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# Dry bone and virtual modality interchangeability for the estimation of sex on the human pelvis

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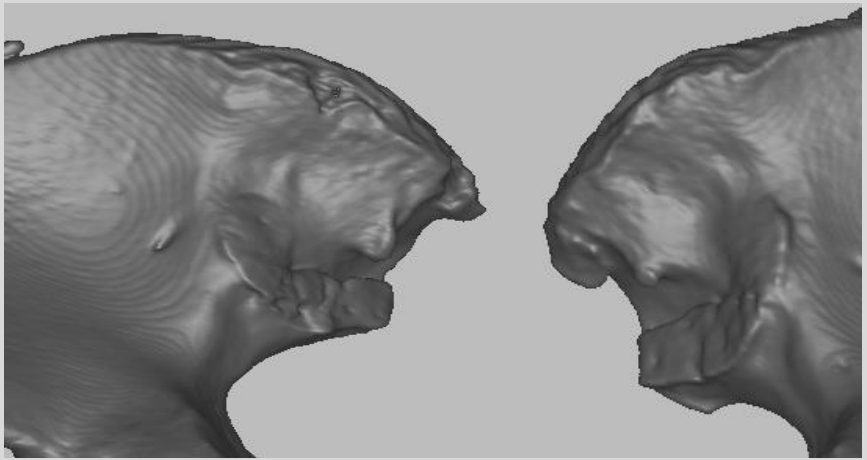
Braun et al. *Int J Legal Med*, submitted

# Introduction:
# Visual-tactile *vs* visual-only sensation

Source: Zweisimmen individual 69, photo: S. Braun

# Introduction:
# Virtual osteological collections

- The New Mexico Decedent Image Database (NMDID, 1972) Albuquerque (Edgar & Berry, 2019)
- Subadult Virtual Anthropology Database (SVAD, 2015) Reno (Stull & Corron, 2022)
- Bakeng se Afrika (BsA, 2019) Pretoria (L'Abbé et al., 2021)

# Introduction: Interchangeability studies

- Research on virtual modalities without direct comparison with dry bones (Decker, Davy-Jow, Ford, & Hilbelink, 2011; Dereli et al., 2018; Grabherr et al., 2009; Ramsthaler, Kettner, Gehl, & Verhoff, 2010; Fahrni et al., 2017)
- Research on modality comparison with small sample sizes (Abegg et al., 2021; Chapman et al., 2014; Corron, Marchal, Condemi, Chaumoître, & Adalian, 2016; Colman et al., 2019)
- Research on interchangeability with narrow anatomical focus (Braun, Ridel, L'Abbé, Theye, & Oettlé, 2022)

# Rationale and research question

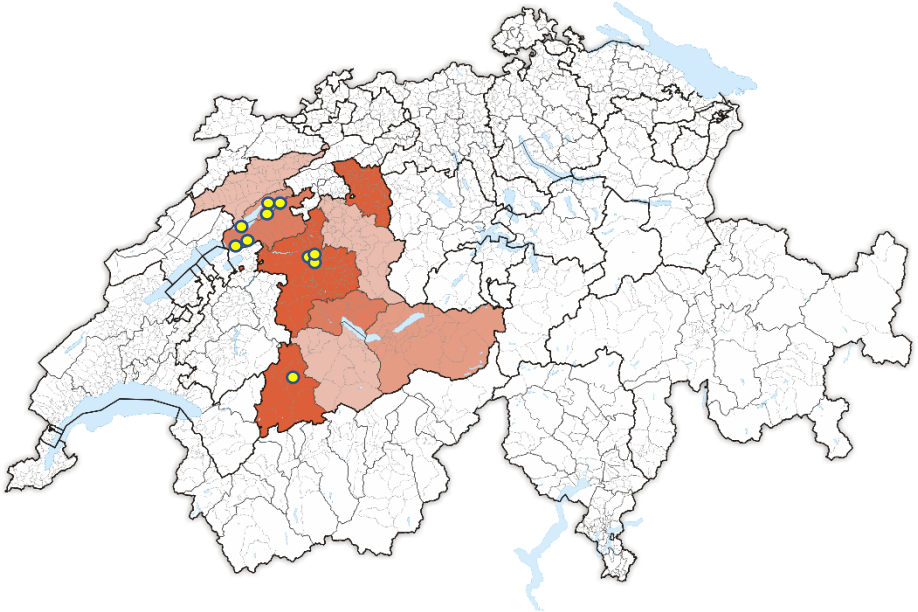
Summarizing rationale:

