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ESPR
European Society of Paediatric Radiology

BONE MINERAL DENSITY IN CHILDREN:

DEXA or QCT ?

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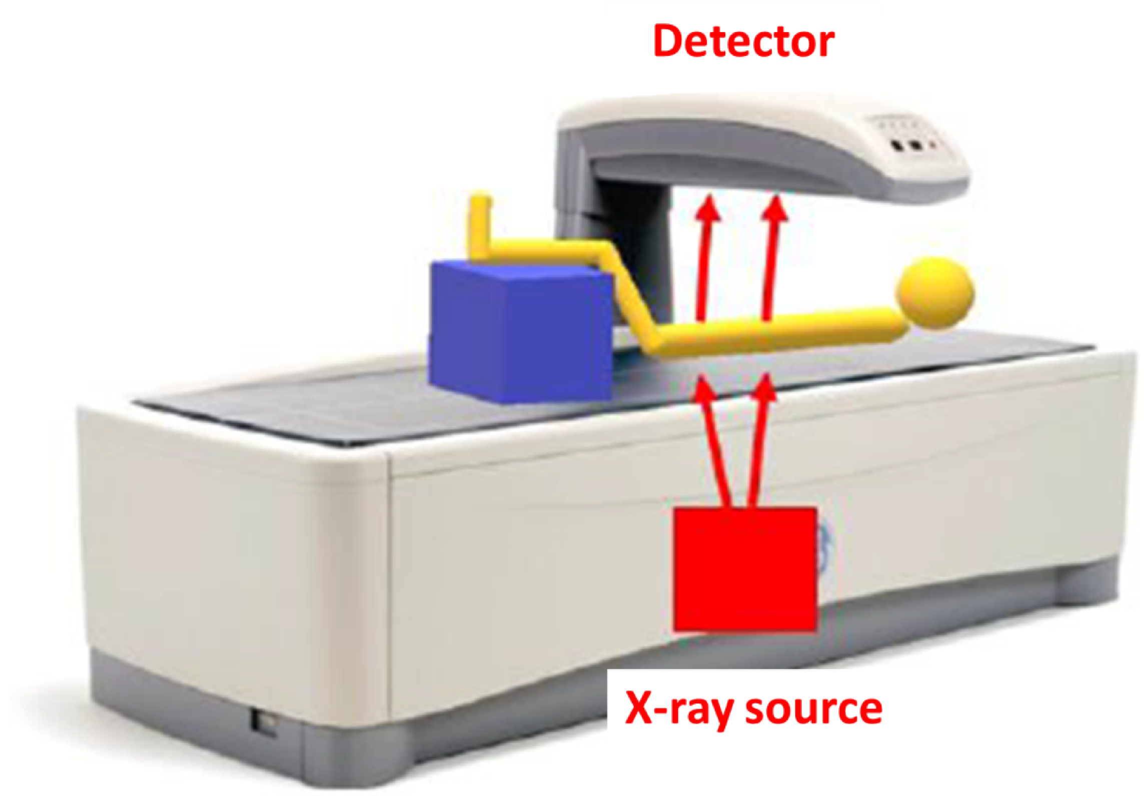
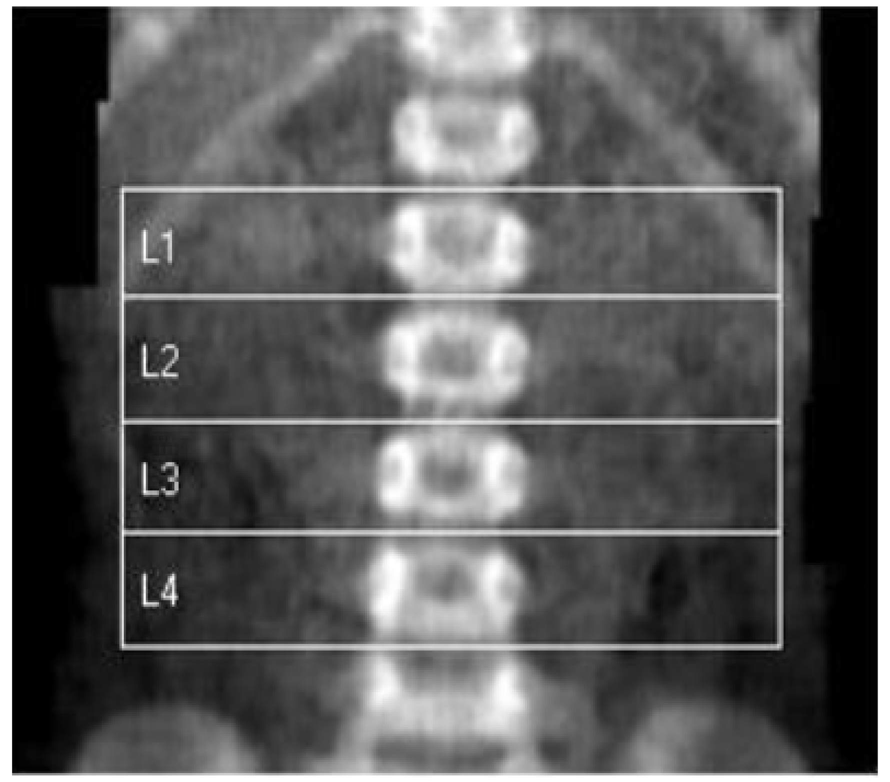
Bone Mineral Density

