Measurement properties of radial and tibial SoS for screening bone health and fragility in 10 to 12 yrs old boys and girls

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INTRODUCTION

Girls and boys with bone fractures reveal usually low bone mineral and bone size and consequently are at risk for osteoporosis later in life [1-3]. Osteoporosis is however 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 around 10-14 years of age in girls and 12-16 years of age in boys seems to be particularly important in the prevention of osteoporosis because about 40% of peak bone mineral mass is acquired during the four year period surrounding peak height velocity, which is around the 12nd and 14th years of life in girls and boys, respectively [4-6]. Beyond DXA, other equipments have been applied in both pediatrics and adults to assess bone mineral status, as the quantitative ultrasonography (QUS), which quantifies the ultrasound velocity and attenuation parameters at the distal regions of the appendicular skeleton [7-9]. 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 the multisite QUS device [7]. However, poor or inconsistent associations between QUS and DXA both in growing patients with pathology [10-12] as in healthy children [13-14] have been found. Given that bone ultrasound are relatively inexpensive and free of ionizing radiation making them a suitable method for screening bone fragility in large pediatric populations, the main objective of this study was to analyze measurement properties of the BeamMed Omnisense QUS to screen bone health and fragility.

METHODS

Subjects. 319 non-obese participants, 160 girls and 159 boys drawn from local schools (5th grade) not taking any medication affecting bone.

Speed of Sound (SoS): radial (distal third) and tibial (midshaft) SoS evaluated by QUS on the non-dominant limb (Sunlight Omnisense TM, BeamMed Ltd; Tel Aviv, Israel); radial and tibial SoS coefficients of variation were 0.6% and 0.3%, respectively.

Bone mineral density (BMD): BMD of the whole body less head (WBLH) obtained from a whole body scan (QDR Explorer; Hologic, Waltham, MA, USA); reproducibility of the whole body scan was not performed to avoid excessive exposure to radiation.

Body size and body composition: standing height (cm) measured in accordance with the International Society for the Advancement of Kinanthropometry [15]; body mass (kg) evaluated with a weighing-scale (Seca Alpha model 770, Hamburg, Germany) with children in underwear and barefoot; body mass index (BMI) calculated as body mass in kilograms divided by body height (in meters squared); total fat mass (%) estimated via Slaughter equations which include calf and triceps skinfolds [16].

Maturity offset: estimated as the years of distance positive or negative from the age of peak height velocity (PHV) using sex-specific prediction equations that include age, body height, sitting height, and body mass [17,18].

Calcium intake: calculated from a semi-quantitative Food Frequency Questionnaire, assessing regular intake of a wide set of a typical Portuguese foods.

Statistical analysis: standardization of all bone variables with previous adjustment of WBLH BMD for body height; validation analysis (radial SoS vs. WBLH BMD; tibial SoS vs. WBLH BMD) conducted by concordance coefficient correlation with differences between the regression and identity lines tested by analyzing the intercepts and slopes; additional use of Kappa statistic to analyze agreement by tertiles, in particular among the first tertiles of the two methods; bone fragility defined as low WBLH BMD measured by DXA [first tertile:-1.0±0.5 SD, 95% CI: -1.1 – (-0.9)] and as past history of fractures evaluated by questionnaire; accuracy of the radial and tibial SoS and of the WBLH BMD to identify participants with past fractures analyzed by logistic regression; statistical significance set at P<0.05; analyses conducted with SPSS (Version 19.0 for Windows; SPSS, Chicago, IL, USA) and MedCalc (MedCalc Software, Mariakerke, Belgium).