- Despite increased use of virtual modalities, no comprehensive study on interchangeability of analogous and virtual pelves

Aim:

- Consistency of methods and traits on dry bone, CT and 3D surface scans

# Materials: 200 archaeological pelves from sites in Switzerland



# Materials: Dry bone (gold standard) / CT (n=200); 3D surface scans (n=39)

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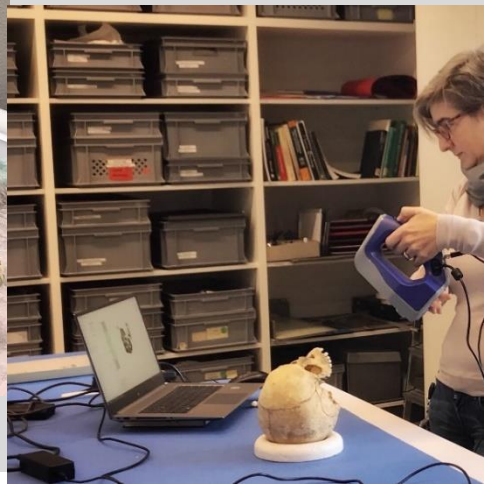
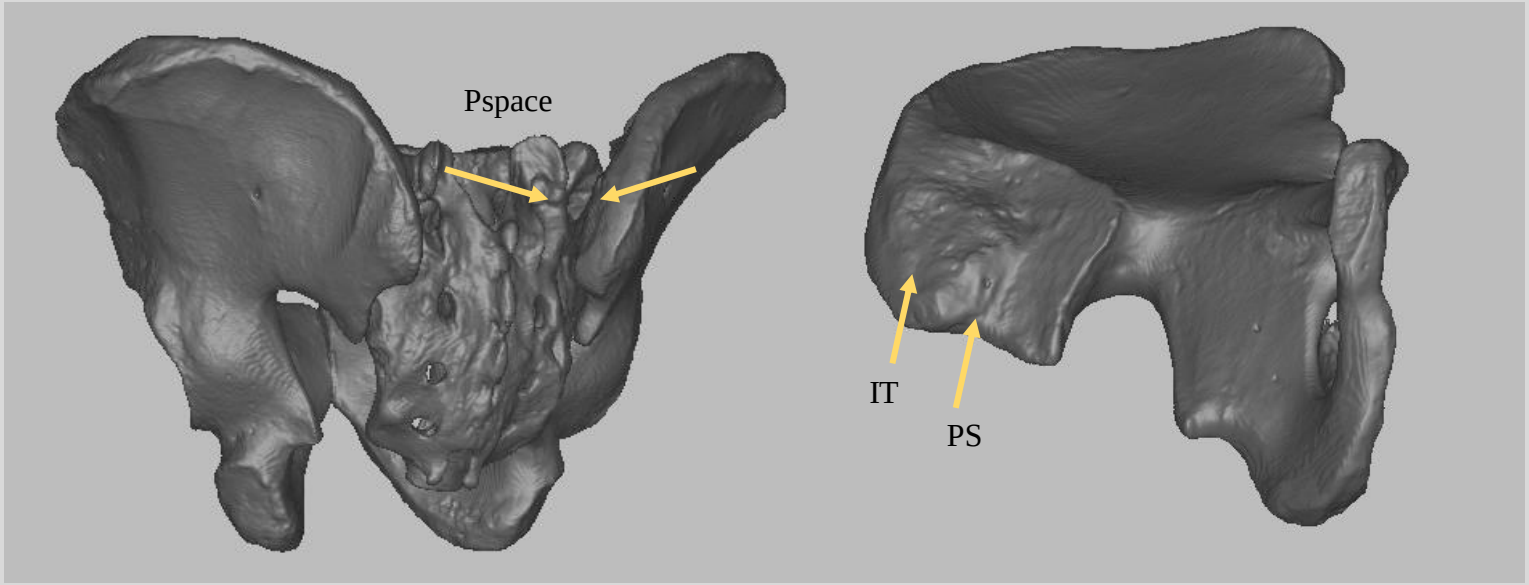
Dry bone (**B**), CT (**C**)