An assessment issue for children at risk of osteoporosis

DEXA

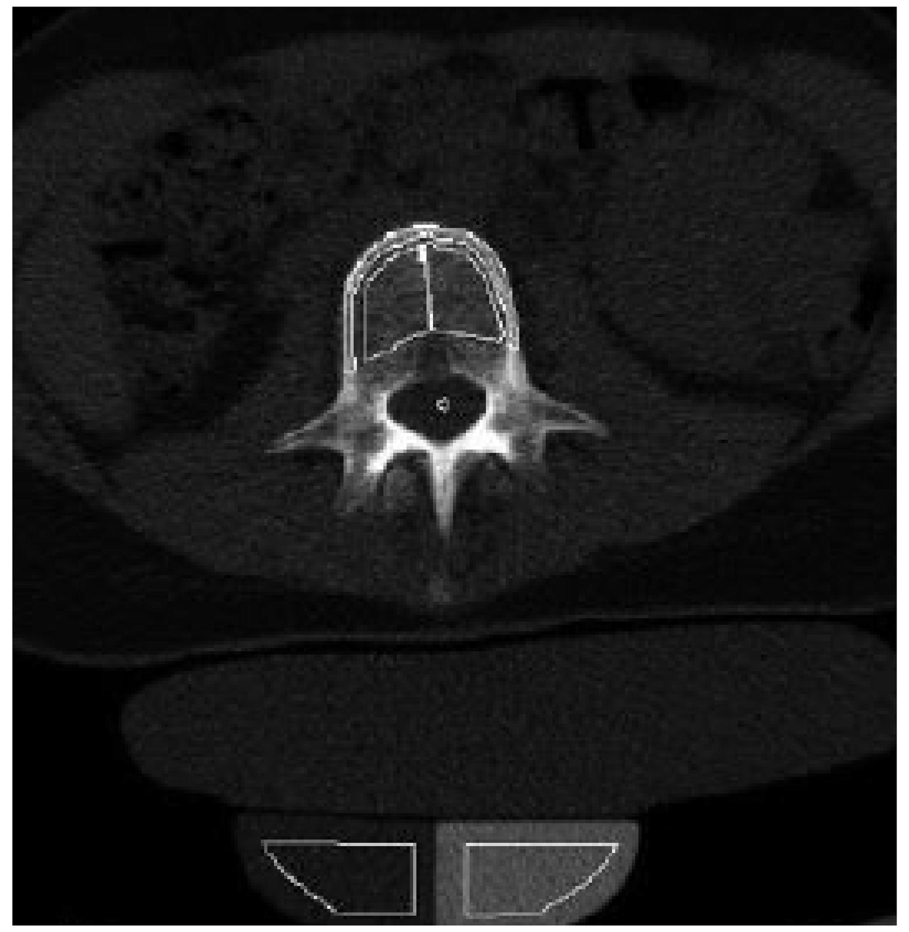
Worldwide recommended method





VS

QCT



DEXA

Pros:
Low radiation exposure
Easily available
Multiple standard references

Cons:
Superimposes the cortical and trabecular bone
Surface density (g/cm^2)
Influence of soft tissues, vertebral posterior arch, material

QCT

Pros:
Differentiates the cortical and trabecular bone
True volumetric density (mg/cm^3)
Free from surrounding soft tissues

Cons:
Low radiation exposure but > DEXA
Less available
Lack of standard references

DEXA: Dual Energy X-Ray Absorptiometry; QCT: Quantitative Computed Tomography; BMD: Bone Mineral Density

DEXA and QCT are two available techniques for assessing BMD in children at the lumbar spine site

However, few studies analyzed the additional value of each of these techniques

Objectives

1. **To assess correlation and agreement in densitometric results (BMD and Z-score) between DEXA and QCT**
2. **To identify differences between subgroups of pathologies**

Patients

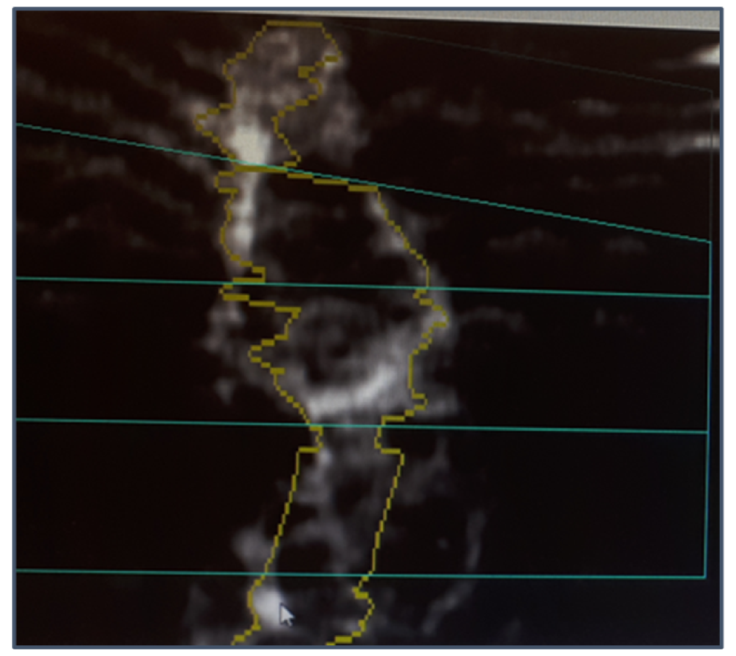
Children and adolescents followed in the reference center for phosphocalcic metabolism disorders (Pr Linglart)

Inclusion criteria

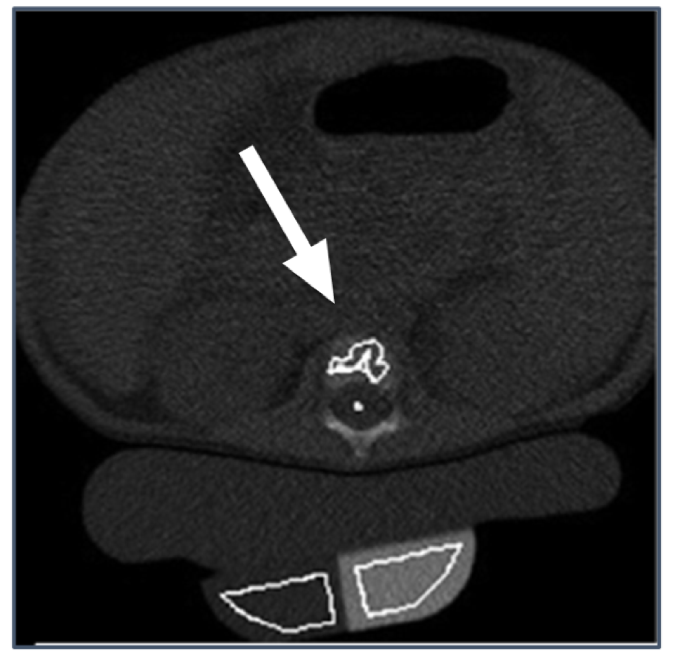
- Aged between 5 and 18 years old
- DEXA and QCT realized within a 3-months time frame
- Lumbar site included L2, L3 and L4 vertebrae