Age and Body Composition

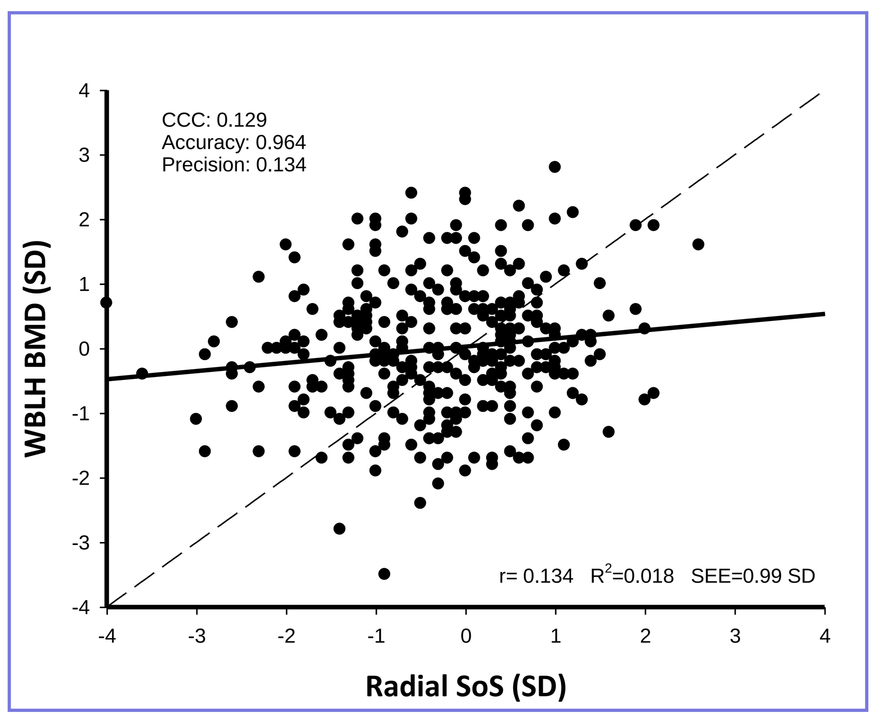
	Boys Mean ± SD	Girls Mean ± SD	P*
Age, yrs	10.8 ± 0.4	10.8 ± 0.4	0.305
Maturity offset, yrs	-3.25 ± 0.41	-3.05 ± 0.44	<0.001
Body mass, kg	36.4 ± 7.1	38.2 ± 7.3	<0.005
Body height, cm	143.4 ± 6.8	145.2 ± 7.5	<0.005
BMI, kg/m²	17.6 ± 2.5	18.1 ± 2.4	0.075
Fat Mass, %	17.3 ± 6.6	21.5 ± 5.7	<0.001

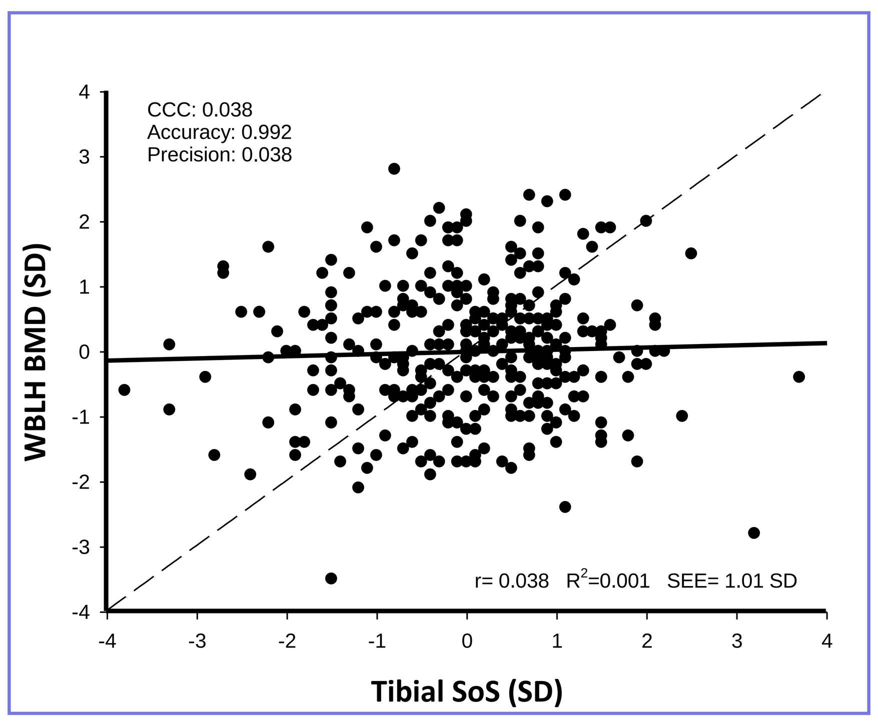
Calcium and Bone Variables

	Boys Mean ± SD	Girls Mean ± SD	P*
Calcium Intake, mg/d	1278 ± 763	1062 ± 534	<0.005
WBLH BMD, g/cm²	0.835 ± 0.057	0.820 ± 0.068	<0.005
Radial SoS, m/s	3753 ± 92	3748 ± 92	0.637
Tibial SoS, m/s	3635 ± 119	3635 ± 129	0.986