Photos: S. Braun, J. Ryan

Artec 3D surface scans (**A**)



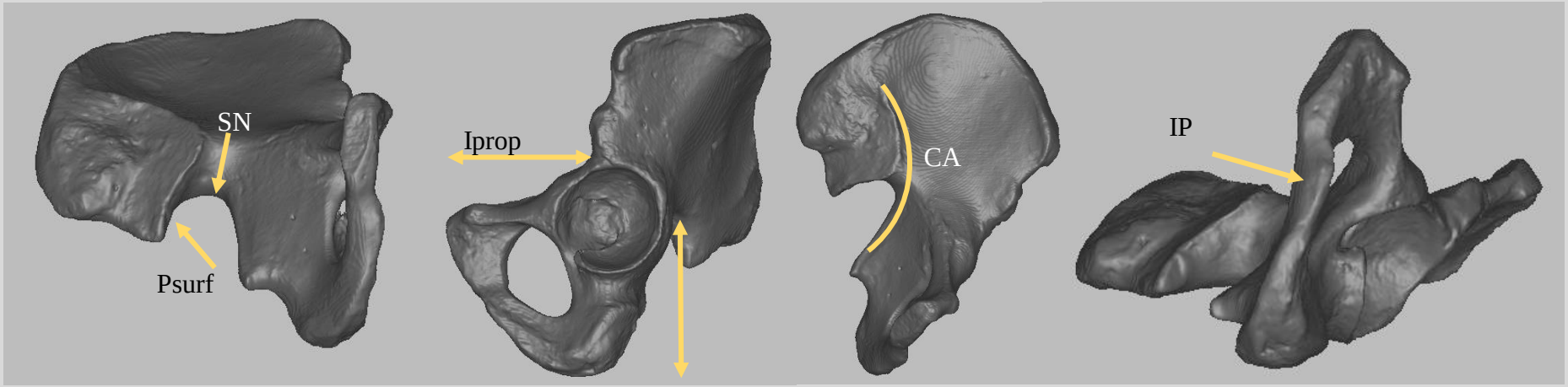
# Methods: Sex estimation protocols *nonmetric*




