Knowledge of Osteoporosis Risk Factors and Prevalence of Risk Factors for Osteoporosis, Falls and Fracture in Functionally Independent Older Adults

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ABSTRACT

Purpose: This study had three goals: (1) to assess knowledge of osteoporosis risk factors, (2) to determine the prevalence of risk factors for osteoporosis, falls, and fractures, and (3) to ascertain the relationship between knowledge and prevalence of osteoporosis risk factors in affluent independent community-dwelling aging adults. **Methods**: Forty-nine individuals over the age of 50 years completed a series of questionnaires and clinical testing procedures to identify osteoporosis knowledge, fall and fracture risk factors. **Results**: Positive correlations were found between greater knowledge of osteoporosis risk factors and confidence in performing activities of daily living ($r = 0.32$, $p = 0.05$), better static and dynamic balance ($r = 0.42$, $p = 0.01$) and greater lower extremity strength ($r=0.33$, $p= 0.05$). Despite these correlations 64% of participants had less than 50% correct responses related to osteoporosis knowledge. The average number of risk factors was 5.5 with many participants having modifiable risk factors including inadequate calcium and vitamin D intake and limitations in agility, balance, strength and flexibility. **Conclusions:** Participants with increased knowledge of risk factors presented with increased confidence performing activities of daily living, greater lower extremity strength and lower fall risk. Knowledge of disease processes, risk factors and strategies for prevention and management may improve patient compliance for behavioral changes necessary in successful participatory management.

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INTRODUCTION

Osteoporosis is a complex, multifactorial, chronic bone disease characterized by compromised bone strength and damaged bone microarchitecture. It is a principal etiological contributor to fractures in the elderly.[1] Osteoporosis is associated with increased mortality and morbidities[2,3] such as vertebral, wrist and hip fracture,[4] chronic pain,[5] and has increased direct care expenditures.[6] According to the World Health Organization there are an estimated 10 million Americans[1] over age 50 with osteoporosis and another 34 million with low bone mass.[7] It is estimated that, in Caucasians over 50 in the United States, 40% of women and 13% of men are likely to sustain a hip, spine, or wrist fracture sometime in the remainder of their lives.[5] As the population increases in age, the incidence of osteoporosis is projected to increase, as is the risk of osteoporosis related falls and fractures.[5]

Falls are one of the most common problems that threaten the independence of older individuals.[1] The risk of falls increases with age and 10% to 15% of falls in the elderly result in fracture.[8] Fall history is also an important predictor of future falls. Older women with osteoporosis may have a greater risk of falls because of greater impairments in balance and muscular strength than in age matched counterparts without osteoporosis.[9] Falls and fractures often share risk factors such as prior history, muscle weakness, gait and balance deficits, and increased age.[1,10] Defining the appropriate number of osteoporosis, fall and fracture risk factors to assess in the elderly may assist in providing individualized targeted treatment and prevention strategies.

One approach to analyzing fracture risk in the elderly is to examine the factors that influence bone mass. A study investigating age, weight, muscle strength, and estrogen use found these to be key influential factors on the bone mass of elderly women.[11] Additional variables such as low levels of daily physical activity and a history of falls, also increase the risk of vertebral fracture.[12] These results are consistent with the findings of the Osteoporotic Fractures Research Group that suggested limited weight bearing and family history of hip fracture were fracture risk factors; these factors were also associated with decreased mobility (eg, inability to rise from a chair without use of the upper extremities).[10] Moreover, older women with osteoporosis are a high fall risk when compared to their age-matched counterparts, in that women with osteoporosis were found to have significantly lower dominant quadriceps strength and lower composite balance scores.[11]

While the ability to identify fall or fracture risk in assessment of osteoporosis risk is critical, there are a number of other modifiable determinants for bone health that are important. They

include weight bearing physical activity,[13] adequate dietary intake of calcium and vitamin D, postmenopausal use of antiresorptive medications or hormone replacement therapy (HRT), and home safety modifications. Cessation of smoking and excessive alcohol consumption are also modifiable determinants of bone health.[1] Collectively, looking at individual risk factors present may provide insight to key determinates of osteoporosis, fracture and fall risk.

