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A Pilot Study to Identify Modifiable and Nonmodifiable Variables Associated With Osteopenia and Osteoporosis in Men

Tracy Fasolino ▼ Theresa Whitright

Osteoporosis is typically associated with women, but men can also be affected. Less is known about the factors influencing the development of osteoporosis in the male population. This pilot study attempted to identify variables associated with osteopenia or osteoporosis in men. The 101 male participants completed a questionnaire that examined modifiable and nonmodifiable variables: alcohol consumption, smoking, exercise history, fracture history as an adult, and family history of osteoporosis. Objective variables collected included age, height, and weight to calculate body mass index. Bone mineral density was calculated using dual-energy x-ray absorptiometry. Osteopenia or osteoporosis was identified in 62 of the male participants. Consumption of alcohol and cigarettes with higher body mass index was correlated with greater likelihood of osteopenia and osteoporosis.

Introduction

Osteoporosis is a well-recognized problem in older women. However, there has been inadequate awareness among the public and healthcare providers that osteopenia and osteoporosis are also a common problem in older men. The National Osteoporosis Foundation (NOF) reported in 2010 that more than 52 million women and men had osteoporosis (NOF, 2012). This number is expected to increase by more than 50% by 2025 with an estimated cumulative cost reaching $228 billion (Burge et al., 2007). Sutton, Dian, and Guy (2011) reported a higher incidence of morbidity and mortality, greater functional decline, and higher healthcare costs for men with osteoporosis as compared with women. An estimated 1–2 million men in the United States have osteoporosis, and an additional 8–13 million have low bone mineral density (BMD) (Gennar & Bilezikian, 2007). One in four men over the age of 60 years will have an osteoporotic fracture in their lifetime (Gruntmanis, 2007). The U.S. Preventive Service Task Force is charged with developing recommendations for preventive services. The task force has established screening guidelines for osteoporosis in women but has had difficulty outlining screening guidelines for men due to insufficient evidence. Without screening guidelines, men with osteopenia or osteoporosis are unaware of the associated risks. In 2012, the Endocrine Society published clinical practice guidelines for screening and management of osteoporosis in men (Watts et al., 2012). Evidence of the associated modifiable and nonmodifiable risk factors contributing to osteoporosis is gradually reaching the public and healthcare providers (Haentiens et al., 2004).

While women are more susceptible to osteoporosis due to less bone mass and faster rate of loss, evidence supports the occurrence of osteopenia and osteoporosis in men (El-Ziny, Elhawary, Elsharkawy, & Salem, 2010). Basic physiological differences between women and men across the lifespan help explain the increased risk in women. For example, infant boys have higher BMDs and bone mineral content than infant girls, and this gender difference continues into adulthood (Raisz, 2005). Vertebrae are larger in men than in women and this size disparity reaches peak at sexual maturity. Calcitonin, a molecule involved in depositing calcium into the bone, is secreted at higher levels in men than in women. When women go through menopause, they experience a rapid reduction in BMD of the spine, whereas the decrease is gradual in men as they age. However, aging women and men experience an acceleration of bone loss as estrogen and testosterone levels decrease resulting osteoporosis. Osteoblasts, osteocytes, and osteoclasts, along with monocytes, macrophages, type I collagen, and noncollagenous proteins, make up the bone matrix. Osteoblasts are derived from mesenchymal stem cells and are stimulated by parathyroid hormone levels and by vitamin D levels in the body. Osteoblasts form new bone and help strengthen existing bone. Osteocytes direct the timing and location of bone remodeling. Osteocytes signal osteoblasts to make new bone when bone formation is needed. In contrast, osteoclasts are involved in bone resorption and are also influenced by the hormone calcitonin. Calcitonin is a

Tracy Fasolino, PhD, FNP, Assistant Professor, Clemson University, Clemson, SC.

Theresa Whitright, MSN, FNP, RN, Nurse Practitioner, Internal Medicine Associates, Greenville, SC.

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32-amino acid linear polypeptide that acts directly on osteoclasts to stop bone resorption. Breakdowns in these pathways from modifiable and nonmodifiable factors lead to the osteopenia and osteoporosis. A fragile skeletal system can be caused by a failure to produce a skeleton of optimal mass and strength during growth, excessive bone resorption, or can be the result of an inadequate bone formation during bone remodeling. As fragility increases, bones become more porous and the person's BMD decreases, leading to an increased risk of fracture (Seeman, 2003).

