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The Osteoporosis Self-Assessment Screening Tool: A Useful Tool for the Orthopaedic Surgeon

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Background: Simple and effective methods are needed to identify patients at risk for osteoporosis or osteoporosis-related fracture so that they can be screened with use of dual x-ray absorptiometry and counseled for treatment. Currently, we use a cumbersome survey assessing thirty-two risk factors. A much simpler score based on the Osteoporosis Self-Assessment Screening Tool (OST score) has been established as highly sensitive and specific in women, but similar data are lacking for men. This score is calculated by subtracting the age of the patient in years from the weight in kilograms and multiplying the result by 0.2. Our goal was to test the hypothesis that the OST score is more sensitive and specific than our extensive risk-assessment survey in men.

Methods: Using axial dual x-ray absorptiometry analysis, we evaluated a cohort of men who had either responded to our newspaper advertisement or were seen as patients in our orthopaedic clinic. Patients filled out the risk-assessment survey at the time of scanning. Osteoporosis was defined as a T-score of −2.5 or less in the lumbar spine, hip, or femoral neck.

Results: Twenty-seven (17%) of 158 white men, with a mean age of 67.5 years and a mean weight of 85.3 kg, had osteoporosis. After analysis of the thirty-two risk factors, two remained as significant independent predictors in the final multivariable model ($p = 0.042$ and $p = 0.015$). This model had an area under the receiver operating characteristic curve of 0.68 (>0.70 is considered to provide acceptable discrimination). The OST scores ranged from −6 (greatest risk) to 16 (least risk). With use of the OST score to predict osteoporosis, the area under the receiver operating characteristic curve was 0.76. The cutoff of an OST score of <2 provided the largest area under the receiver operating characteristic curve (0.74), with test characteristics for an OST score of <2 including a sensitivity of 85%, specificity of 64%, positive predictive value of 31%, and negative predictive value of 96%.

Conclusions: The Osteoporosis Self-Assessment Screening Tool score is superior to a broad risk-factor analysis in the identification of men at risk for osteoporosis or osteoporotic fractures. We have found it simple to use in our clinic to determine which patients should undergo dual x-ray absorptiometry screening.

Level of Evidence: Diagnostic <u>Level I</u>. See Instructions to Authors for a complete description of levels of evidence.

T he number of patients treated by orthopaedic surgeons for osteoporotic fractures is increasing at an exponential rate[1-3], and health-care costs in the United States for the treatment of osteoporotic fractures are conservatively estimated to range from ten to fifteen billion dollars annually[4]. Consequently, orthopaedic surgeons are in a unique and important position to confront osteoporosis in the community. For example, orthopaedic surgeons are ideally situated to help to identify and treat osteoporosis and osteopenia in middle-aged to elderly patients. Such involvement should help to offset the projected epidemic increases in hip and other low-energy fractures in the older population. However, a number

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of recent studies have demonstrated that, although orthopaedic surgeons are generally interested in expanding their practices to encompass diagnostic workup and nonsurgical medical care for their patients at risk for osteoporosis and osteopenia, many of these same surgeons are hesitant or unwilling to do so[5-14]. Since initiating an osteoporosis workup of all orthopaedic patients is neither practical nor beneficial, simple criteria for identifying individuals at risk for osteoporosis or osteoporosis-related fracture may aid orthopaedic surgeons in determining which of their patients would benefit from diagnostic workup.

Individuals with low bone-mineral density are at increased risk for osteoporotic fracture, and dual x-ray absorptiometry scanning is accepted as the most effective means of determining low bone-mineral density[15]. However, the time and monetary costs of dual x-ray absorptiometry scans are often prohibitive, and, as alluded to above, determining the appropriate population to screen remains a topic of controversy. Additionally, a low-energy fracture in an adult is more predictive of future fracture than a dual x-ray absorptiometry measurement alone, and in these patients preventative treatments are warranted regardless of the dual x-ray absorptiometry measurement[16]. In our orthopaedic specialty clinic, we use a risk-factor questionnaire that assesses thirty-two known or suspected risk factors for osteopenia, osteoporosis, or osteoporosis-related fracture (see Appendix). This questionnaire includes scoring criteria for men and women who have not had a low-energy fracture as an adult, and we use it to screen all of our male patients over the age of fifty-five years and all of our female patients over the age of forty-five years who have not had a fracture. Although we have used this questionnaire in our clinic to identify candidates for dual x-ray absorptiometry scanning and to provide documentation of risk to insurance companies when requesting authorization for payment, many patients find the questionnaire cumbersome, resulting in a large number (approximately 20%) of the surveys with incomplete or contradictory responses. Furthermore, in our clinic, some of the surgeons and their staff found it difficult to be sufficiently compulsive in ensuring that their patients receive and/or complete the survey. In view of these issues, the objective of this study was to find a method for osteoporosis and/or osteopenia screening that would be more efficient and effective than the so-called standard multiple question screening survey that we currently employ.

