whole body BMD (%)	105 ± 6	95 ± 6	< 0.0001
Lumbar spine BMD (%)	105 ± 9	87 ± 13	< 0.0001
Total proximal femur BMD (%)	102 ± 8	85 ± 9	< 0.0001
Total forearm BMD (%)	103 ± 7	95 ± 8	< 0.0001

^aP-values from *t*-test comparisons between groups.

APPENDIX B

Introductory Statement and Legally Implied Consent Statement

Participant's Code Number: _____
Date: _____
Dial Telephone Number: _____

Good morning/good afternoon/good evening.
This is (your name) _____ calling from the BONE Laboratory at Virginia
Tech. May I speak with Ms. _____?
If participant is on-line, continue with the phone call.
If participant is not available, ask for the best time to contact the individual: _____

Ms. _____, this is _____ (your name) _____. I am working
with Dr. Nickols-Richardson in the Department of Human Nutrition, Foods and Exercise at
Virginia Tech. You participated in a study related to Osteoporosis Health Beliefs and Bone
Mineral Density in the last year in our BONE Laboratory, and we would like to ask you a
few questions related to your actions and follow-up after you received your bone mineral
density testing information or results. The purpose of this phone call is to conduct a follow-
up study regarding the actions that the approximately 200 women who participated in this
first study have taken after they received their bone mineral density results.

Is this an appropriate time to talk with you or should I call back later?
If yes, continue with the phone call.
If no, ask for the best time to call and the appropriate phone number: _____

Thank you for your time. I will contact you at this later time. Have a nice
day/evening.

If yes: We are conducting this phone survey for research purposes. There are no risks to your
participation in this study, and we will keep any information that you share with us
confidential. It will take about 30 minutes of your time to answer our questions.

Are you willing to participate by answering some questions? YES NO (Circle one)
Date and time: _____ Investigator's initials: _____
If no: Thank you for your time. Have a nice day/evening.

If yes: I will ask you several questions. Please respond to the best of your ability. If there is
a question that you prefer not to answer, you may decline to answer that question.

APPENDIX C

Study Questionnaire

Participant's Code Number: _____

Date: _____

Investigator's Initials: _____

After participating in our original study, you received bone mineral density results for your total body, your hip, your spine, and your forearm.

1. Were you surprised by the results of your bone mineral density testing results? YES NO
a. If yes, did you think that your bone density results would be: (check all that apply)

Better (Higher)

Worse (Lower)

Other (Identify): _____

Why? _____

2. Did you share your bone mineral density results with a health care professional? YES NO

- a. If yes, with whom did you share your bone density results? (Check all that apply)

Primary care physician

Registered nurse or Nurse practitioner

Obstetrician/Gynecologist

Physician's assistant

Endocrinologist

Chiropractor

Rheumatologist

Dietitian

Orthopedist (Orthopedic physician)

Pharmacist

Gerontologist

Other specialist (Identify): _____

Other (Identify): _____

- b. Did this _____ (health professional - listed above) recommend that you receive further medical care or medical treatment or have any other laboratory tests conducted? YES NO

- c. If yes, what medical care or treatment or laboratory tests were completed? (Check all that apply)

Blood work or complete blood cell count

Blood levels of sodium, potassium, albumin, or other serum chemistry studies

Vitamin D level in blood, serum, or plasma

Parathyroid hormone level in blood, serum, or plasma

Estrogen level in blood, serum, or plasma

Progesterone level in blood, serum, or plasma

Bone turnover markers in blood, serum, plasma such as osteocalcin or cross-links

Thyroid level in blood, serum, or plasma

Urine analysis

Mammography

X-rays

- Additional bone mineral density scans or studies (Identify): _____
- Other (Identify): _____

d. Did this _____ (health professional - listed above) prescribe any dietary changes for you? YES NO

e. If yes, what changes were prescribed or recommended to you? (Check all that apply)