To date, few studies have examined the relationship between knowledge of osteoporosis risk factors and the prevalence of risk factors for developing osteoporosis. This study had 3 goals: (1) to describe knowledge of osteoporosis risk factors; (2) to determine the prevalence of risk factors for osteoporosis, falls, and fractures; and (3) to ascertain the relationship between knowledge of osteoporosis and the prevalence of risk factors in a group of affluent independent community-dwelling aging adults. We hypothesized that community dwelling aging adults with knowledge of osteoporosis and its risk factors would practice lifestyle behaviors that promote bone health and prevent fractures.

METHODS

Subjects

A convenience sample of 49 older adults was recruited from the 211 residents of an independent living retirement community, either by invitation from the activity director and /or distribution of flyers describing the biweekly 6-week multidisciplinary osteoporosis educational intervention study. Potential subjects were eligible to participate if they were 50 years of age or older, were able to walk 50 feet with or without an assistive device, and had endurance sufficient to participate in 1-hour physical testing procedures performed before and after the educational intervention. Participants were also required to understand and read English, and be willing to attend a 1 hour biweekly osteoporosis and fall reduction educational class for 6 weeks. Potential subjects who were unable to attend all sessions of the educational intervention or could not tolerate the physical testing were excluded.

This study was approved by the Institutional Review Board of California State University, Fresno which insured protection of human subjects. Participants signed an informed consent prior to testing.

Study Protocol

Participants were given a packet of questionnaires to complete and return prior to initiation of the educational intervention. Questionnaires collected information about demographics, osteoporosis knowledge, osteoporosis risk factors, medication history, calcium and vitamin D food frequency, smoking and alcohol intake, balance confidence, home safety, and fracture and fall history (Table 1). Physical fitness and balance testing procedures were performed to determine fall and fracture risk related to physical performance in a circuit training format completed over 1 to 2 sessions by the interdisciplinary team (physical therapist, graduate physical therapy students and a family nurse practitioner). Following baseline testing participants were assigned to attend a total of 12 educational sessions, (2 per week) over a 6-week period. Subsequent to the educational sessions a report card was provided to participants, which identified individualized osteoporosis and fall risk factors based on the information obtained in the aforementioned measures.

Osteoporosis Knowledge

Osteoporosis knowledge of risk factors was determined using the Osteoporosis Knowledge Assessment Tool (OKAT) which is both valid and reliable (Cronbach's α = .70). The osteoporosis knowledge assessment tool is a 20-item instrument with true, false, and don't know responses. Examples of questions include, "Osteoporosis leads to an increased risk of bone fractures" and "Osteoporosis is more common in men." Ten or less answers on the OKAT were rated as poor knowledge by the authors.[14]

Osteoporosis Risk

Osteoporosis risk factors were quantified using the Osteoporosis Self Assessment Tool (OST) described[15] and validated by Richy et al[16] to calculate risk for osteoporosis. The OST is a calculated risk index based on self reported age and weight (weight in kilograms - age in years) x 0.2, truncated to an integer. This tool identifies 3 categories of risk (high > 20, moderate 0-20, or low < 0) based on a standardized matrix.[16] The OST has been found to be a highly sensitive tool for identifying individuals at increased risk of osteoporosis, ranging from 85% for the lumbar spine to 97% at the total hip region.[16]

Simple clinical screening measures of height and weight were also used to assess osteoporosis risk. The Surgeon General's report on bone health identified weight less than 127 pounds and/or a loss of height greater than 2 inches from self-reported height as "at risk."[1]

Dietary calcium and vitamin D intake was determined using a short screening instrument, a food frequency questionnaire, derived from the Block-National Cancer Institute Health Habits and History Questionnaire.[17] The instrument included 22 foods and beverages that are rich in either of these nutrients. The short form is designed for self administration and asks respondents how frequently they consume each food or beverage and their usual serving size. Scores are calculated based on the nutrient content of each food. They are then correlated to calcium and vitamin D intakes as compared to a 7-day food diary, and have a positive predictive value of 91.7% and 100% for identifying individuals with low nutrient intakes of calcium and vitamin D, respectively.[18] Dietary intake of calcium less than 1200 mg/day and vitamin D less than 400 iu/day are considered to be inadequate and related to osteoporosis risk.[1]