*Independent Sample T-Tests.; PHV- peak height velocity; BMD – bone mineral density; SoS - speed of sound

Concordance Coefficient Correlation and Linear Regression Analysis





Concordance coefficient correlation and linear regression analysis for whole body less head BMD and radial SoS (left panel) and tibial SoS (right panel). The solid and dotted lines represent regression and identity line, respectively.

CCC, concordance coefficient correlation; r, correlation coefficient; R^2, determination coefficient; SEE, standard error of estimation

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Cross classification analysis between QUS and DXA

DXA - WBLH BMD tertiles		QUS - Radial SoS tertiles				QUS - Tibial SoS tertiles			
		1	2	3	Total	1	2	3	Total
1	N	41	40	32	113	38	37	38	113
	% within tertile of DXA	36.3%	35.4%	28.3%	100.0%	33.6%	32.7%	33.6%	100%
	% within tertile of QUS	40.6%	36.7%	29.4%	35.4%	38.4%	33.6%	34.5%	35.4%
	% of total sample	12.9%	12.5%	10.0%	35.4%	11.9%	11.6%	11.9%	35.4%
2	N	33	31	41	105	28	36	41	105
	% within tertile of DXA	31.4%	29.5%	39.0%	100.0%	26.7%	34.3%	39.0%	100%
	% within tertile of QUS	32.7%	28.4%	37.6%	32.9%	28.3%	32.7%	37.3%	32.9%
	% of total sample	10.3%	9.7%	12.9%	32.9%	8.8%	11.3%	12.9%	32.9%
3	N	27	38	36	101	33	37	31	101
	% within tertile of DXA	26.7%	37.6%	35.6%	100.0%	32.7%	36.6%	30.7%	100.0%
	% within tertile of QUS	26.7%	34.9%	33.0%	31.7%	33.3%	33.6%	28.2%	31.7%
	% of total sample	8.5%	11.9%	11.3%	31.7%	10.3%	11.6%	9.7%	31.7%
Total	N	101	109	109	319	99	110	110	319

DXA, dual energy x-ray absorptiometry; BMD, bone mineral density; WBLH, whole body less head; QUS, quantitative ultrasound; SoS, speed of sound

Binary Logistic Regression

Measurement	Coefficient	SE	OR	95% CI for OR	p-value
Radial SoS (SD)	-0.344	0.148	0.709	0.530 – 0.948	0.020
Tibial SoS (SD)	-0.274	0.142	0.760	0.575 – 1.004	0.054
WBLH BMD (SD)	-0.035	0.178	0.966	0.682 – 1.369	0.846

SoS, speed of sound; WBLH, whole body less head; BMD, bone mineral density; SE, standard error; OR, odds ratio; CI, confidence interval

CONCLUSIONS

- **Concordance coefficient correlations** between WBLH BMD and radial and tibial SoS of 0.129 and 0.038 respectively, with regression lines different from the identity lines.
- Radial and tibial SoS explaining less than 2% of the **variability** of the WBLH BMD.
- **Kappa coefficients** near 0 suggests that the equipments ratings were largely different, even in the group of bone fragility [first tertile of WBLH BMD:-1.0±0.5 SD, 95% CI: -1.1 – (-0.9)]
- **Cross classification** showed that only 41 participants (36.3%) were categorized in the first tertile of radial SoS and 38 participants (33.6%) in the first tertile of tibial SOS, concerning bone fragility identified in the first tertile of DXA measurements.
- **Logistic regression** adjusted for gender and maturity showed that radial SoS was the only significant variable in predicting OR for identifying participants with past fractures; each SD increase in radial SoS decreased fracture odds ratio in 29.1%.
- **The BeamMead Omnisense QUS provides significant fracture prediction when measured at the radius in youth 10-12 years old revealing to be a valuable tool for screening bone fragility despite the absence of agreement with DXA WBLH BMD.**

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