F = female
M = male

İşcan & Derrick 1984

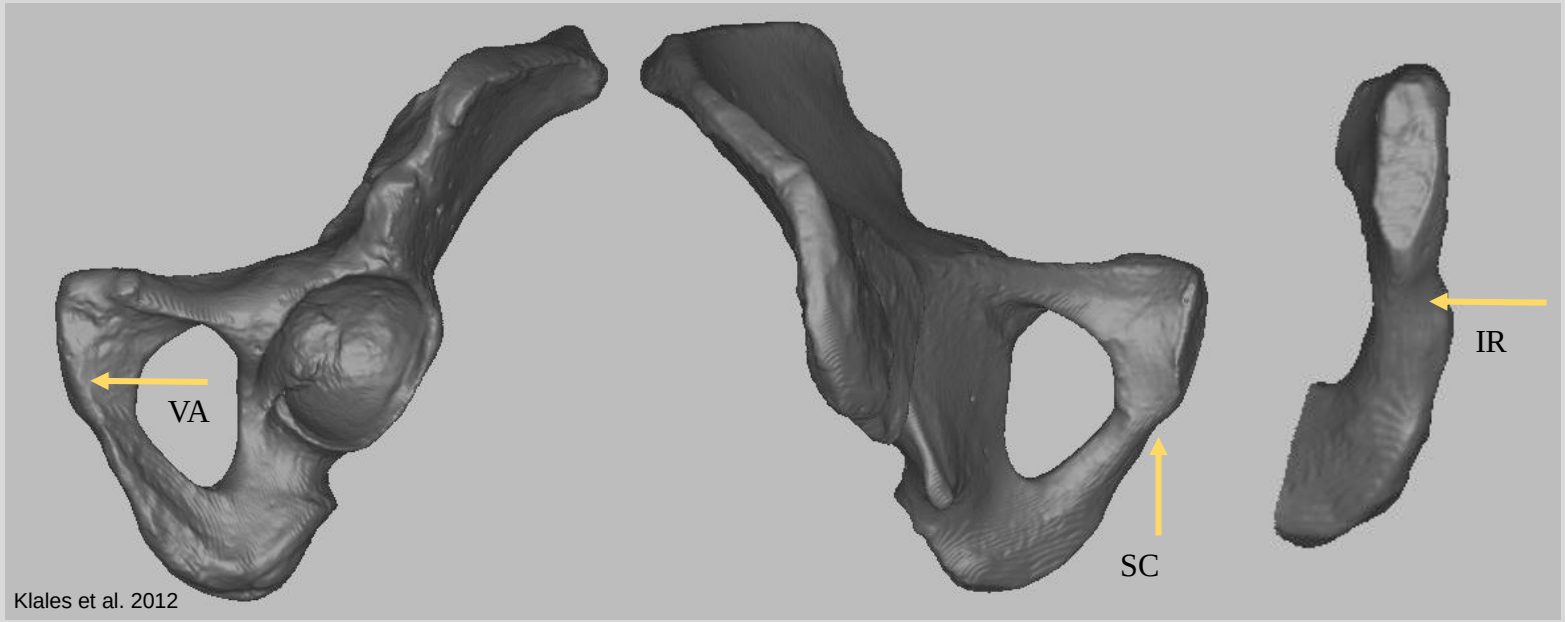
# Methods: Sex estimation protocols
## *nonmetric*




Bruzek 2002

F = female; M = male

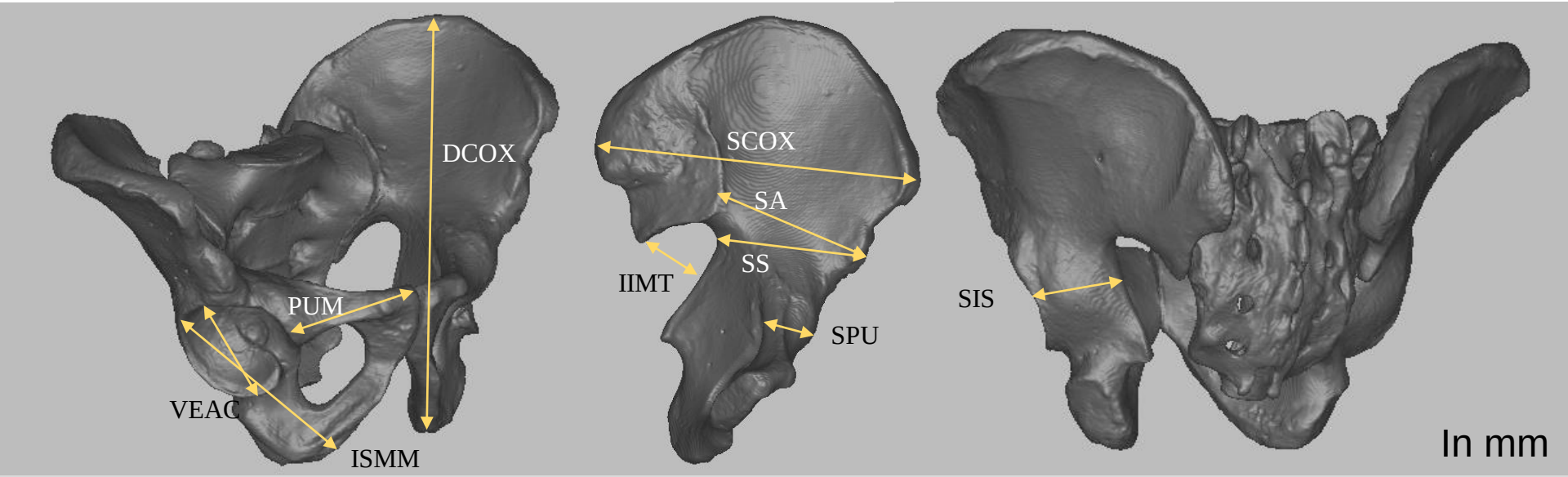
# Methods: Sex estimation protocols
## *nonmetric*