Background

Modifiable and nonmodifiable variables related to osteopenia and osteoporosis require investigation to determine the impact on the male population. Research on modifiable variables, such as alcohol consumption, tobacco use, exercise history, and body mass index (BMI) has been focused primarily on women with minimal investigation into the impact on men. Further investigation is needed to determine whether these same variables are related to the development of osteopenia and osteoporosis in men rather than assuming that the variables affect both genders. In addition, research on nonmodifiable variables, such as fracture history as an adult, family history of osteoporosis, and age, has been shown to impact the BMDs of women but limited data are available for men (Maurel, Boisseau, Benhamou, & Jaffre, 2012; Watts et al., 2012). Determining the association of these variables to the development of osteopenia and osteoporosis provides the evidence necessary to develop screening guidelines.

Alcohol consumption has been shown to affect bone matrix at the cellular level. Alcohol interferes with calcium absorption and also increases parathyroid hormone activity, leading to a decrease in bone formation and an increase in bone resorption. Alcohol consumption has also been shown to affect the healing of bones by delayed development of a fracture callus. The delay in callus formation is the result of decreased osteoblastic activity, particularly in individuals with sustained alcohol use (Atalr et al., 2009). Determining the association between alcohol consumption and BMD can help establish an associated risk.

Exercise has been shown to improve cardiovascular health and lengthen the lives of men, but there has been inconsistent evidence that demonstrates exercise correlates to BMDs. Michaëlsson et al. (2007) reported a reduced risk of hip fractures in men when engaged in exercise. Boyd (2003) suggested that exercise could inhibit bone resorption and prevent bone loss. The clinical implications for linking physical activity to BMD would allow healthcare providers to counsel their patients about the importance of exercise to improve bone health.

Another potential risk factor for development of osteopenia or osteoporosis is smoking. Previous studies have demonstrated that smoking leads to lower bone density by suppressing sex hormones that facilitate new bone development. Smoking has also been shown to decrease calcium absorption (Bleicher et al., 2010). However, research studies investigating the relationship between smoking and BMD have been sparse and inconclusive.

A high BMI has long been thought to be protective for bones. Mascolini (2012) reported lower BMI with high rates of osteopenia and osteoporosis. Conversely, Paniagua, Malphurs, and Samos (2006) found overweight and obese men have a high prevalence of osteopenia and osteoporosis. Leanness (BMI < 20), regardless of age, sex, and weight loss, has been associated with greater bone loss and increased risk of fracture. However, new research has indicated that a high BMI may not be protective for fracture occurrence. The Osteoporotic Fractures in Men Study (Nielson et al., 2011) demonstrated that greater than 60% of fractures occur in overweight and obese men. Vitamin D levels in obese men typically are lower and can increase the risk of a fracture. Obese men also have a disruption in the hypothalamic–pituitary axis altering androgen levels that influence BMDs (Papaioannou et al., 2009). With a growing population of obese men in the United States, examining the relationship with BMI and BMD will be important. Aging men is another area with sparse research. The loss of bone with aging has been linked to increased osteoclastic activity that is not offset by new bone development. Further research is needed to determine whether aging is a risk factor for men in the development of osteopenia or osteoporosis.

A personal history of fracture may be a risk factor that is reflective of the BMD level. One study has examined the relationship between fracture prevalence and the rate of bone loss (Kanis, Johannson, Oden, & Johnell, 2004). Additional research is needed to establish whether a personal history of fracture as an adult is a risk factor for low BMD. A family history of osteoporosis may be another nonmodifiable risk factor in the development of low BMD in men. Studies have shown that a family history of osteoporosis can increase the risk of fractures in men independent of the BMD level (NOF, 2013). The purpose of this study was to explore the relationship of modifiable and nonmodifiable

Table 1. Comparison Between Participants' Differences in Means With Continuous Data

BMD Category	Pack Years	Body Mass Index[a]	Age
Normal BMD ($n = 30$)	78.4 (150.2)	28.2 (3.8)	70.6 (3.1)
Osteopenia ($n = 43$)	85.8 (170.8)	26.0 (4.2)	70.9 (3.3)
Osteoporosis ($n = 19$)	68.6 (145.6)	26.0 (4.3)	71.4 (2.9)

Note. Values represent mean (*SD*). BMD = bone mineral density.
[a]$p = .02$.

variables to the presence of osteopenia and osteoporosis in the male population by examining the BMDs. The variables explored included alcohol consumption, exercise history, smoking, BMI, age, fracture history as an adult, and family history of osteoporosis.

Methods

This pilot, exploratory study utilized self-report questionnaires by the participants to collect data on modifiable and nonmodifiable variables. At the time of enrollment, none of the participants had been diagnosed or were aware of the presence of osteopenia and/or osteoporosis. The sample was drawn from established patients in an internal medicine practice. The participants completed a BMD study utilizing the dual-energy x-ray absorptiometry (DXA). The study was approved by the academic institutional review board. The inclusion criteria were men aged 65–75 years, physically able to get on and off the DXA scan table, and able to lie flat for approximately 15 minutes. The exclusion criterion included a previous diagnosis of osteopenia or osteoporosis, current treatment with a bisphosphonate, and/or a previous diagnosis of an overactive thyroid gland or parathyroid gland.