Exclusion criteria

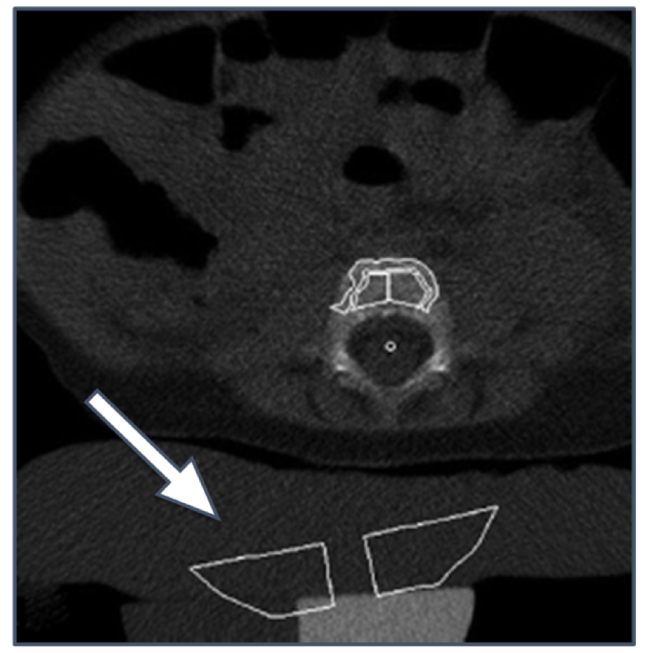
- Uninterpretable exam



Marked spine deformity with difficulty to contour the vertebrae



Incorrect vertebral ROI placement



Incorrect phantom ROI placement

Definitions

Z-score: number of standard deviation compared to mean BMD for the same age-and-gender-matched reference values

Low mineral density: Z-score ≤ - 2

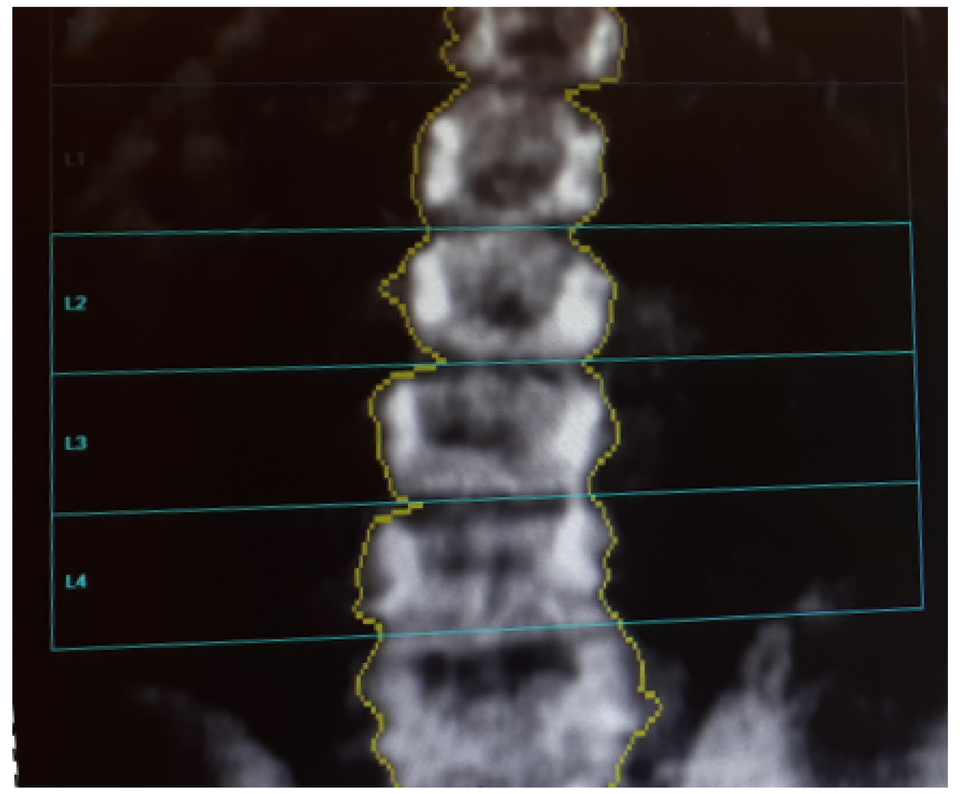
Statistics

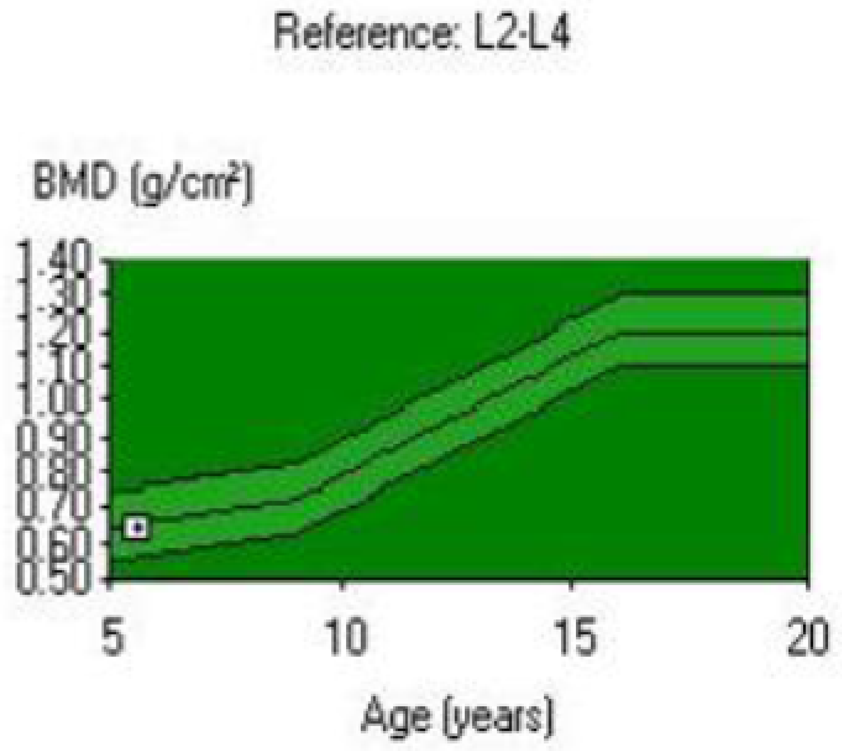
BMD correlation: Spearman method (correlation coefficient r_s)

