Ultrasound velocity and cortical bone characteristics in vivo

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Axial transmission of ultrasound along cortical bone may reflect a combination of material and structural properties of long bone cortices. The goal of this study was to determine the association of speed of sound (SOS) with cortical density (CoD), cortical wall thickness (CWT), and total cortical area (CoA). Quantitative ultrasound (QUS) and peripheral quantitative computed tomography (pQCT) were used to measure the above variables in the distal third of radius and the midshaft of tibia in 51 postmenopausal women aged 62 to 71 years. Univariate regression analysis showed that the site-specific CoD accounted for 34% of the variability in the radial SOS and 29% of that in the tibial SOS ($p < 0.001$ both). SOS was only moderately associated with radial CWT ($R2 = 0.14$, $p < 0.05$) and CoA ($R2 = 0.12$, $p < 0.05$), but not with tibial CWT nor CoA. After controlling for CoD, these dimension-related associations disappeared. Stepwise multiple regression analysis showed that CoD was the only significant determinant of radial SOS (adjusted $R2 = 0.31$), whereas for tibia, not only CoD but also the years since menopause were associated with SOS (adjusted $R2 = 0.41$). In conclusion, out of the studied macroscopic cortical variables, CoD (an apparent surrogate for material properties of bone) was the only determinant of SOS measured in vivo at radial and tibial shafts. The key question that still needs to be answered is whether the SOS information obtained from the peripheral long bone cortical shafts can be translated to describe the mechanical competence and quality of clinically pertinent bones (e.g. proximal femur) of a given individual.

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