Fall & Fracture Risk

The Balance Efficacy Scale (BES), developed by Rose and colleagues,[19] was used to evaluate how confident an individual is while performing activities of daily living that require balance. Individuals rate their level of confidence in performing 18 different tasks (eg, rise from a chair) without losing their balance, on a scale of 0 to 100%. The individual's total score is divided by 1800 and multiplied by 100 to get a percentage representative of balance efficacy. Rose et al determined that individuals with scores that are less than or equal to 50% should be considered to have low self-confidence while performing various activities requiring balance.[19]

Dynamic balance and agility was determined by the participant's performance on the 8-Foot Up and Go Test (UG). This performance-based functional test measures how quickly an individual can, on command, stand from an armless chair, walk around a cone placed 8 feet away, and return to the original position. Because the

Table 1. Outcome Measures for Osteoporosis Risk

Concept	Measure	Variable	Process
Osteoporosis Knowledge	Osteoporosis Knowledge Assessment Tool (OKAT)	20 Item True/ False/Don't Know	Self-Report
Osteoporosis Risk	Osteoporosis Self Assessment Tool	Total Score	Self-Report
	Height & Weight	Height (in) Weight (lb)	Self-Report
	Medications	Type, Dosage	Self-Report
	Block-National Cancer Institute Health Habits & History Questionnaire	3-Day Food Frequency Estimates Intake	Self-Report
	Smoking	Duration Consumption	Self-Report
	Alcohol Intake	Amount Frequency	Self-Report
Fall and Fracture Risk	Balance Efficacy Scale	18-items Total Score	Self-Report
	8 Foot Up and Go (UG)	Seconds Stand, Walk 8 feet, Turn	Clinician Administration
	50-Foot Walk Test (preferred & fast speed)	Seconds to Walk 50 feet	Clinician Administration
	Berg Balance Scale (BBS)	Total Score	Clinician Administration
	National Safety Council Home Safety Questionnaire	65 Item Yes/No	Self-Report
	Number of Falls Last 12 months	Total Falls	Self-Report
	Previous Fractures	Total Fractures	Self-Report
Senior Fitness Test	Arm Curl (upper body strength)	Arm Curls in 30 Seconds	Clinician Administration
	30-Second Chair Stand (lower body strength)	Full Stands in 30 Seconds	Clinician Administration
	Back Scratch (upper body flexibility)	Inches Between Extended Middle fingers	Clinician Administration
	Chair Sit and Reach (lower body flexibility)	Inches From Fingers To Toes	Clinician Administration
	2-Minute Step Test (endurance)	Steps Completed in 2 Minutes	Clinician Administration

unit of measurement is number of seconds to complete the task, this measure provides continuous data. The UG is a valid and reliable (r= .95) measure for quantifying functional mobility[20] with a high sensitivity (78%) and specificity (86%) for predicting falls for individuals with a score of 8.5 seconds or above.[21,22]

Functional mobility in terms of the ability to adapt gait speed and variability in velocity was measured using the 50-foot walk test.[19] Gait velocity is measured during ambulation of 70 feet with timing occurring between the 10 and 50- foot markers, first at preferred and then at fast speeds. The literature suggests that slow gait speeds are associated with fall risk[21] and variation in gait speeds are associated with fall direction and impact location.[23] Van Swearingen et al found a 72% sensitivity and 74% specificity for gait speed in recognizing the risk of recurrent falls in frail older adults, with a cutoff score of 0.56m/s for risk of recurrent falls.[24]

The Berg Balance Scale (BBS) is a performance-based measure of static and dynamic balance abilities. The BBS has been found to be both a valid measure (r =.81) and to have inter-rater reliability (.98 ICC), and to be a useful predictor of risk for future falls in aging adults.[25,26] This 14 item instrument uses an ordinal scale from 0 to 4 (0=disabled, 4= able). The BBS has a maximum score of 56 with scores of 45 and below associated with a higher risk for falls in older adults.[25,26]

The National Safety Council Home Safety Questionnaire is used to measure environmental fall and fracture risk factors. This 65-item questionnaire is scored by summing each negative answer (each equal to 1 point) to safety questions in the following domains: housekeeping, floors, bathroom, traffic lanes, lighting, stairways, ladders and step stools, outdoor area, footwear, and personal precautions (eg, "are all carpet edges tacked down" and "are all stairways well lit"). A score between 1 and 7 indicates excellent home safety conditions while a score of 15 or more indicates hazardous conditions which could increase fall risk.[27]