Z-score agreement: Bland and Altman graph and Kappa method (Z-score ≤ -2)

DEXA

- **Lunar Prodigy Advance (GE) bone densitomer**
- Radiation exposure depending on weight and height
- BMD in g/cm²
- **Z-score:** obtained with integrated data of normative references depending on age, sex and ethnicity

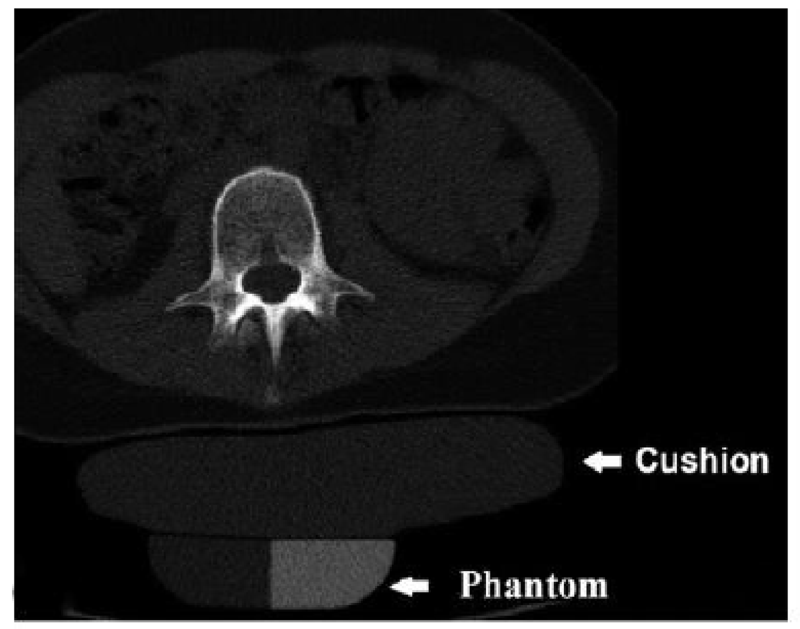


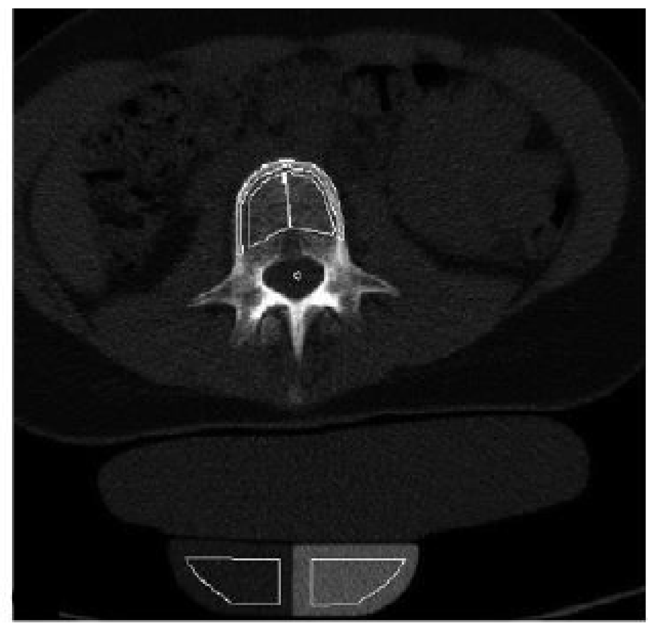


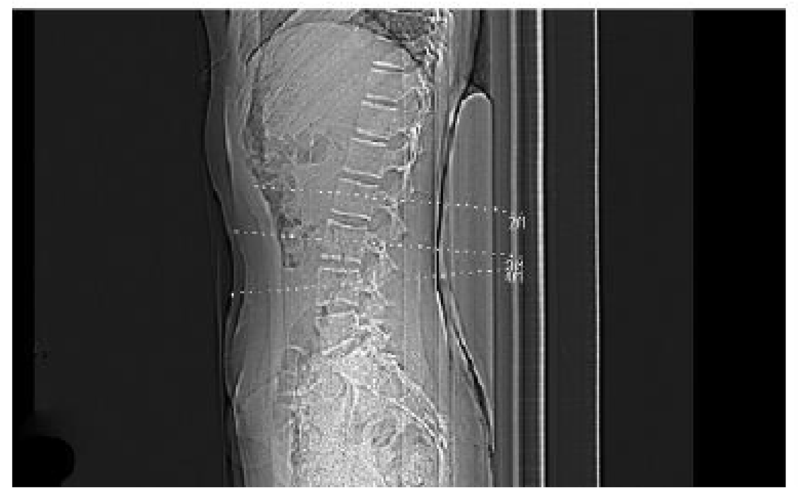
Region	BMD [1] (g/cm²)	Young-Adult [2] T-Score	Age-Matched [3] Z-Score
L1	0.622	-	0.5
L2	0.630	-	-0.1
L3	0.674	-	0.3
L4	0.642	-	0.0
L2-L4	0.648	-	0.0

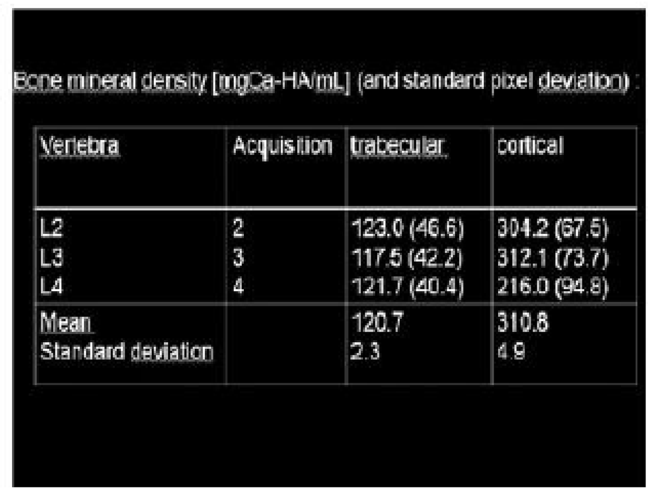
QCT

- **Somatom CT-scan with Syngo-Osteo software (Siemens)**
- Hydroxyapatite phantom of known BMD
- 80 kV, automatic mAs
- Separated cortical and trabecular BMD in mg/cm³
- **Z-score** obtained by comparison of **trabecular BMD** to both:
  - **American published references (Gilsanz 2009): standard references today**
  - **Mindways software references (Siemens)**