The Osteoporosis Self-Assessment Screening Tool (OST), which was developed by Koh et al.[17], yields a score based solely on the age and weight of the patient and has been shown to be a highly sensitive tool for predicting osteoporosis by dual x-ray absorptiometry scanning. The OST score is expressed as a simple integer value that is calculated by subtracting the age of the patient in years from the weight in kilograms and multiplying the result by 0.2. The result is then truncated to the nearest integer. The OST score has been shown to be highly sensitive (84% to 88%) and specific (52% to 59%) for detecting osteoporosis in a large population of 35,513 women[18] and in 181 male American veterans who were seen in pulmonary and

rheumatology clinics[19]. The objectives of the present study were (1) to test the hypothesis that the OST yields a score (the OST score) that is more sensitive and specific in identifying patients at risk of osteoporosis than our standard risk survey, and (2) to introduce the OST score to the orthopaedic community as a simple and effective way to identify patients at risk for severe osteopenia, osteoporosis, or osteoporosis-related fracture. Because the predictive power of the OST score in men has been limited to patients from pulmonary and rheumatology clinics at a Veterans Affairs hospital[19], we conducted our study only on non-hospitalized white men who were deemed representative of the patients who seek orthopaedic consultation from our greater referral area.

We also evaluated OST scores in the context of two T-score thresholds: (1) less than or equal to −2.5 (osteoporosis), and (2) less than or equal to −2.0. The rationale for analyzing the two thresholds stems from several studies that support changing the World Health Organization (WHO) criterion for osteoporosis from a T-score of −2.5 or less to −2.0 or less, which helps to identify patients with less severe low bone mass who are nonetheless at increased risk for future fractures[20-23].

Materials and Methods

After approval was received from the institutional review board at our institution, data were collected prospectively from male patients enrolled from a community-based newspaper advertisement and they were collected retrospectively (29% of total sample) and prospectively from individuals presenting to our orthopaedic specialty clinic. All study patients were adults, and all prospectively enrolled patients signed an informed-consent form. All patients filled out our standard survey questionnaire (see Appendix) that included known risk factors for osteopenia, osteoporosis, and osteoporosis-related fracture. The questionnaire was based on data from various sources[24-37].

The OST score is calculated as (weight in kilograms − age in years) × 0.2 and is truncated to the nearest integer[17].

Bone mineral density of the femoral neck, total hip, and lumbar spine (levels L1-L4, individually tailored in patients with osteoarthritis) was then measured for each patient with use of a dual x-ray absorptiometry scanner (Lunar Prodigy; GE Lunar, Madison, Wisconsin).

