Journal of Clinical Densitometry: Assessment & Management of Musculoskeletal Health, vol. ■, no. ■, 1−8, 2015

1094-6950/■:1−8/$36.00
http://dx.doi.org/10.1016/j.jocd.2015.05.068

Original Article

Age-Adjusted Dual X-ray Absorptiometry−Derived Trabecular Bone Score Curve for the Lumbar Spine in Thai Females and Males

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Abstract

Trabecular bone score (TBS), which has been shown to discriminate patients with fractures from healthy individuals, decreases with age. This study was conducted to derive an age-adjusted normative TBS curve for each gender aged 30−80 + years to serve as reference data for Thai males and females. A cross-sectional study was conducted among employees from the Electricity Generating Authority of Thailand cohorts, after excluding those with conditions potentially affecting bone metabolism and analysis. The values of TBS at L1−L4 vertebrae were analyzed using a commercial software. Age-adjusted TBS curves were constructed using segmental linear regression analysis for each gender. Additional analysis was also performed on TBS with age, body mass index, and body mineral density (BMD) at L1−L4 vertebrae as covariates. A database of 848 healthy subjects (341 females and 507 males) aged 30−80+ years was created. The BMDs of both male and female subjects in the youngest decade were not statistically different from previous reports ($p = 0.31$ and 0.22 for females and males, respectively). In this age group, the mean TBS was higher in females, albeit not statistically significant ($p = 0.12$). Between the ages of 30−80+ years, female and male TBS dropped by 19.8% (0.40% per year) and 10.1% (0.20% per year), respectively. The association with TBS was weak for body mass index and moderate for BMD (coefficients of about −0.01 and 0.4−0.5, respectively). The age-adjusted reference curves for healthy Thai females and males aged 30−80+ years have been established.

Key Words: Bone mineral density; dual X-ray absorptiometry; reference data; Thai; trabecular bone score.

Introduction

Osteoporosis is a health problem worldwide. It leads to fragility fractures, resulting in poor quality of life and increasing mortality. Its economic burden has become a concern not only in industrialized countries but also in Asian countries *(1)* including Thailand *(2)*. Although the condition mainly affects women *(3)*, men are also at risk *(4)*.

Because effective interventions to avert fractures exist, efforts have been made to screen subjects at risk. Although the standard screening procedure is the assessment of bone mineral density (BMD) using dual X-ray absorptiometry (DXA), BMD captures only 1 of many aspects contributing to fracture risk. Among these factors is microstructure, which can be assessed noninvasively by the trabecular bone score (TBS). TBS is a texture parameter that provides an indirect indicator of bone microarchitecture based on

Received 04/12/15; Revised 05/19/15; Accepted 05/21/15.
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gray-level variations in DXA images of the lumbar spine (5). More numerous and connected and less sparse trabeculae translate into a high TBS value, whereas a low trabecular number and connectivity and high trabecular separation translate into a low TBS, independent of BMD (6). Studies have shown that TBS is associated with osteoporotic fractures (7−10), particularly when below 1.2 (11). However, there is no study indicating that this threshold is relevant to begin antiosteporotic treatment (11). To choose a relevant threshold, a reference range should be established in healthy populations. We conducted this study, aiming to derived age-adjusted normative curves of TBS, which may serve as reference data for adult males and females, which may help to define a proper threshold.

Subjects and Methods

This was a cross-sectional study on current and ex-employees at the headquarters of the Electricity Generating Authority of Thailand (EGAT), Bangkok. The cohort profile has been described in a previous report (12). In addition to the initial aim of studying cardiovascular risk factors in the first cohort in 1985, the survey was extended to collect data on other metabolic disorders as well as bone health.

The study was approved by the Institutional Review Board and by the Committee on Human Rights Related to Research Involving Human Subjects, Faculty of Medicine, Ramathibodi Hospital, Mahidol University. All subjects gave written informed consent before the commencement of the study.

As described previously (13), the survey procedures included a questionnaire (including information on general health condition, medications, and past illnesses), physical examination by internists, blood chemistry analysis, and DXA.

Construction of the Reference Dataset

All subjects' data were reviewed and included for further random selection unless they met any of the following exclusion criteria, which were designed to exclude subjects with BMD (Z-score) exceeding ±2 standard deviation (SD) of the mean of their age group or with conditions potentially affecting bone metabolism or DXA analysis:

(1) Any lesions or artifact at any of L1−L4 vertebrae,
(2) Low-energy fracture at any site,
(3) Traumatic fracture involving the spine or femur,
(4) Any treatment and/or illness that would be expected to affect bone metabolism except hormone replacement therapy and calcium and vitamin D supplementation,
(5) Spinal surgery (such as orthopedic implant, laminectomy, or vertebroplasty),
(6) Early menopause or surgical menopause and/or orchiectomy,
(7) Scoliosis of the lumbar spine, with Cobb angle of more than 20°.

Subjects aged 30−59 years were from the second survey of the third cohort (EGAT 3/2) in 2014, and those 60−80+ years were from the fifth survey of the first cohort (EGAT 1/5) in 2012. Unlike male subjects, there was no female subject older than 80 years.

Sample Size Calculation

The TBS software developer recommended 70 subjects in each decade to ensure that each decade was well represented. Nevertheless, we also calculated the sample size needed for accurate estimation in our setting. Sample size calculation depends on variance and acceptable error: the larger the variance and the smaller the acceptable error, the larger the sample size required. We set the level of confidence at 95%. An acceptable error of TBS of 2.26% was obtained from a phantom study using fast array mode, the same mode used in this study (14). To ensure an adequate number of subjects, we used the mean TBS from the oldest groups reported, as they have the lowest mean TBS and, hence, smaller acceptable error. Based on previous reports (15,16), the mean TBS at L1−L4 vertebrae of these groups (75−85 and 80−90 years) ranged from 1.167 to 1.178 and the SD from 0.08 to 0.1. The sample size for each decade was calculated using the following formula:

$$n = Z^2_{\alpha/2}\sigma^2/d^2$$

Where α, significant level, = 0.05; $Z_{\alpha/2}$, 2-tailed standard normal deviate, = 1.96; σ, or SD of the data, = 0.1 (a larger value was used to ensure an adequate number of subjects); and d, acceptable error, = 0.0226 × 1.167 (the lower mean TBS value was chosen to ensure adequate sample size).

Hence, for each gender and each decade, the sample size needed was 56 subjects, which was well covered by 70 subjects recommended by the TBS software developer. Therefore, we randomly selected at least 70 subjects in each decade from among those eligible after applying the exclusion criteria.

BMD Assessment

Similar to a previous report (13), each subject changed into light clothing before undergoing BMD assessment by DXA at the lumbar spine (L1−L4 vertebrae) and hip (femoral neck and total hip). Using fast array mode, all measurement procedures were performed according to the International Society for Clinical Densitometry recommendations (17) by International Society for Clinical Densitometry−certified densitometer technologists using the same Hologic Discovery W DXA scanner on all subjects (Hologic, Bedford, MA). Quality assurance procedures using a spine phantom were performed daily. The lumbar spine BMD root mean square (RMS) coefficient of variation and RMS SD were 0.69% and 0.006 g/cm^2, respectively.

TBS Assessment

Using TBS iNsight software version 2.1 (medimaps, Mérignac, France) on the same regions of interest (ROIs) as those used for lumbar spine BMD, TBS was calculated as the mean value of the individual measurements for each