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Original Article

Measurement Properties of Radial and Tibial Speed of Sound for Screening Bone Fragility in 10- to 12-Year-Old Boys and Girls

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Abstract

The objective of this study was to analyze measurement properties of the radial and tibial speed of sound (SoS) evaluated by quantitative ultrasound (QUS) for screening bone fragility. Bone fragility was defined as low whole body less head bone mineral density (WBLH BMD) measured by DXA (first tertile, 95% CI −1.1 to −0.9) and as past fractures evaluated by questionnaire. The sample included 319 nonobese boys and girls, ages 10–12 yr. All bone variables were standardized. The results revealed concordance coefficient correlations between WBLH BMD and radial and tibial SoS of 0.129 and 0.038, respectively. The regression lines between DXA and QUS variables were different from the identity lines. Cross-classification analysis by Kappa statistic showed that only 34% and 36% of the 113 participants categorized in the first tertile of WBLH BMD were also categorized in the first tertile of tibial and radial SoS, correspondingly. Logistic regression with gender and maturity adjustments demonstrates that radial SoS was the single significant variable in predicting OR for identifying participants with past fractures. In conclusion, the radial QUS revealed itself to be a valuable tool for screening bone fragility in youth of 10–12 yr, despite the absence of agreement with DXA WBLH BMD.

Key Words: Bone density; DXA; QUS; speed of sound; youth.

Introduction

A significant number of girls (27%–40%) and boys (42%–64%) sustain at least one bone fracture during growth, with two-thirds of these fractures occurring in subjects who experience a fracture on more than one occasion *(1)*. Because the person who experiences a bone fracture has a high risk of sustaining subsequent fractures, this means that some children and adolescents are more prone to sustaining this type of injury *(2)*. In fact, girls and boys with bone fractures usually reveal low bone mineral and bone size and consequently are at risk for osteoporosis later in life. However, osteoporosis is a disease that could have a slow and long progression starting in the period of growth associated with an insufficient acquisition of bone mineral. The screening of bone health at approximately 10–14 yr of age in girls and 12–16 yr of age in boys seems to be particularly important in the prevention of osteoporosis because approximately 40% of peak bone mineral mass is acquired during the 4-yr period surrounding peak height velocity *(3)*.

The International Society for Clinical Densitometry recommends dual-energy X-ray absorptiometry (DXA) as the most appropriate technique for the evaluation of bone health *(4)* with the bone mineral of the whole body less head (WBLH) and the anteroposterior lumbar spine as the most recommended parameter/sites for bone measurements in children and adolescents 5–19 yr old *(4)*. The diagnosis of osteoporosis in this age group requires the presence of both low bone mineral and clinically significant bone fracture history

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(5). Beyond DXA, other equipment, parameters, and bone sites have been applied in both pediatrics and adults to assess bone mineral status (6). Quantitative ultrasonography (QUS), which is used to quantify the ultrasound velocity and attenuation parameters at the distal regions of the appendicular skeleton, has been one of the most used tools for screening bone fragility because of its cost, ease of technique application, and mostly because the patient is not exposed to ionizing radiation (6). However, the existence of several types of QUS, along with different types of US transmission (trabecular transverse transmission, cortical transverse transmission, and cortical axial transmission), and the evaluation of different bone regions (radius, tibia, heel or phalanges) complicates the choice of apparatus within a bone health screening. In children and adolescents, the tibia (midshaft) and the radius (distal third) with cortical axial transmission of ultrasound have been the skeletal sites most often assessed by multisite QUS (6).

Some studies reveal an association between data obtained by QUS (based on bone velocity and attenuation) and DXA (based on bone mineral), suggesting that QUS and DXA parameters, even measured at different skeletal sites, may show similar results in children with disturbances of growth or disorders affecting bone health (7−9). However, other studies show poor or inconsistent associations between QUS and DXA both in growing patients with pathology (10−12) as in healthy children (13,14). Given that bone US is relatively inexpensive and free of ionizing radiation, making it a suitable method for screening bone fragility in large pediatric populations, the main objective of this study was to analyze measurement properties of the Omnisense QUS (Sunlight Omnisense TM; BeamMed Ltd, Tel Aviv, Israel), a common type of ultrasound machine used for screening bone fragility, in boys and girls 10−12 yr.

Materials and Methods

Subjects

Five-hundred sixty-five participants between 10 and 12 yr of age were drawn from schools. Because of the difficulties in the measuring the speed of the sound (SoS) in bone related to the thickness of soft tissues, 234 participants were excluded from the study; 12 obese participants according to Cole criteria (15) with SoS data also were excluded. The final sample consisted of 319 nonobese participants (160 girls and 159 boys) who completed QUS and DXA evaluations. A history of bone fracture was self-reported by 46 participants at the upper limbs (38 participants, 47 fractures) and at the lower limbs (8 participants, 11 fractures). None of the subjects were taking any medication that could affect the bone. The study was approved by the Ethics Committee of the Faculty of Human Kinetics.

Speed of Sound

Evaluation of radial (distal third) and tibial (midshaft) SoS was conducted with the QUS Omnisense on the subject's nondominant limb. The evaluation was conducted on the dominant limb in case of past fracture in the bone site being evaluated. Both the calibration and evaluation were performed by the same technician according to the manufacturer's standards. The coefficients of variation for the radial and tibial SoS sites were 0.6% and 0.3%, respectively.

Bone Mineral Density

Bone mineral density (BMD) of the WBLH was obtained from a whole-body scan with DXA (QDR Explorer; Hologic, Waltham, MA). Scans and analyses were performed accordingly to the standard protocol of the operator's manual supplied by the manufacturer by the same technician. Reproducibility of the whole-body scan was not performed to avoid excessive exposure to radiation.

Body Size and Body Composition

Standing height was measured in accordance with the International Society for the Advancement of Kinanthropometry (16). Body mass was evaluated with a weighing-scale (Seca Alpha model 770, Hamburg, Germany) with children wearing only underwear and barefoot. Body mass index was calculated as body mass in kilograms divided by body height (in meters squared). Total fat mass was estimated via Slaughter equations (17). All anthropometric measures were made by the same trained researcher.

Maturity and Calcium Intake

Maturity (±yr) was estimated as the years of distance positive or negative from the age of peak height velocity by the use of sex-specific prediction equations (18). Calcium intake was calculated from a semiquantitative Food Frequency Questionnaire that was used to assess regular intake of a wide set of a typical Portuguese foods.

Physical Activity

Evaluation of physical activity was conducted with the GT1 M accelerometer (Actigraph, Fort Walton Beach, FL) with 15-second epochs. Participants wore the monitor for 4 days (2 weekdays and 2 weekend days) providing at least 600 minutes per day of accelerometer data. The children were asked to wear the accelerometer all day, except during activities in water and sleeping. Those who did not comply with these requirements were excluded from the sample. Data were obtained from 243 participants (115 boys and 128 girls). Activity data were analyzed and processed by use of the MAHUffe analysis program (www.mrc-epid.cam.ac.uk). The total amount of physical activity was expressed as total counts divided by registered time, i.e., counts per minute, which is an indicator of the total physical activity.

Statistical Analysis

All data were first described by mean and SD after all bone variables were standardized to test validity of the radial and tibial SoS to assess bone health and fragility. Previously to the standardization the WBLH BMD was adjusted for body height. The standardization process was conducted separately for each sex and age groups. To form the groups by age,