Osteoporosis was defined as a T-score of −2.5 or less in any of the three regions: total hip, femoral neck, or lumbar spine. An additional classification of osteoporosis that encompasses severe osteopenia was defined as a T-score of −2.0 or less in any of the same three regions. As noted in the introduction, the rationale for analyzing the two thresholds stems from several studies that have supported changing the WHO criterion for osteoporosis from a T-score of −2.5 or less to −2.0 or less, which helps to identify patients with less severe low-bone mass who are nonetheless at increased risk for future fractures[20-23]. In untreated postmenopausal women, there is a strong correlation between T-score and fracture risk and that fracture risk increases approximately twofold for every standard deviation decrease in bone mineral density[38]. This abso-
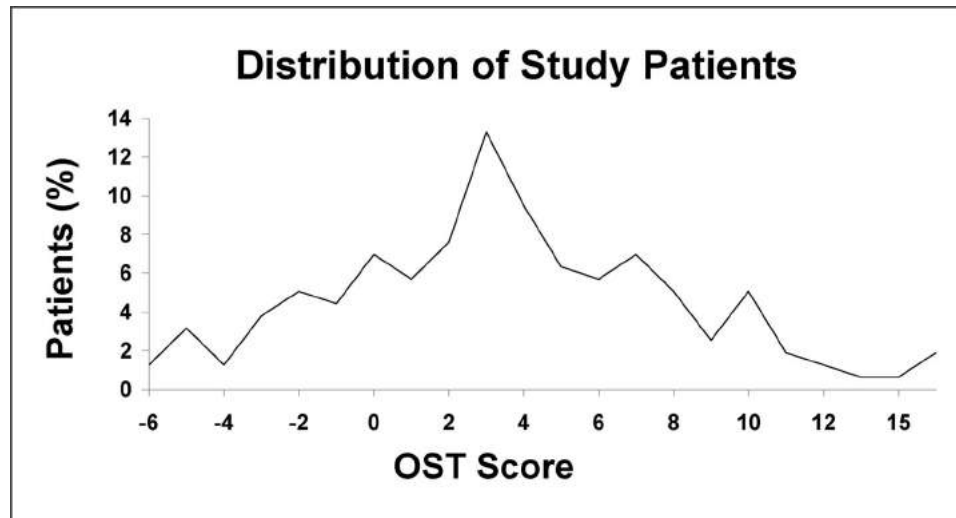
Fig. 1

The distribution of study patients on the basis of the Osteoporosis Self-Assessment Screening Tool (OST) scores. See text for calculation of the OST score.

lute risk of fracture is no different in men and women of the same age and bone mineral density[39].

Statistical Methods

The risk factors obtained from the questionnaire were scored as present or absent. The group of patients with osteoporosis was compared with the group without osteoporosis on each of the risk factors, with use of a chi-square test or Fisher exact test, as appropriate. The risk factors with a p value of <0.25 were entered into a multivariable logistic regression model of osteoporosis (a T-score of −2.5 or less), and they were interactively removed from the model in the order of least significance (backward variable selection)[40,41]. The final multivariable model included only the risk factors (predictors) with a p value of <0.05. The area under the receiver operating characteristic curve, which is also called the c-statistic, was calculated for the final multivariable logistic regression model. The c-statistic is a measure of the predictive ability (measure of diagnostic discrimination) of a prognostic model. A c-statistic of at least 0.70 is considered to provide acceptable discrimination[42].

To determine the best cut-point for the OST score, all possible cut-points across the range of the OST scores were used to create dichotomized OST score predictor variables, which were scored as 1 if the score was above the cut-point and 0 if it was below. A univariable logistic regression model was fitted for each of these OST score dichotomizations and was then attempted in univariable logistic regression with varying OST score thresholds as the predictor, after which the c-statistic was calculated. Since the c-statistic is a measure of the predictive ability, it is a natural choice for basing the optimal cut-point for the OST score. The best cut-point was selected as the cut-point that produced the largest c-statistic (i.e., the strongest predictor) in these models.

This entire analysis was repeated for the additional outcome (a T-score of −2.0 or less). All statistical tests were for a two-sided comparison and were calculated with use of commercially available statistical analysis software (Stata 9.0; Stata, College Station, Texas).

Results

A total of 158 white men with a mean age (and standard deviation) of 67.5 ± 13.1 years and a mean weight of 85.3 ± 16.0 kg completed the risk-assessment questionnaire and underwent axial dual x-ray absorptiometry scanning. Twenty-seven men (17%) had osteoporosis. Additional characteristics of the patients are reported in the Appendix. The OST scores ranged from −6 (greatest risk) to 16 (least risk). The percent distribution of the patients according to the OST score is shown in Figure 1. Survey questions and responses can be viewed in the Appendix.