- Increase dietary calcium intake (drink more milk, eat more cheese, etc.)
- Take a calcium supplement
- Increase dietary vitamin D intake (drink more milk, etc.)
- Take a vitamin D supplement
- Decrease caffeine intake (drink less soda, drink less coffee, drink less tea, etc.)
- Decrease dietary protein intake (eat less meat, etc.)
- Decrease dietary salt or sodium intake (use less salt, eat less salty foods, etc.)
- Decrease alcohol intake (drink less wine, beer, or liquor, etc.)
- Increase soy in your diet (drink soy milk, eat tofu, etc.)
- Take a soy supplement
- Other recommendation for your diet: _____

f. Did this _____ (health professional - listed above) prescribe any medications or pharmacological agents for you? YES NO

g. If yes, what medications or pharmacological agents were prescribed or recommended for you? (Check all that apply)

- Estrogen replacement therapy or hormone replacement therapy (such as estrogen pills, Premarin, Prem-pro, etc.)
- Bisphosphonates (Fosamax, Actonel, etc.)
- Calcitonin or salmon calcitonin
- Raloxifene (Evista)
- Other (Identify): _____

h. Did this _____ (health professional - listed above) recommend any other changes to you? YES NO

- i. If yes, what changes were recommended? (Check all that apply)
- | | |
|--|--|
| <input type="checkbox"/> Increase exercise (in general) | <input type="checkbox"/> Meditation |
| <input type="checkbox"/> Lift weights or weight lifting | <input type="checkbox"/> Tai Chi |
| <input type="checkbox"/> Increase weight-bearing exercise (in general) | <input type="checkbox"/> Balance exercises |
| <input type="checkbox"/> Increase walking | <input type="checkbox"/> Stair climbing |
| <input type="checkbox"/> Stretching exercises | <input type="checkbox"/> Rowing machine |
| <input type="checkbox"/> Increase jogging or running | <input type="checkbox"/> Quit smoking |
| | <input type="checkbox"/> Other (Identify): _____ |
| | _____ |
| | _____ |

3. Did you change your behavior based on your bone mineral density results? YES NO

- a. If yes, what did you do that was different before you received your bone mineral density results? (Check all that apply)
- Increased exercise
 - Began medication
 - Changed dietary intake (diet)
 - Began taking a vitamin and/or mineral and/or other nutrition supplement
 - Quit smoking
 - Other (Identify): _____
 - _____
 - _____

b. Describe each one checked above: _____

4. Did you investigate osteoporosis or bone mineral density any further on your own, without medical supervision, after you received your bone mineral density testing results? YES NO

- a. If yes, what sources did you use to gain additional information? (Circle all that apply)
- Friend
 - Relative
 - Radio program or advertisement
 - Television program or advertisement
 - Book (general)
 - Textbook (such as physiology or biology book, etc.)
 - Health magazine (such as Shape, Prevention, etc.)
 - Women's magazine (such as Women's Day, Glamour, Family Circle, etc.)
 - Scientific journal (such as Science, Nature, etc.)
 - Pamphlets (such as from a pharmacy or doctor's office, etc.)
 - Internet or websites
 - Nutrition supplement store (such as GNC, etc.)
 - Health newsletters (such as Tuft's Newsletter, etc.)

- Other newsletters
- Newspapers
- Other (Identify): _____

5. Did you discuss your bone mineral density testing results with anyone else? YES NO

a. If yes, whom did you discuss your bone density results with? (Circle all that apply)

- Family member(s)
- Friend(s)
- Other (Identify): _____

6. Did you encourage anyone else to have a bone mineral density test completed based upon your results or your experience with this study? YES NO

a. If yes, whom did you encourage to have bone mineral density testing done?

- Family member(s)
- Friend(s)
- Other (Identify): _____

7. Were the results of your body fat mass or muscle mass of concern to you for any reason?

YES NO

a. If yes, why? _____

b. If yes, did your results from your body fat mass and muscle mass testing result in any changes in your lifestyle or health behaviors? YES NO

*If yes, briefly describe these changes: _____

8. Would you be interested in having follow-up testing of your bone mineral density?

YES NO

9. Have you broken any bones since you had your bone mineral density tested in our study?

YES NO

a. If yes, which bone(s)? _____

10. Did you find your participation in the first study beneficial? YES NO

a. If yes, how so? _____

b. If no, why not? _____

Do you have any questions about the information that we collected? (Let participant ask questions or clarify any answers if needed/desired.) Answer questions of participant as needed.