Fracture risk was assessed using self-reported history of frac-

tures, age, and scores on the Senior Fitness Test (SFT). The SFT uses 5 items to quantify strength, flexibility, and endurance using strategies found to be reliable and valid in community dwelling older adults (60-94 years of age).[20] All tests were administered by the same individuals trained or certified according to protocols outlined in the Senior Fitness Test Manual. This assessment has demonstrated reliability and validity[20, 28-30]and was developed to test underlying physical impairments associated with functional mobility. The results from these tests were compared to norm-referenced standards based on a sample of 7,183 community-dwelling older adults ranging from 60-94 years of age.[20]

Data Analyses

All data analysis was conducted using SPSS version 14.0 for Windows (SPSS Inc. Chicago, Ill.) Participant demographic characteristics were summarized using conventional descriptive statistics. Bivariate correlations were performed to determine the relationship between osteoporosis knowledge and osteoporosis risk factors, as well as, between osteoporosis knowledge and performance on physical performance measures. Spearman rho and Pearson's correlation coefficients were calculated depending on the data (nominal, ordinal or continuous).

RESULTS

Subjects

The study sample (N=49) included 41 females and 8 males with ages ranging from 78-98 years, a mean age of 84.4 and a standard deviation of 5.2 years. Participants included 48 Caucasians and 1 Asian Pacific Islander which is representative of the retirement living community but not the surrounding area of Fresno, California.

Health History

Participant's health history including fall and fracture history and the use of bone enhancing medications are summarized in Table 2. All female participants were postmenopausal, with an average of 34.6 years since onset of menopause.

Osteoporosis Knowledge

The mean number of correct responses related to osteoporosis knowledge was 8 (SD = 4) out of 20 possible questions, or 41% of the possible maximum score. The range of correct answers was 1-16. In a study designed to measure osteoporosis in Australian women, Winzenberg et al found an average score of 8.8 out of 20 on the OKAT suggesting that the OKAT may be sensitive to change, as well as, being applicable to other Caucasian populations.[14]

Osteoporosis Risk

An osteoporosis risk factor score was created by summing the number of risk factors found for each subject. These included number of previous falls and fractures, tobacco use, low body weight, alcohol use, female gender, white race, 65 years of age and older, and low calcium and vitamin D intake. Results for the sample are summarized in Table 2. The average number of osteoporosis risk factors per subject was 5.5 (SD=1.2) with a range of 4 to 8. Osteoporosis risk using the Osteoporosis Self-assessment Tool found that 17.4% of respondents were at low risk, 21.7% were at moderate risk, and 60.9% were at high risk (see Figure 1).

Table 2. Participant Health History Relative to Osteoporosis Risk (N=49)

Fall and Fracture Risk	N	%
1-4 Falls in previous year	16	32.6
Fractures in lifetime	13	26.5
Other Risk Factors		
Smoker	6	12.2
Low body weight	17	34.7
Alcohol use	7	14.3
Female gender	41	83.7
White race	48	97.9
Age (65 and older)	49	100.0
History of falls	16	32.6
Low Ca+ Intake (<1200mg)	41	83.7
Low Vitamin D Intake (<400 iu)	47	95.9
Bone Enhancing Medications		
Hormone Replacement Therapy	5	10.2
Bisphosphates	8	16.3
Ca++ supplement	24	48.9

Fall/Fracture Risk

The mean score for the Balance Efficacy Scale while performing daily activities was 70.9%, with scores ranging from 17% to 100%. The 8-foot up and go test revealed a mean score of 8.9 seconds with a range of 3.6 to 6.0 indicating that 39% of the participants were below the 50th percentile for their age. Steffen et al[31] has supported the use of age and gender related differences when using the timed up & go test to make clinical judgements for older adults. The 50 foot walk test preferred walking speed averages were 3.3 feet/sec with a range of 1.9 to 4.7 and fast walking speed averages of 4.3 feet/sec with a range of 2.3 to 6.8. The participants Berg Balance Scale mean score was 46.9, with scores ranging from 26 to 56 and 18 (36.7%) of the participants at risk for falls. Typical Berg Balance Scores in this population range from 50 to 55 depending on age and gender.[31]