Osteoporosis (A T-Score of −2.5 or Less)

Of the thirty-two risk factors for osteoporosis that are addressed in the questionnaire, four were found to be significantly associated with osteoporosis: a low body weight (p = 0.15), a loss of ≥1.5 in (≥3.81 cm) in height (p = 0.019), an inability to rise from a chair without use of the chair arms (p = 0.035), and an age of more than sixty-five years (p = 0.004). When these four risk factors, with five others with a p value of <0.25 (a lifelong history of low calcium or vitamin D in diet; frequent imbalance or falls; exercise less than three times a week; caffeine intake of more than two cups of coffee a day or the equivalent; and gastrointestinal malabsorption, removal of stomach or small bowel, diarrhea, or Crohn disease) were entered and then the factors that were not significant were eliminated in a backward selection fashion, a final model resulted with only two risk factors that contributed a significant inde-

TABLE I Logistic Regression Models of Osteoporosis (T-Score of −2.5 or Less)				
Predictors	Odds Ratio	95% Confidence Interval	P Value	C-Statistic
Model 1: Final questionnaire multivariable model				
Low body weight	11.1	1.1-112.4	0.042	0.68
Age of >65 yr	4.1	1.3-12.6	0.015	
Model 2: OST score, univariable model				
OST score, per 1 unit increase	0.8	0.7-0.9	<0.001	0.76
Model 3: Combined questionnaire and OST score model				
Low body weight	4.4	0.4-52.7	0.238	0.75
Age of >65 yr	1.8	0.5-7.1	0.397	
OST score, per 1 unit increase	0.8	0.7-1.0	0.051	
Model 4: Dichotomized OST score, univariable model				
OST score of ≤2	9.6	3.1-29.6	<0.001	0.74

pendent association with osteoporosis (model 1 in Table I). This model, which included low body weight (odds ratio, 11.1; 95% confidence interval, 1.1 to 112.4) (p = 0.042) and an age of more than sixty-five years (odds ratio, 4.1; 95% confidence interval, 1.3 to 12.6) (p = 0.015) failed to achieve acceptable discrimination, as its c-statistic of 0.68 did not reach the 0.70 rule-of-thumb cutoff for acceptable discrimination[42].

Analysis of the OST score, however, provided acceptable discrimination (c-statistic = 0.76) in a univariable logistic regression model predicting osteoporosis (model 2 in Table I). As expected, the increasing OST scores were associated with a lower odds ratio for osteoporosis (odds ratio, 0.8; 95% confidence interval, 0.7 to 0.9) (p < 0.001). When the questionnaire risk factors were combined with the OST score, these risk factors failed to provide any independent predictability of osteoporosis beyond what the OST score already provided (model 3 in Table I).

For usefulness as a clinical decision tool, an optimal cut-point for the OST score that maximizes discrimination was sought. With each possible cut-point for the OST score attempted in a univariable logistic regression, across the entire OST score range of −6 to 16, the largest c-statistic was achieved for the cut-point OST score of ≤2, with a c-statistic of 0.74 (model 4 in Table I). The next closest choices were the

OST score of ≤0 (c-statistic = 0.68), ≤1 (c-statistic = 0.70), ≤3 (c-statistic = 0.72), and ≤4 (c-statistic = 0.67). The test characteristics for an OST score of ≤2 for predicting osteoporosis are shown in Table II. Additionally, we observed no significant difference among c-statistics for the three dual x-ray absorptiometry sites (lumbar spine, femoral neck, and total hip) analyzed in the present study (Table III).

Alternate Osteoporosis Threshold
(A T-Score of −2.0 or Less)

When a T-score of −2.0 or less was used as the threshold, the same four risk factors were also found to be significantly associated with osteoporosis: a low body weight (p = 0.059), a loss of ≥1.5 in (≥3.81 cm) in height (p < 0.001), an inability to rise from a chair without use of the chair arms (p = 0.044), and an age of more than sixty-five years (p < 0.001). When these four risk factors, with two others that had a p value of <0.25 (a personal history of fracture as an adult and exercising less than three times a week), were entered, and with the nonsignificant factors then eliminated in a backward selection fashion, a final model resulted with only two risk factors that contributed a significant independent association with a T-score of −2.0 or less (model 1 in Table IV). This model included loss of ≥1.5 in (≥3.81 cm) in height (odds ratio, 4.1; 95% confidence interval,