The self-report questionnaire examined modifiable variables of alcohol consumption, exercise history, and tobacco use (calculated pack years). Alcohol consumption and exercise history were categorical and tobacco use was interval level data. The questions related to alcohol consumption and exercise included asking about the amount and frequency the participants engaged in these activities. For example, the participant was to mark alcohol consumption as one of the following: one drink per week, 2–3 drinks per week, 4–6 drinks per week, or 6+ drinks per week. Pack years is a unit of measurement to quantify the amount a person has smoked over a period of time. The calculation is completed by multiplying the number of packs of cigarettes smoked per day by the number of years the person has smoked. Nonmodifiable variables on the questionnaire included fracture history as an adult and family history of osteoporosis and were categorical level data. The participant's age, height, and weight were interval level data. The BMI was calculated from height and weight. The National Heart, Lung, and Blood Institute (2014) outlines BMI of 18.5–24.9 as normal, BMI of 25.0–29.9 as overweight, BMI of 30.0–39.9 as obesity, and 40.0+ as extreme obesity.

Participants' bone density was determined through the use of DXA, considered to be the most accurate tool to measure BMDs (NOF, 2013). Each participant had DXA scans completed on the GE Lunar Bone Densitometry with BMDs calculated from the hip and spine region. The density scores were categorized using the World Health Organization's standards for diagnosing osteopenia and osteoporosis. There are several classification models for osteopenia and osteoporosis, but inconsistencies have been reported with each method. Our team selected the World Health Organization standards because a large portion of prior research has utilized this classification guideline. The diagnosis of osteopenia is reported when the BMD is between 1 and 2.5 standard deviations lower than (T-score, −1.0 to −2.5) that of a young healthy adult. The diagnosis of osteoporosis is reported when the BMD is greater than 2.5 standard deviations lower than (T-score, −2.5) that of a young healthy adult. Research participants were divided into three categories on the basis of their BMD scores; normal BMDs, osteopenia, or osteoporosis. Statistical analyses were performed using the 2011 version of Statistical Product and Service Solutions (SPSS Inc., Chicago). Frequencies, means, and standard deviations were calculated for categorical level. Spearman's correlation and analysis of variance (ANOVA) were utilized to calculate categorical and interval level data with significance level set at $p < .05$.

Results

A total of 101 male participants enrolled into the study with 92 completing the self-report questionnaire. The mean age was 70.7 (SD = 3.1) years and predominantly Caucasians (99%). The results of the BMDs via DXA scan found 39 males (38.6%) with normal BMDs, 43 males (42.6%) with osteopenia, and 19 males (18.8%) with osteoporosis (see Table 1).

Modifiable Variables

Alcohol consumption was reported by 48 of the participants (52%) versus 44 participants abstaining (48%). In the osteopenia and osteoporosis groups (n = 62), 30 participants (48%) reported alcohol consumption. Spearman correlation coefficient for alcohol consumption and BMD osteopenia/osteoporosis was $rs = -.098$ and not statistically significant ($p = .33$). Approximately 78 of the 92 participants (85%) reported being engaged in exercise. Within the osteopenia and osteoporosis groups (n = 61), 50 participants (82%) reported participating in exercise. Spearman correlation coefficient for engaging in exercise and BMD osteopenia/osteoporosis was $rs = -.151$ and not statistically significant ($p = .13$).

Tobacco use was common in those who participated in this study (74.2%). Within the osteopenia and osteoporosis groups (n = 62), 47 participants (75%) reported tobacco use. Those participants with BMDs of osteoporosis (n = 19) reported the highest tobacco use (89%) with mean pack years of 78.4 (SD = 150.2). An ANOVA showed that the effect of tobacco use as calculated by pack years on BMD osteopenia/osteoporosis was not significant ($F = 0.864$, $p = .42$). The mean BMI for all participants was 28.18 (SD = 3.8). The participants in the osteopenia and osteoporosis groups had slightly lower BMI of 26.0 (SD = 4.3). An ANOVA showed that the effect of BMI on BMD osteopenia/osteoporosis was significant ($F = 0.3.969$, $p = .02$). The mean age for all participants was 70.7 (SD = 3.1) years. An ANOVA showed that the effect of age on BMD osteopenia/osteoporosis was not significant ($F = 1.338$, $p = .26$).