Bone mineral density [mgCa-HA/mL] (and standard pixel deviation) :

Vertebra	Acquisition	trabecular	cortical
L2	2	123.0 (46.6)	304.2 (67.5)
L3	3	117.5 (42.2)	312.1 (73.7)
L4	4	121.7 (40.4)	216.0 (94.8)
Mean		120.7	310.8
Standard deviation		2.3	4.9

Gervais-André 2016

Population

246 patients — 5 years old to < 18 years old; DEXA and QCT < 3 months

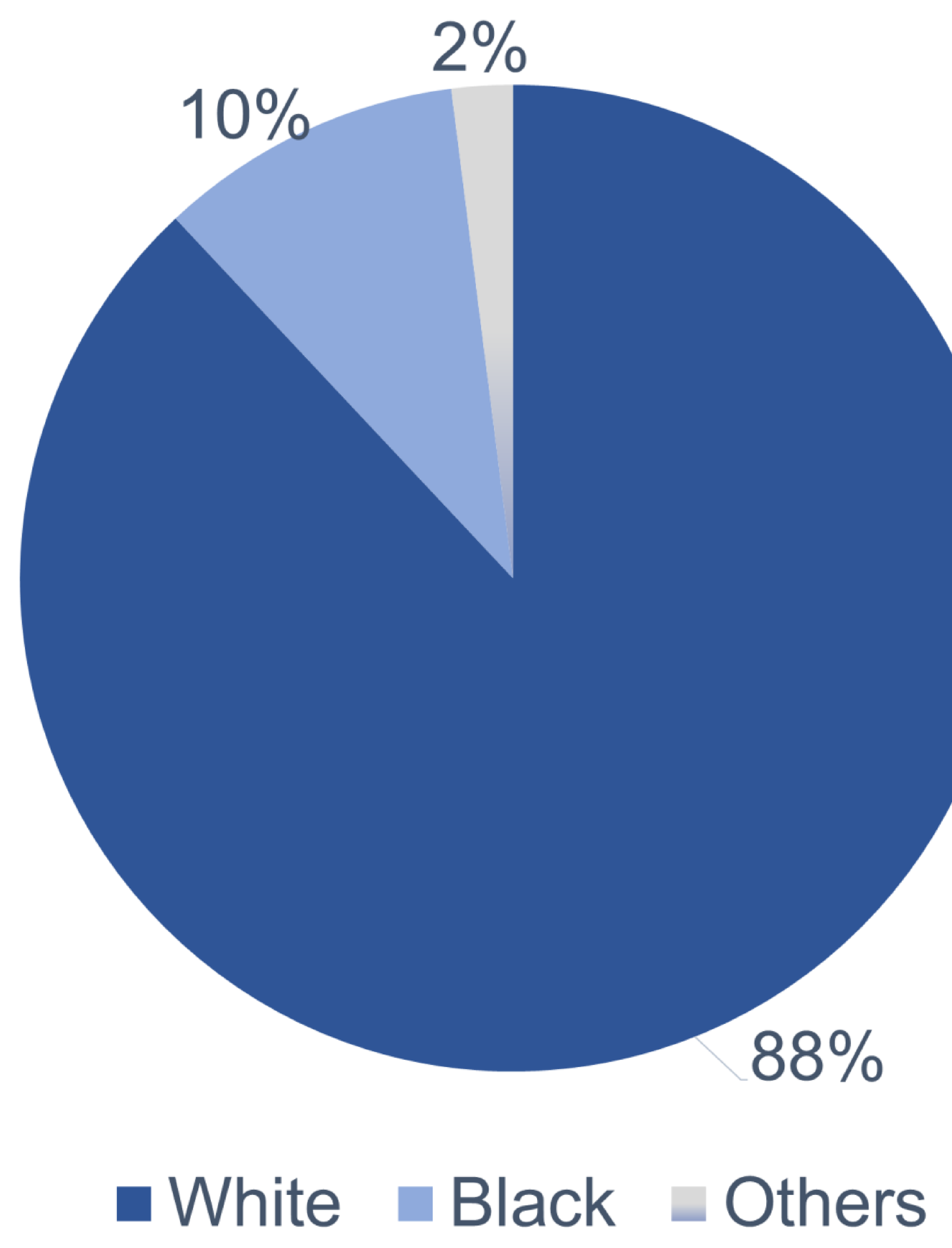
26 excluded patients — Uninterpretable DEXA and/or QCT