TABLE II Test Characteristics of the OST Score for Predicting Osteoporosis (Considering Any Site Evaluated)				
	Osteoporosis (T-Score of −2.5 or Less)		Osteoporosis (T-Score of −2.0 or Less)	
	Prediction Rule: OST Score of ≤2		Prediction Rule: OST Score of ≤2	
Test Characteristic	Estimate	95% Confidence Interval	Estimate	95% Confidence Interval
Sensitivity (%)	84.60	65.1-95.6	76.20	60.5-87.9
Specificity (%)	63.60	54.8-71.8	67.20	57.9-75.7
Positive predictive value (%)	31.40	30.9-43.6	45.70	33.7-58.1
Negative predictive value (%)	95.50	88.8-98.7	88.60	80.1-94.5
C-statistic	0.74	0.66-0.82	0.72	0.64-0.80

TABLE III C-Statistics for the OST Score at Various Sites*		
	T-Score†	
OST Score	−2.5 or Less	−2.0 or Less
Lumbar spine	0.69 (0.53-0.85)	0.69 (0.57-0.80)
Femoral neck	0.81 (0.73-0.90)	0.79 (0.70-0.87)
Total hip	0.85 (0.76-0.95)	0.80 (0.69-0.91)
Any site	0.76 (0.66-0.86)	0.75 (0.66-0.84)

*The c-statistic is equal to the area under the receiver operating characteristic curve. The OST (Osteoporosis Self-Assessment Screening Tool) score is used as a continuous score, rather than dichotomized at a cut-point. †The values are given as the mean c-statistic with the 95% confidence interval in parentheses.

1.7 to 10.3) (p = 0.002), which is a different risk factor than in the final osteoporosis model (a T-score of −2.5 or less), and an age of more than sixty-five years (odds ratio, 3.7; 95% confidence interval, 1.5 to 9.3) (p = 0.006). This model achieved acceptable discrimination, with a c-statistic of 0.73.

The OST score provided only slightly better discrimination (c-statistic = 0.75) than the two risk factors in a univariable logistic regression model predicting a T-score of −2.0 or less (model 2 in Table IV). Increasing OST scores were associated with a lower odds ratio for a T-score of 2.0 or less (odds ratio, 0.8; 95% confidence interval, 0.7 to 0.9) (p < 0.001). When the questionnaire risk factors were combined with the OST score, the risk factor of a loss of ≥1.5 in (≥3.81 cm) in height contributed independent predictability of a T-score of −2.0 or less beyond what the OST score already provided (c-statistic = 0.75; model 3 in Table IV).

When each possible cut-point for OST scores in a univariable logistic regression was attempted, across the entire range of OST scores from −6 to 16, the largest c-statistic for predicting a T-score of −2.0 or less was achieved for the cut-point score of ≤2, with a c-statistic of 0.72 (model 4 in Table IV). The next closest choices were the following OST scores: ≤0 (c-statistic = 0.65), ≤1 (c-statistic = 0.69), ≤3 (c-statistic = 0.70), and ≤4 (c-statistic = 0.68).

This same cut-point of ≤2 also achieved the largest c-statistic when the OST score was combined with the risk factor of a loss of ≥1.5 in (≥3.81 cm) in height in the same model (c-statistic = 0.76; model 5 in Table IV). The next closest choices were the following OST scores: ≤0 (c-statistic = 0.74), ≤1 (c-statistic = 0.75), ≤3 (c-statistic = 0.758), and ≤4 (c-statistic = 0.74).

The test characteristics for the OST score of ≤2 for predicting a T-score of −2.0 or less are shown in Table II. The test characteristics for predicting a T-score of −2.0 or less with use of the OST score of ≤2, combined with a loss of ≥1.5 in (≥3.81 cm) in height, are shown in Table V. On examination of these test characteristics and c-statistics, it is clear that the two factors should be combined as one "or" the other, rather than one "and" the other, as the "and" approach fails to achieve acceptable discrimination (c-statistic = 0.62). However, the improvement in prediction by augmenting the OST score with the risk factor of a loss of ≥1.5 in (≥3.81 cm) in height is only slight, and a statistical comparison between the two c-statistics (c-statistic = 0.72 for OST score alone or 0.76 for OST score or loss in height) failed to achieve significance (p = 0.29). Additionally, we observed no significant differences between c-statistics for the three dual x-ray absorptiometry sites (lumbar spine, femoral neck, and total hip) analyzed in the present study (Table III).

