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Validity of quantitative ultrasound (QUS) and bioelectrical impedance analysis (BIA) against dual X-ray absorptiometry (DXA) for measuring bone quality and body composition in children

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Background

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- Dual energy X-ray absorptiometry (DXA) is a radiological device, which is designed primarily for measuring bone mineral density (BMD) [1].
- DXA can also provide information on bone mineral content (BMC) [2], and other compartments of body composition including fat mass (FM), lean mass (LM), and percentage of fat mass (%FM) [3].
- Quantitative ultrasound (QUS) provides information about bone mineral status, which may be important in determining fracture risk [4].
- BIA is able to estimate the volume of total body water (TBW), LM, and FM [5].

Aim

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- To examine the validity of quantitative ultrasound (QUS) and bioelectrical impedance analysis (BIA) measurements against dual X-ray absorptiometry (DXA) for bone quality and body composition in children (8-13 years) living in Auckland, New Zealand.

Methods (Sample size)

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- Cross-sectional study
- A sample of 128 children was calculated based on G*Power program [version 3.1 software [6]: medium effect size: 0.6; power: 95%; level of significance: 5%].
- Recruited a total of 127 children (58), aged 8–13 years

Methods (Dual Energy X-ray Absorptiometry)

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- The DXA measurements were performed on a Hologic QDR Discovery A (Hologic Inc, Bedford, MA, USA) with APEX V. 3.2 software.
- Total body (TB) scans were performed and lumbar spine (LS) values were derived from TB scans.
- Bone mineral content (BMC) (g) and BMD (g/cm^2) of the total body (TB) and lumbar spine (LS).
- Lean mass (LM) (kg), fat mass (FM) (kg), and body fat percentage (%FM) were measured.

Methods (Quantitative Ultrasound)

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- The calcaneal BMD was measured by Quantitative Ultrasound (QUS) (Sahara Clinical Bone Sonometre Hologic Inc, USA).
- Speed of sound (SOS) (m/s), broadband ultrasound attenuation (BUA) (dB/MHz), and the quantitative ultrasound index or “stiffness (SI)” were assessed.

Methods (Bioelectrical Impedance Analysis)

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- LM (kg), FM (kg), and %BF were measured by bioelectrical impedance analysis (BIA) (InBody 230, Biospace Co. Ltd., Seoul, Korea).

Measurement Posture

- **Statistical analysis**
- Relative validity was assessed using Pearson correlation coefficients, cross-classification, and weighted κ-statistic.

Results

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Baseline characteristics of participants (mean (SD))[1]

Variable	Total (127)
Age (years)	10.46 (1.19)
Height (cm)	147.57 (13.04)
Weight (kg)	42.07 (10.77)
BMI (kg/m^2) [2]	21.15 (26.77)

[1]*SD* standard deviation, [2]*BMI* body mass index

Results (continued)

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Bone quality measurements from DXA and correlations with QUS variables

Variable	DXA mean (SD)	QUS SI correlations	QUS BMD (g/m^2) correlations
LS BMC (g)	28.24 (7.35)	0.40*	0.11
LS BMD (g/cm^2)	0.74 (0.10)	0.45*	0.24*
TB BMC (g)	1188.91 (257.35)	0.40*	0.09
TB BMD (g/cm^2)	0.77 (0.08)	0.43*	0.18*

*Correlation is significant at the 0.05 level (two-tailed), ** Correlation is significant at the 0.01 level (two-tailed)

Results (continued)

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Body composition measurements and correlations between BIA and DXA

Variable	BIA mean (SD)	DXA mean (SD)	Correlations	*P*-value
Total LM (kg)	25.83 (7.06)	29.71 (6.66)	0.90	<0.01
Total FM (kg)	9.63 (5.99)	11.34 (5.49)	0.97	<0.01
%FM (kg)	21.77 (8.38)	26.01 (6.42)	0.88	<0.01

*Correlation is significant at the 0.05 level (two-tailed), ** Correlation is significant at the 0.01 level (two-tailed)

Results (continued)

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Cross-classification between QUS and DXA variables

Variable	%CC	%GM	Weighted κ -statistic
QUS SI vs. DXA TB BMD[4]	52	8	0.40
QUS SI vs. DXA LS BMD	52	5	0.42
QUS BMD vs. DXA TB BMD	49	11	0.29
QUS BMD vs. DXA LS BMD	50	8	0.37

Results (continued)

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Cross-classification between DXA and BIA variables

Variable	%CC	%GM	Weighted κ -statistic
BIA LM vs. DXA LM	73	0	0.70
BIA FM vs. DXA FM	84	0	0.82
BIA %FM vs. DXA %FM	70	0	0.65

Conclusion

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- Fair to moderate agreement was found between QUS and DXA parameters, suggesting the QUS has reasonable validity for measuring bone mineral density in children.
- The BIA demonstrated good validity and is suitable for measuring body composition in healthy children, providing similar estimates to DXA of LM, FM, and %FM.
- QUS and BIA provide efficient, safe and economically feasible alternative methods for assessing bone status and body composition in children, particularly in large cohort field studies.

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