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Original Article

Bone Speed of Sound Throughout Lifetime Assessed With Quantitative Ultrasound in a Mexican Population

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Abstract

The purpose of this study was to assess the bone speed of sound (SoS) through lifetime of a large Mexican population sample by determining the SoS from the radius and tibia using quantitative ultrasound (QUS). This is a cross-sectional evaluation of participants in the Mexican Health Workers Cohort Study. QUS measurements were performed using Sunlight Omnisense 8000P; Z- and T-scores were calculated for both sexes at the distal third of the radius and midshaft tibia, both on the nondominant side. A locally weighted regression smoothing scatterplot model was used to identify different phases of bone accretion and loss. A total of 9128 participants aged 1–75 yr were measured with QUS. Bone SoS accretion began 5 yr earlier in girls than boys ($p < 0.05$). Maximal SoS or peak bone SoS was noted at 28 yr in the radius and at 22 yr in the tibia. Postmenopausal women (45–50 yr) showed significant SOS decrease at both sites ($p < 0.05$) compared with men. Using the locally weighted regression smoothing scatterplot model, we found 5 different phases that constitute the biological development of bone over the life course, from ages 1–6, 7–12, 12–25, 25–50, and 50–75 yr ($p < 0.05$). Our study shows the age- and sex-dependent changes and different phases of bone development expressed by SoS measurements of the radius and tibia. The values reported in this study can be used as a reference for urban Mexican population.

Key Words: Bone health; osteoporosis; quantitative ultrasound; reference values.

Background

Osteoporosis and fragility fractures are a widespread public health problem, and Mexico is not the exception *(1)*. The quality of life consequences and high costs of treating fractures make osteoporosis a clear focus for clinical research, with growing interest in developing new methods for screening and assessing bone health *(2,3)*. Dual-energy X-ray absorptiometry (DXA) is the gold standard for bone assessment and has been used widely over the last 25 yr to determine bone mineral density (BMD) at various anatomical sites. This technology has also been used for early detection of individuals at high risk of osteoporotic fractures *(4)*. Yet despite the proven efficacy of DXA, it is not widely available. According to a recent Latin America audit, in Mexico, there are only 1.8–2.3 DXAs per million individuals aged 50 yr and older *(5)*.

An alternative technology for measuring bone density is quantitative ultrasound (QUS), a diagnostic method that measures the speed of sound (SoS) in bone. QUS has the advantages of being free of radiation, easy to use, portable, and lower in cost than DXA *(6)*. It has also been suggested that QUS may identify aspects of bone quality not captured by

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DXA, such as bone microarchitecture or material properties [e.g., bone elasticity (7)].

QUS, thus, has potential for being used in bone health or integrity assessment (8) and has a fairly good correlation with vertebral and femoral DXA, $r = 0.48$ and 0.70, respectively (9). It can be used in varied pathologies, treatment results, and growth assessment in pediatric population (10−12).

In Mexico, evidence shows that both the quality and quantity of bone can vary between populations and different ethnic groups (13). Therefore, reference values must be developed for each population where this technology is available, as has already been done in Portugal (14), Israel (15), Turkey (16), and Greece (17). Here, we aim to provide this reference data, including sex comparisons and age-group differences in the attenuation of SoS in 2 anatomical sites (radius and tibia), measured simultaneously in a large sample of Urban Mexicans.

Methods

The study population was drawn from data of the healthy employees and their healthy relatives from 3 different health and academic institutions in México: Instituto Mexicano del Seguro Social, Instituto Nacional de Salud Pública in Cuernavaca, Morelos, Comité Mexicano para la prevención de la osteoporosis in México City, and employees from the Universidad Autónoma del Estado de México in Toluca, Estado de México. Pediatric population was recruited by invitation in Comité Mexicano para la prevención de la osteoporosis, in México City. The ethical committees of each participating institution approved this study, and informed consent was obtained in all cases.

Out of a total population of 13,275 study candidates identified between March 2004 and April 2006. For the present analysis, we included only healthy volunteers and relatives aged 1−75 yr who had QUS measurements done either at the radius (9229) or tibia (9308).