Discussion

The results of the present study support the hypothesis that an OST score of ≤2 is more sensitive and specific than our standard multiple risk-factor questionnaire in detecting white

TABLE IV Logistic Regression Models of Osteoporosis (T-Score of −2.0 or Less)				
Predictors	Odds Ratio	95% Confidence Interval	P Value	C-Statistic
Model 1: Final questionnaire multivariable model				
Loss of ≥1.5 in (≥3.81 cm) in height	4.1	1.7-10.3	0.002	0.73
Age of >65 yr	3.7	1.5-9.3	0.006	
Model 2: OST score, univariable model				
OST score, per 1 unit increase	0.8	0.7-0.9	<0.001	0.75
Model 3: Combined questionnaire and OST score model				
Loss of ≥1.5 in (≥3.81 cm) in height	3.4	1.3-8.6	0.012	0.75
Age of >65 yr	1.9	0.6-5.6	0.271	
OST score, per 1 unit increase	0.9	0.8-1.0	0.034	
Model 4: Dichotomized OST score, univariable model				
OST score of ≤2	6.6	2.9-14.8	<0.001	0.72
Model 5: Combined questionnaire and OST score model				
Loss of ≥1.5 in (≥3.81 cm) in height	3.4	1.4-9.5	0.007	0.76
OST score of ≤2	5	2.2-11.6	<0.001	

TABLE V Test Characteristics of the OST Score and Loss of 1.5 Inches (3.81 Centimeters) or More in Height for Predicting a T-Score of −2.0 or Less

	Prediction Rule			
	OST Score of ≤2 and Loss of ≥1.5 in (3.81 cm) in Height		OST Score of ≤2 or Loss of ≥1.5 in (3.81 cm) in Height	
Test Characteristic	Estimate	95% Confidence Interval	Estimate	95% Confidence Interval
Sensitivity (%)	31.0	17.6-47.1	83.30	68.6-93.0
Specificity (%)	93.10	86.9-97.0	64.70	55.2-73.3
Positive predictive value (%)	61.90	38.4-81.9	46.10	34.5-57.9
Negative predictive value (%)	78.80	71.0-85.3	91.50	83.2-96.5
C-Statistic	0.62	0.55-0.70	0.76	0.67-0.81

male patients who are at risk for osteoporosis (a T-score of −2.5 or less or a T-score of −2.0 or less). These results corroborate those of Adler et al.[19] who previously showed that the OST score is a simple and sensitive tool for detecting osteoporosis in a sample of 181 men (fifty-four black men, 124 white, and three other) who were seen in pulmonary and rheumatology clinics at a Veterans Affairs hospital. The OST score has been even more rigorously validated for predicting osteoporosis in women[17,43]. In view of these results, it may be concluded that the OST score is a highly sensitive and specific method for deciding which patients without a fracture to screen for osteoporosis with dual x-ray absorptiometry scanning.

Despite these results, some orthopaedic surgeons (e.g., trauma specialists and some general orthopaedists) might conclude that the OST score is not useful for many of their elderly male patients because a majority of them seek initial consultation for the treatment of a recent fragility fracture, and the occurrence of a low-energy fracture is a stronger predictor of a future fracture than a dual x-ray absorptiometry measurement[44]. However, recent data from the Centers for Disease Control and Prevention (CDC) showed that only about 18% of patients who are sixty-five years of age or older who see an orthopaedic surgeon for initial consultation do so because they have sustained a fracture[16]. Although this percentage value includes both men and women (no gender distinction is made for this value in this CDC publication), it is reasonable to estimate that this represents disproportionately more women than men since the lifetime risk of fracture of the hip, vertebra, or forearm at the age of fifty years is approximately 40% for white women compared with approximately 13% for white men[45]. Consequently, the majority (conservatively estimated at 60% to 70% when fracture sites in addition to the hip, vertebra, and forearm are considered)[46-49] of male patients who are sixty-five years of age or older and present to the orthopaedic surgeon for an initial consultation would benefit from screening with use of the OST score.

From these perspectives, and on the basis of previous studies demonstrating the value of the OST score in women without low-energy fractures, we advocate using the OST score to screen all women over the age of forty-five years and all men over the age of fifty-five years unless they have had a sentinel low-energy fracture as an adult.