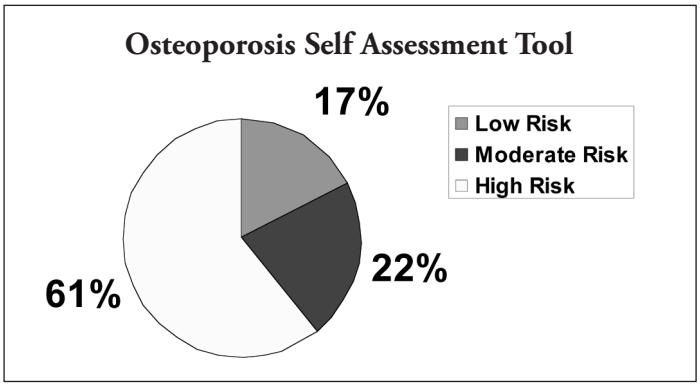

Figure 1. Osteoporosis risk determined by the Osteoporosis Self Assessment Tool (OST) (N=49).

Scores on the Senior Fitness test are interpreted by considering the individuals score relative to the 50th percentile based on normative data. Those below the 50th percentile are likely to have difficulty with functional activities (eg, personal care, shopping, housework). Thirty-eight to 75% of the participants in this study scored below the 50th percentile (at risk zone) as compared to normative age matched peers (Table 3).

The National Safety Council Home Safety questionnaire indicated that 83% of the participants had excellent home safety and 16.3 % had good home safety.

Relationships between Osteoporosis Knowledge and Risk Factor Prevalence

Correlations were calculated between osteoporosis knowledge and body weight, balance confidence, home safety, functional balance, smoking, alcohol use, calcium and vitamin D intake, fall risk. Pearson product moment correlations are presented in Table 4. Scores demonstrated relatively weak positive relationships, but statistically significant correlations were found between osteoporosis knowledge and the balance efficacy scale, Berg balance scale, and the 30- second chair stand.

DISCUSSION

We hypothesized that participants who demonstrated greater knowledge of osteoporosis risk factors would also demonstrate healthy bone behaviors and thus have fewer identifiable risk factors. The present study showed a weak to moderate positive correlation between greater knowledge of osteoporosis risk factors and confidence in performing activities of daily living, better static and dynamic balance, and greater lower extremity strength. Each of these, theoretically, may be associated with lower fall risk. Piaseu et al suggest that knowledge about osteoporosis may be an important contributor to improved exercise behavior for osteoporosis prevention.[32] There is growing evidence that women who know their bone mineral density is low and those who are educated about osteoporosis, or both, are most likely to follow clinical recommendations and adopt osteoporosis protective behaviors.[33,34]

Despite the encouraging finding that those who had more knowledge regarding osteoporosis also had improved bone health behaviors, 64% of our participants received scores below 50% on the Osteoporosis Knowledge Assessment Tool. This suggests that there is much work to do in osteoporosis education for our community. Since osteoporosis is generally asymptomatic and patients typically first become aware of their condition when they sustain fracture,[1] increased knowledge of behaviors facilitating good bone health and encouragement to adopt those behaviors are essential.

Among subjects in the study, other modifiable risk factors were not managed at levels conducive for optimal bone health. Participants had inadequate calcium intake and vitamin D intake with only 48% reporting taking calcium supplementation. Consuming adequate levels of calcium and vitamin D are also critically important to an individual's bone health.

Osteoporosis risk, when combined with risk of falls, contributes to likelihood of fracture, an important threat to morbidity and mortality. Many subjects in this study demonstrated limitations in agility, dynamic balance, endurance, extremity strength, and flexibility; all of these are indicators of impaired physical performance associated with higher risk of falls. More than one-third of the participants were at risk for falling as indicated by BBS scores below 45 points. Nearly one-third of participants reported haven fallen 1 to 4 times in the previous year. Nearly half of the participants had poor endurance and more than three-fourths had reduced flexibility and demonstrated lower physical activity levels than the general population. Many independent older adults function dangerously close to their maximum ability level during normal activities[35] suggesting that with the impaired physical performance findings in the study at hand, many of the participants were susceptible for sustaining a fracture if a fall should occur while performing simple or normal activities of daily living.