Anthropometric Parameters

Basic anthropometric parameters were taken for each subject. These included height (measured using a wall-mounted ruler [mm]), weight (measured on a standardized scale), and body mass index, calculated as the ratio of weight/height^2 (kg/m^2).

BMD Assessment

Bone density measurements were performed at the nondominant proximal femur and whole body using a DXA Lunar DPX NT instrument. The user manual instructions and International Society of Clinical Densitometry procedures were strictly followed (18). Densitometry technicians performed all BMD measurements according to standardized protocols. Instruments were calibrated daily using the phantom provided by the manufacturer; technicians ensured that the daily coefficient of variation was within normal operational standards, and in vivo coefficient of variation was lower than 1.5%.

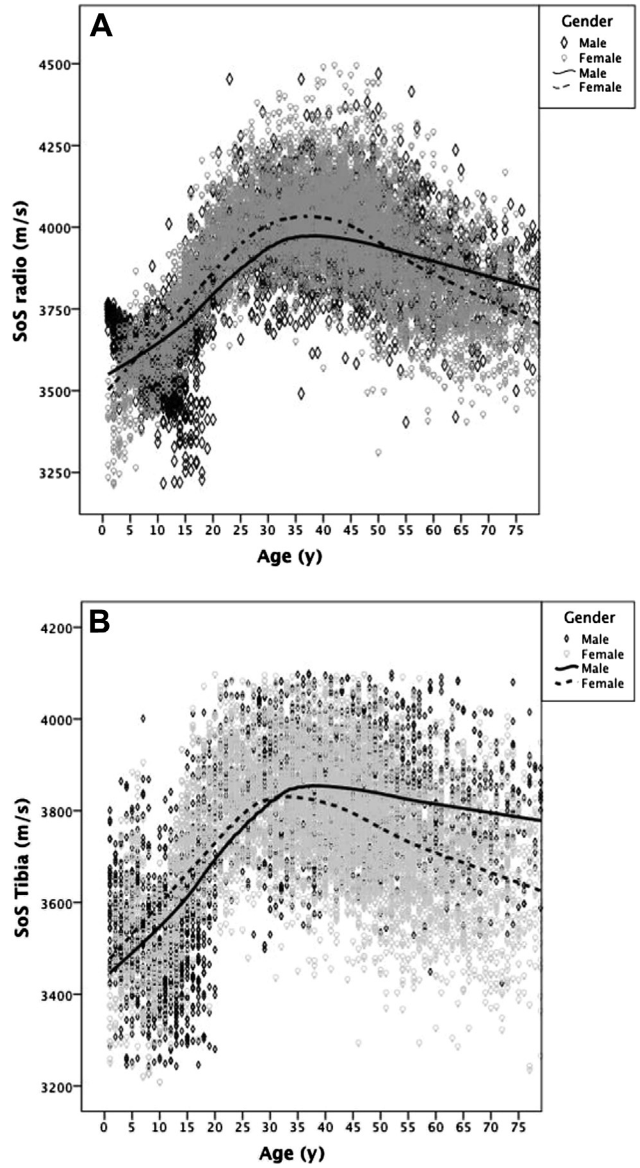

Fig. 1. (**A**) Plot with original data from SoS radius across the life course. LOESS model curve included. (**B**) Plots with original data from SoS age-related accretion in the tibia. LOESS model curves by sex. SoS, speed of sound.

Quantitative Ultrasonography Assessment

QUS measurements were performed using a commercial device (Sunlight Omnisense 8000P; BeamMed Ltd, Tel Aviv, Israel) equipped with a hand-held probe. This probe contains 4 sets of transducers (2 transmitters and 2 receivers) that produce pulsed acoustic waves at a mean frequency of 1.25 MHz. These generated waves traverse the soft issue and enter the bone at an expected ‘‘critical angle.’’ The shortest propagation time of the signal between the transmitter and the receiver is used to calculate the SoS (19).

SoS was measured at 2 sites on the nondominant side—distal third of the radius and midshaft tibia—and was expressed