Nonmodifiable Variables

A history of fracture as an adult was reported by 32 of the participants (35%) versus 60 participants with no history of fracture ($\chi^2 = 4.041$, $N = 101$, ns). Within the osteopenia and osteoporosis groups ($n = 62$), 20 participants (33%) reported a history of fracture as an

adult. Spearman's correlation coefficient for history of fractures and BMD osteopenia/osteoporosis was $rs = -.155$ and not statistically significant ($p = .12$). A family history of osteoporosis was reported in 20 of the participants (33%) versus 62 participants with no family history of osteoporosis ($\chi^2 = 0.284$, $N = 101$, *ns*). Within the osteopenia and osteoporosis groups, 14 participants (22.5%) reported a family history of osteoporosis. Spearman's correlation coefficient for family history of osteoporosis and BMD osteopenia/osteoporosis was $rs = .037$ and not statistically significant ($p = .72$).

Discussion

Primary prevention of osteopenia and osteoporosis entails finding those men at risk and developing a treatment plan to reduce poor outcomes. The American College of Physicians (Qaseem, Snow, & Shekelle, 2008), the International Society for Clinical Densitometry (Baim et al., 2008), and the American College of Preventive Medicine (Lim, Hoeksema, & Sherin, 2009) support screening men at or after the age of 70 years by DXA of the spine and hip. For males younger than 70, the presence of risk factors would highlight the need for a DXA evaluation. As previously mentioned, the U.S. Preventive Services Task Force (2011) does not advocate for regularly DXA screening due to insufficient evidence of benefit versus potential harm. This study identified more than 50% of the participants between the ages of 65 and 75 years having osteopenia and osteoporosis. Based upon these results, screening of BMDs utilizing DXA may need to begin prior to 70 years of age.

In this study there were a disproportionally large number of men reporting tobacco usage, with nearly 75% reporting consumption, as compared to 20.5% reports from the Center for Disease Control & Prevention (Centers for Disease Control and Prevention, 2015). Three of four participants diagnosed with osteopenia or osteoporosis report tobacco consumption, even though the correlation was not found to be statistically significant. The percentage of smokers in this study was surprising given recent statistics by the Centers for Disease Control and Prevention (2015) that 20.5% of adult men currently smoke and overall smoking prevalence is declining. The combination of alcohol and tobacco use may be a contributing factor for development of osteopenia and osteoporosis, but the results from this study are inconclusive.

A large number of participants in the study reported engagement in physical activity. Interestingly, the BMI for the sample was 28.18, which suggests that these men are overweight. The percentage reporting physical activity is contradictory to recent published finding that less than 25% of the U.S. population older than 65 years engages in physical activity (Centers for Disease Control and Prevention, 2013). Our study results reflect the consistent issues associated with self-report of physical activity. Researchers have compared physical activity levels through direct measurement versus self-report and found higher reports of physical activity with self-report (Adams et al., 2005).

The relationship of the BMI to osteopenia and osteoporosis has been inconclusive with conflicting findings. Our study found statistical significance for BMI and the presence of osteopenia and osteoporosis; those with a lower BMI were in the ostepenia and osteoporosis group. However, it must be noted that the mean BMIs for all groups was in the overweight category. The BMI of participants with osteopenia and osteoporosis varied from that of the normal bone density group. The osteopenia group had higher BMI than the osteoporosis or normal BMD groups. All three groups had BMIs in the range of overweight (25-29.9; National Heart, Lung, and Blood Institute, 2014). Our results are inconsistent with reports from Paniagua et al. (2006) and the Osteoporotic-Fractures in Men Study (Cawthon et al., 2009), reporting overweight and obese men having a high prevalence of osteopenia and osteoporosis. Our study results are inconclusive since men in the osteopenia group had higher BMIs than those in the normal group. Furthermore, men in the osteoporosis group had lower BMIs than those in the normal group. The statistical significance is worthy of noting that overweight men may develop osteopenia and/or osteoporosis, but further research is needed. These findings may be partially explained by the prevalence of sedentary lifestyle, alcohol consumption, and tobacco usage with relative lack of activity (direct vs. self-report measures) by this age group.

This study targeted participants in an age range between 65 and 75 years allowing for screening of a younger range of men. We were able to complete the screening and provide counseling, education, and interventions for those patients identified as having osteopenia and osteoporosis. The small sample size and categorical variables reduced the overall quality of the study. Our results cannot be generalized to all male groups, because most of the men in our study were Caucasians.

Conclusion

Osteoporosis in men is an inadequately appreciated health issue and is a growing problem with direct impact on morbidity and mortality. Earlier disproportionate emphasis on osteoporosis in women has led to insufficient data in men. Healthcare providers and members of the public need to maintain a heightened awareness of male osteoporosis and implement strategies to abate the development and progression of the disease. One modifiable risk factor supported by this study was BMI. Additionally, research is warranted to identify other modifiable risk factors that may contribute to osteopenia and osteoporosis. Additional research is needed on clinical guidelines for screening, diagnosing, and treating osteopenia and osteoporosis in men.

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