Education and awareness of osteoporosis are the first steps to increasing public awareness of the need to be screened or evaluated for risk factors for falls. A likely next step, once predisposing and precipitating factors have been identified, would be interventions based on results of screening. A number of studies in fall prevention have reported the most consistently successful approach has been multifactorial assessment, followed by interventions targeting the identifiable risk factors.[36-39] Many of our study participants requested specific information on how, where, and when they should take action on individually identified risks (ie, at risk for falls or calcium intake below the recommended daily allowance) identified in the report card they received. They hoped to stop the disease progression or prevent falls and fracture. The report card appeared to provide a significant buy-in mechanism to making changes toward improved bone health and preventative behaviors. In addition it

Table 3. Mean Scores on Senior Fitness Test (N=49)

Senior Fitness Test	Mean (SD)	Range	Risk Zone (%) (<50th percentile for age)
Chair Stand (# in 30 sec)	9.3 (3.6)	0-17	38.8
Arm Curl (# in 30 sec)	12.0 (3.1)	1-19	42.9
2 Minute Step Test (total # steps)	66 (26.1)	14-132	44.9
Back Scratch Test (distance between fingers, inches)	-7.1 (6.3)	-26.0-2.0	75.7
Sit and Reach (distance between fingers and toes, inches.)	-3.2 (5.5)	-22.0-7.0	53.0

Table 4. Pearson Correlations* between Osteoporosis Knowledge and Body Weight, Balance Efficacy Scale, Home Safety, Berg Balance Scale, 30 second Chair Stand, Smoking, Alcohol Use, Calcium and Vitamin D Intake and the Timed Up and Go (N=49)

Variable	Osteoporosis Knowledge Assessment Tool
Body Weight	-0.12
Balance Efficacy Scale	0.32*
Home Safety	0.27
Berg Balance Scale	0.47**
30 second Chair Stand	0.33*
Smoking	-0.11
Alcohol Use	-0.11
Calcium Intake	-0.23
Vitamin D intake	-0.15
Timed Up and Go	-0.26
*P<0.05 (2-tailed) **P<.01(2-tailed)	

provided information to the participant on how they could personally impact their bone health future.

Limitations

As this study investigated knowledge of osteoporosis and osteoporosis risk in a small sample of affluent, Caucasian, community dwelling elders, generalizability of the findings are limited to older adult populations at large. The applicability of the study is also limited as it was a cross-sectional analysis of a small cohort and findings have not been replicated or investigated over time. Positive bone health habits relative to osteoporosis are cumulative over a lifetime. This study only provided a survey of current behaviors and knowledge relative to bone health at the latter part of the participant's life span. There is some empirical support that osteoporosis education positively influences favorable bone health behaviors, however, further research is needed to study larger populations of varied socioeconomic and demographic backgrounds to verify this finding. Moreover, further prospective longitudinal studies examining the impacts knowledge and practice of osteoporosis preventative behaviors over an individual's lifetime is warranted.

CONCLUSION

The Surgeon General reported in 2004 that tremendous progress has been made in bone health over the last several decades as it relates to the identification, prevention and treatment of osteoporosis. Despite these advances many in the public and medical communities consider osteoporosis to be a natural consequence of aging.[1] Although participants appeared not to have any barriers to accessing quality, comprehensive health care, they were unaware of their actual osteoporosis risk until they participated in the present study and learned the many factors involved in osteoporosis, falls, and fractures. Knowledge of disease processes, risk factors, and what can be done specifically for prevention and management may better prepare clients to make behavioral changes required for successful participatory disease management.

Community based osteoporosis education and screening should be comprehensive, personalized, and provided by a health care team that includes physicians, nurses, physical therapists, nutritionists, and health educators who are knowledgeable about osteoporosis in order for informed decisions about bone health to be determined. Physical therapy clinicians should routinely include questions about height, weight, fall and fracture history, and use of current medications and supplements related to bone health during the history and system review portion of the physical therapy examination. Specific functional fitness and balance measures may assist in determining fall and fracture risk and to devise a comprehensive individualized treatment plan. In doing so, physical therapists can use their expertise in the areas of pathophysiology, screening, and specific interventions to impact fall risk and provide education regarding osteoporosis risk and positive bone health behaviors. Additionally, physical therapists can also take an active role in patient advocacy for bone health by consulting physicians for follow up in areas outside of practice guidelines such as nutrition, bone mineral density testing, or pharmacological intervention.

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