220 included patients

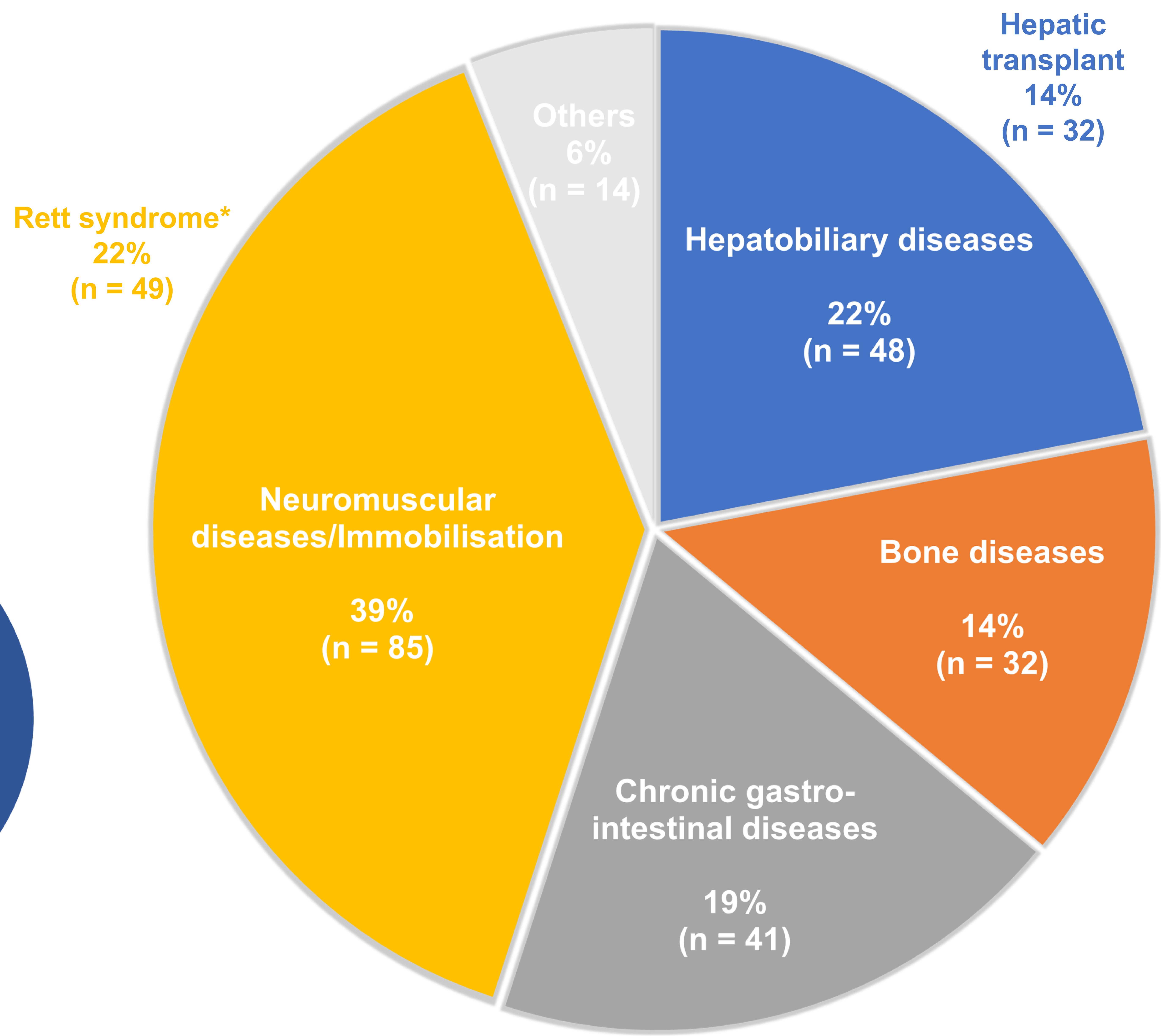
♀ 62% ♂ 38%
Mean age: 10,6 ± 3,2 years old
Mean height: 136,2 ± 19,6 cm
Mean weight: 32,7 ± 13,6 kg

<u>Mean X-ray exposure</u>
DEXA: 19,2 ± 13,2 µGy
QCT: 6 ± 2,7 mGy.cm
(2% of abdominal CT-scan exposure if realized)

Ethnicities



Pathologies



**Rett syndrome: genetic disorder affecting girls, leading to a neurodevelopmental regression with an important intellectual and motor handicap*

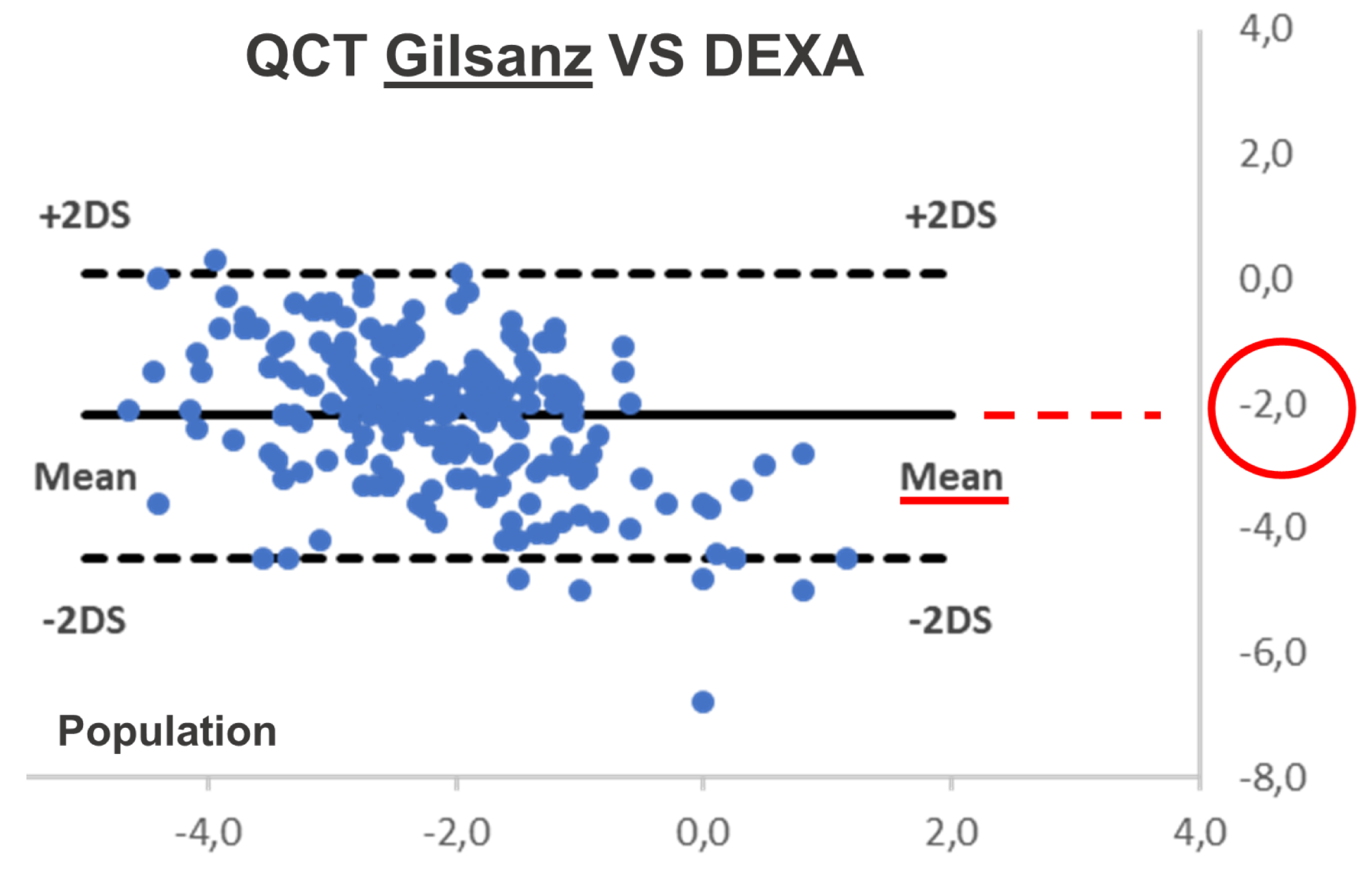
Poor correlation between QCT and DEXA BMD values