Although some may argue that a previous fragility fracture is a so-called sentinel event and warrants treatment irrespective of bone density measurements, it is important to note that our clinic is not a fracture clinic, and the majority of our patients have not had a fragility fracture but rather present with symptoms and sequelae of arthritis. In this context, our clinic is an ideal place to test the utility of tools, such as the OST score, which enhance our ability to detect patients with low bone density who may not have a history of fragility fracture but may be at risk for an initial event. Having adopted this view in our clinical practice, we have sought ways to enhance our detection of patients at risk for fracture. These include (1) screening with use of an on-site axial dual x-ray absorptiometry scanner (housed in the radiology center of our building), (2) distributing educational materials for the prevention and treatment of osteoporosis and osteopenia, and (3) use of a template-based system for easily communicating dual x-ray absorptiometry results with the patient's primary-care physician. Consequently, confirming that the OST score is more sensitive and specific than our standard and cumbersome risk-factor questionnaire is an important adjunct to our osteoporosis intervention program. This approach complements the growing interest of orthopaedic surgeons in becoming more aware of the far-reaching clinical implications of fragility or low-energy fractures[6,10,11,37].

Use of the OST score for predicting low bone-mineral density has also rectified some of the problems we have had in utilizing our cumbersome thirty-two-item risk-assessment questionnaire, as calculation of the OST score requires only measurements of age and weight rather than a lengthy and complicated checklist. The simplicity of this tool and the universal applicability to both women and men add to the value of this calculation. It is important, however, to emphasize that the use of a screening tool such as the OST score must not undermine the importance of a full medical history to work up secondary causes of osteoporosis. If the orthopaedic surgeon believes that initiation of this workup is out of his or her purview, it is essential that the surgeon initiate a referral to the ap-

propriate primary health-care provider to ensure that the workup is conducted. This is imperative because it is estimated that an underlying secondary cause of osteoporosis, although less common in postmenopausal women, is present in approximately 40% to 60% of men[50,51].

A number of risk-assessment models that correlate osteoporosis risk with the benefit of dual x-ray absorptiometry screening have been proposed[18,52,53]. However, these models have also routinely focused on women with little or no emphasis on risk factors that may indicate an advantage for dual x-ray absorptiometry screening in men[24]. Consequently, the OST score is an important advance in the screening of both male and female patients for further medical workup. Additionally, expanding the focus of these studies to men is important because osteoporosis in men is a serious condition that is increasing in prevalence, yet is often not addressed in many studies[32,54-56]. Hip fractures in males also account for >25% of all hip fractures, and the increased mortality rate in the year following fracture has been shown to be higher in men than in women[4,57,58]. Furthermore, men are generally less likely than women to receive antiresorptive medication or other treatment for osteoporosis[58].

The present study has several limitations. (1) The study patients were white males from the same geographical region, (2) the sample size was relatively small (158 patients), and (3) the fracture incidence of this population was not assessed. Additionally, these limitations may confound attempts to apply this study to the general population since (1) a subset of the data, although small, was retrospective, and (2) there may be some selection bias among participants who responded to the newspaper advertisement. Our statistical analysis also suggests that differential weighting of questionnaire responses might provide predictive power similar to the OST score. For example, an increased predictive power of the OST score occurred when it was considered with a loss of ≥1.5 in (≥3.81 cm) in height. But this improvement was only slight (the c-statistic was 0.72 for the OST score alone or 0.76 for the OST score or loss in height) and failed to achieve significance. Additional studies that might explore other differential weighting schemes and/or combinations of risk factors for yielding indices with greater predictive power are warranted. Furthermore, as previously mentioned, no attempts were made to predict future fracture risk or to assess the utility of bone density measurements in patients who have sustained a fragility fracture. In this context, the greatest utility of the OST score may therefore be in the setting of patients with no history of fracture, especially since a low-energy fracture in an adult is stronger than a dual x-ray absorptiometry scan measurement in predicting a future fracture. Nevertheless, the results of this study complement the findings of previous studies[18,19] and demonstrate that the OST score outperforms our risk-assessment survey and performs as well as or better than a number of other risk-factor questionnaires and complex predictive models that have been used with varying success in different populations of men[59,60] and women[18,52,53,61].

In summary, the results of this study show that the OST score has greater predictive power than a broad risk-factor analysis in a sample of white men, and we have found that this index is simple to implement in our orthopaedic clinic.

Appendix

Tables showing the extensive risk-factor questionnaire and individual responses and the demographic data on the study participants are available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ∎

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