Thank you for your time. We greatly appreciate your answering these questions.

APPENDIX D

Coding Design for Raw Data

Question 1. Yes = 1, No = 0, Missing = 9

Question 1a.

Better: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Worse: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Other: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Why: 01 = high current calcium intake 11 = history of amenorrhea
02 = no family history-osteoporosis 12 = high current level of exercise
03 = young age or premenopausal 13 = no risk factors identified
04 = high past calcium intake 14 = self-perceived health was better
05 = taking an oral contraceptive 15 = older age
06 = taking a bisphosphonate 16 = bone-resorbing medication use
07 = low past calcium intake 17 = healthy dietary intake
08 = low present calcium intake 88 = not applicable
09 = fear the worst 99 = missing or not needed
10 = did not know what to expect

Question 2. Yes = 1, No = 0, Missing = 9

Question 2a.

For all responses: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Question 2b.

Yes = 1, No = 0, Not applicable = 8, Missing = 9

Question 2c.

For all responses: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Question 2d.

Yes = 1, No = 0, Not applicable = 8, Missing = 9

Question 2e.

For all responses: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Question 2f.

Yes = 1, No = 0, Not applicable = 8, Missing = 9

Question 2g.

For all responses: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Question 2h.

Yes = 1, No = 0, Not applicable = 8, Missing = 9

Question 2i.

For all responses: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Question 3. Yes = 1, No = 0, Missing = 9

Question 3a.

For all responses: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Question 3b.

Do not code; analysis for qualitative data.

Question 4. Yes = 1, No = 0, Missing = 9

Question 4a.

For all responses: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Question 5. Yes = 1, No = 0, Missing = 9

Question 5a.

For all responses: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Other: 01 = coworkers

05 = roommates

02 = dietetic interns

06 = dietitians

03 = physicians

88 = not applicable

04 = personal trainer

99 = missing or not needed

Question 6. Yes = 1, No = 0, Missing = 9

Question 6a.

For all responses: If checked = 1, If unchecked = 0, Not applicable = 8, Missing = 9

Other: 01 = coworkers

06 = all females

02 = neighbors

07 = patients

03 = female athletes

88 = not applicable

04 = everyone

99 = missing or not needed

05 = students

Question 7. Yes = 1, No = 0, Missing = 9

Question 7a.

Why: 01 = body fat too high

05 = general dissatisfaction

02 = desire more muscle

06 = inconsistent with other measures

03 = relation to general health

88 = not applicable

04 = relation to overall weight

99 = missing or not needed

Question 7b.

Yes = 1, No = 0, Not applicable = 8, Missing = 9

If yes: 01 = increase in exercise

88 = not applicable

02 = dietary intake changes

99 = missing or not needed

03 = weight loss, general practices

Question 8. Yes = 1, No = 0, Missing = 9

Question 9. Yes = 1, No = 0, Missing = 9

Question 9a.

If yes: 01 = rib

02 = hip

03 = fibula

88 = not applicable

Question 10.

Yes = 1, No = 0, Yes and No = 2, Missing = 9

Question 10a.

If yes :

- 01 = increase in awareness and knowledge of personal bone density status
- 02 = ability to share information with health care professionals
- 03 = baseline information to allow monitoring of changes
- 04 = encouraged others to participate - led to treatment for them
- 05 = reassurance that health behaviors are appropriate for bone health
- 06 = comprehensive results obtained
- 07 = free tests; only way to have tests completed
- 08 = confirmation that osteoporosis is not present
- 09 = confirmation that past health status did not affect present bone status
- 10 = led to diagnosis and treatment
- 11 = did not understand results
- 12 = led to behavioral changes
- 13 = led to reflection of behaviors
- 14 = receipt of additional nutritional information
- 15 = comparison of current results with previous results
- 16 = sparked inquiry about family history
- 18 = increase in awareness of risk factors for osteoporosis
- 88 = not applicable
- 99 = missing or not needed

Vitae

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