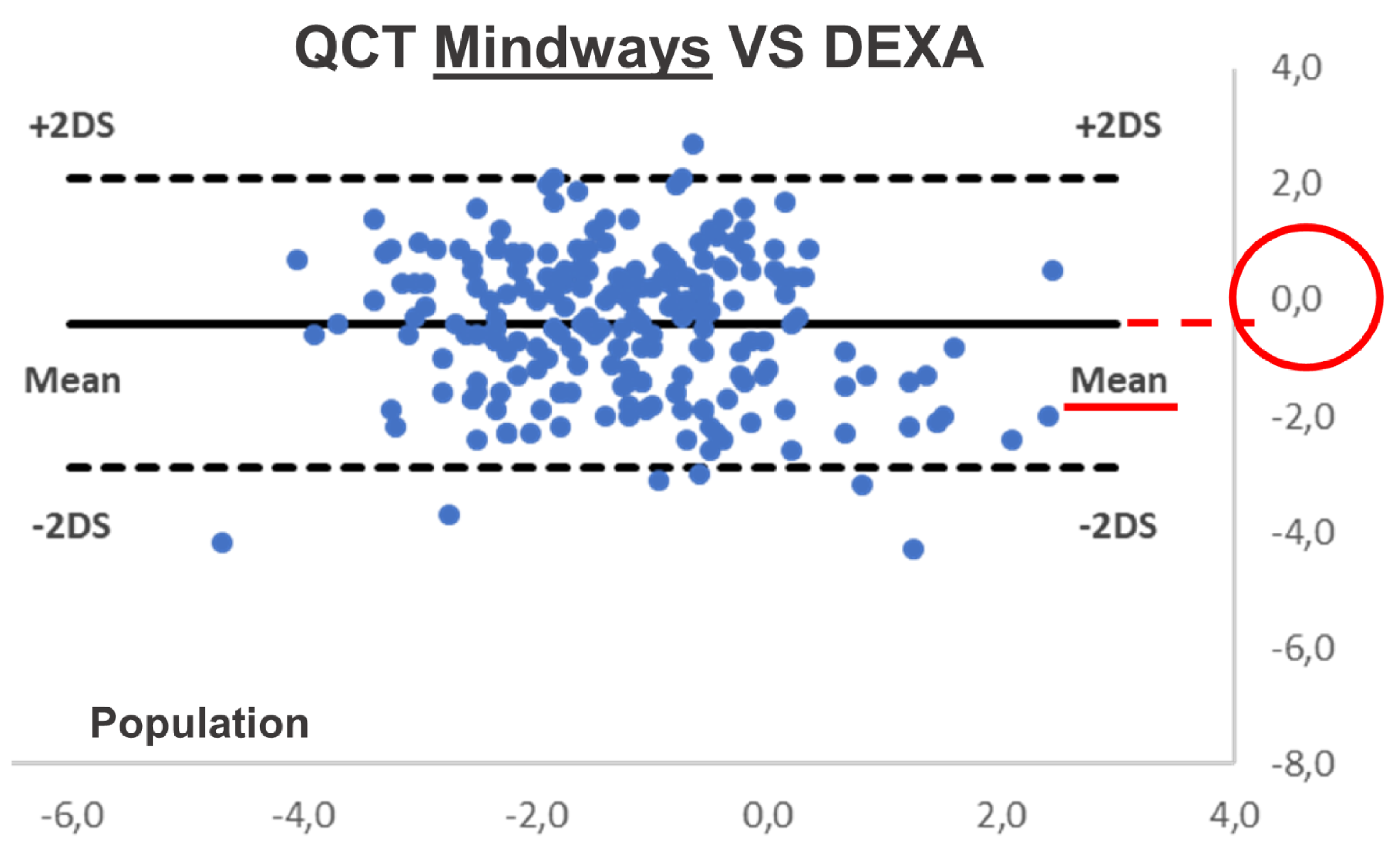
	n	Trabecular QCT vs DEXA r_s (IC)	Cortical QCT vs DEXA r_s (IC)
Population	**220**	**0,50 (0,39 - 0,61)**	**0,74 (0,66 - 0,81)**
Population without Rett syndrome	171	0,45 (0,31 - 0,58)	0,70 (0,60 - 0,80)
Girls	137	0,62 (0,50 - 0,74)	0,81 (0,73 - 0,89)
Boys	83	0,29 (0,07 - 0,50)	0,52 (0,34 - 0,71)
Hepatobiliary diseases	**48**	**0,54 (0,31 - 0,77)**	**0,71 (0,50 - 0,91)**
Hepatic transplant	32	0,61 (0,36 - 0,86)	0,79 (0,58 - 0,98)
Chronic gastro-intestinal diseases	**41**	**0,19 (0,14 - 0,52)**	**0,82 (0,68 - 0,96)**
Bone diseases	**32**	**0,66 (0,42 - 0,89)**	**0,78 (0,59 - 0,96)**
Neuromuscular diseases/Immobilization	**85**	**0,51 (0,32 - 0,69)**	**0,64 (0,51 - 0,77)**
Rett syndrome	49	0,61 (0,39 - 0,83)	0,73 (0,57 - 0,89)

DEXA BMD was better correlated to cortical QCT than to trabecular QCT BMD

No statistical difference was found between subgroups of pathologies (overlapping confidence intervals)

Poor agreement of Z-score values and diagnostic of low BMD (Z-score ≤ -2) between QCT and DEXA

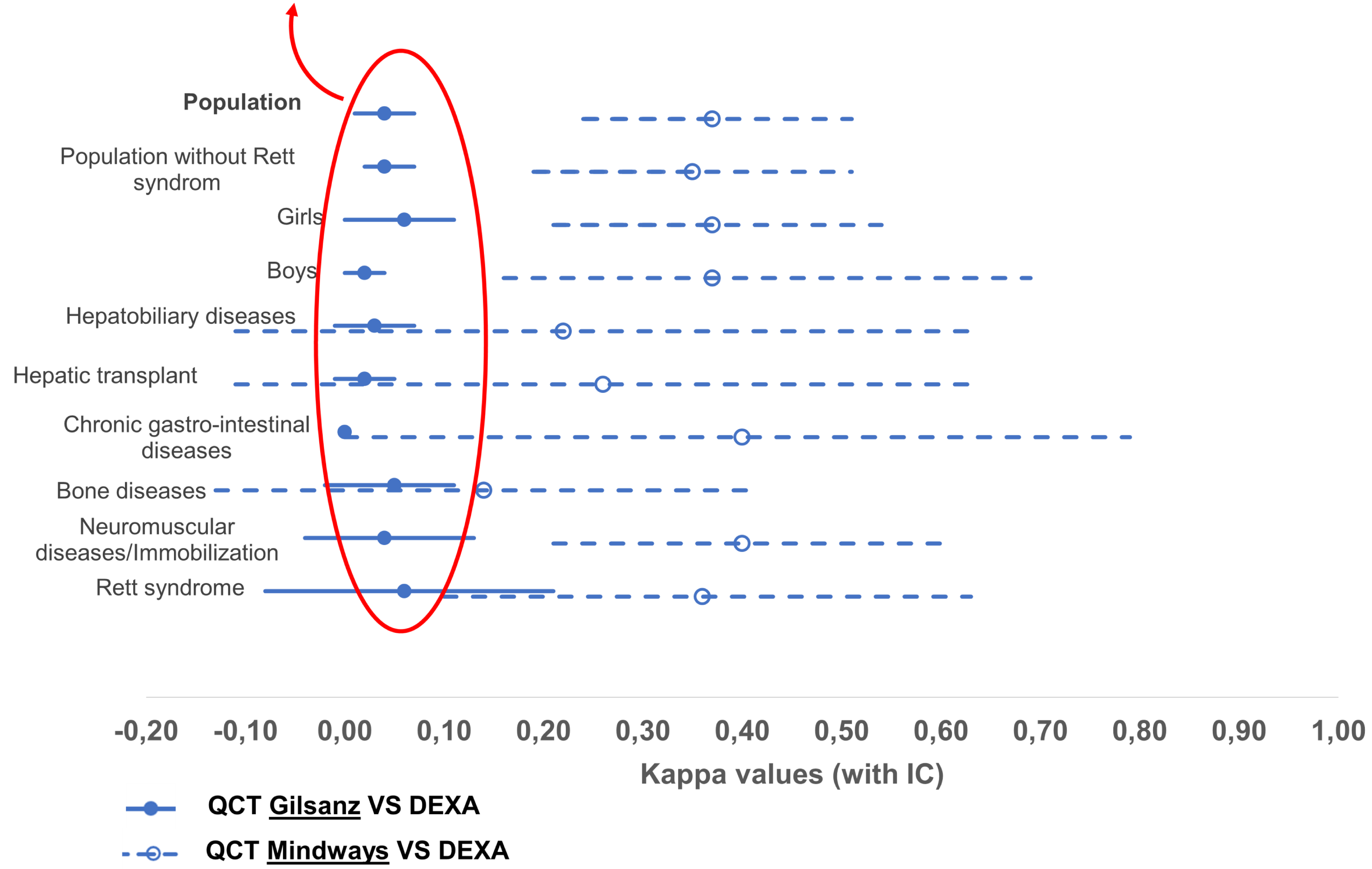




Different agreement according to the QCT references used

With Gilsanz QCT references, we found

- Lower QCT Z-score than DEXA Z-score
- And poorest agreement on diagnostic of low BMD compared to DEXA



No statistical difference was found between subgroups of pathologies (overlapping confidence intervals)

DEXA and QCT disagreed to assess BMD in children population

- Other studies also showed poor BMD correlation between DEXA and QCT. It may be explained because DEXA provides a surface density BMD that depends on the child's height.

  QCT Versus DXA in 320 survivors of childhood cancer: Association of BMD with fracture history, Kaste et al., Pediatric Blood Cancer 2006

  Bone Acquisition in Healthy Children and Adolescents: Comparisons of Dual-Energy X-Ray Absorptiometry and Computed Tomography Measures, Wren et al., The Journal of Clinical Endocrinology & Metabolism 2006

- One study found also a poor agreement between DEXA and QCT using Mindways references.

  QCT Versus DXA in 320 survivors of childhood cancer: Association of BMD with fracture history, Kaste et al., Pediatric Blood Cancer 2006

QCT standard references appear questionable: this is the first study showing lower Z-score in QCT when using Gilsanz references

- Previous studies found lower Z-score in DEXA with Gilsanz references for QCT, but not with the same CT-scan.

  Quantitative Computed Tomography (QCT) versus Dual-X-Ray Absorptiometry (DXA) in the Assessment of Bone Mineral Density in HIV-1 Infected Children, Lin et al., World Journal of AIDS 2012

  Bone densitometry in pediatric populations discrepancies in the diagnosis of osteoporosis by DXA and CT, Wren et al., The journal of Pediatrics 2005

- BMD normal values published by Gilsanz in 2009 are higher than those published in the 1990's.

  Quantitative CT Reference Values for Vertebral Trabecular Bone Density in Children and Young Adults, Gilsanz et al., Radiology 2009

  Gender differences in vertebral body size in children and adolescent, Gilsanz et al., Radiology 1994

- Are Gilsanz reference values for QCT too high for our population? Or not adapted to our equipment?

⇒ Using Z-score in QCT seems inadequate to assess BMD in children

⇒ At present, BMD QCT can be used only in the follow-up by comparison to each patient's own baseline