Klales et al. 2012

Scores 1-5

# Methods: Sex estimation protocols *metric*




Bruzek et al. 2017

# Methods: Statistical analyses

- Cohen's kappa (dichotomous) and
- Cohen's weighted kappa (ordinal) (Cohen, 1968)
  - κ -1 to 1 (Landis & Koch, 1977)
  - **κ > 0.6 acceptable agreement**

- Relative technical error of measurement (metric) (Bruzek et al., 2017)
  - **rTEM < 5% acceptable error**

- R version 4.1.4 in RStudio

# Results: Nature of data

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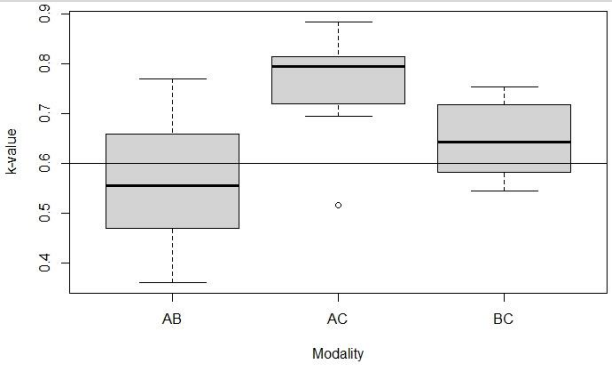
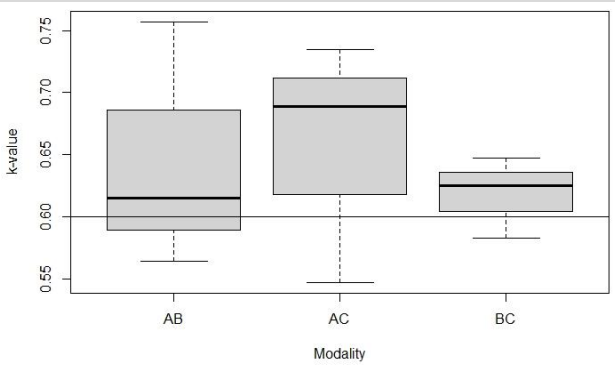
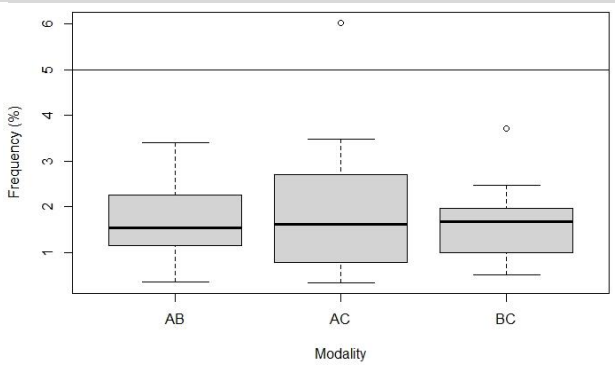
## Dichotomous




## Ordinal




## Metric




Metric data performed best, followed by ordinal and dichotomous data

# Results: Trait analysis

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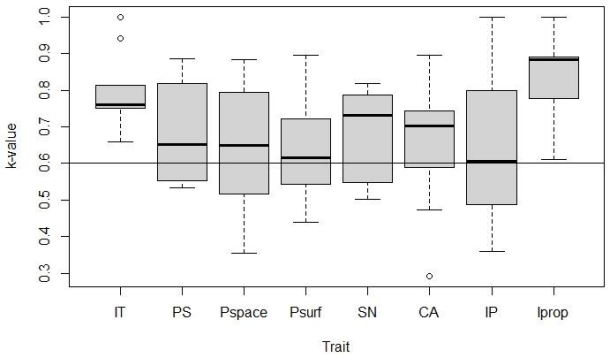
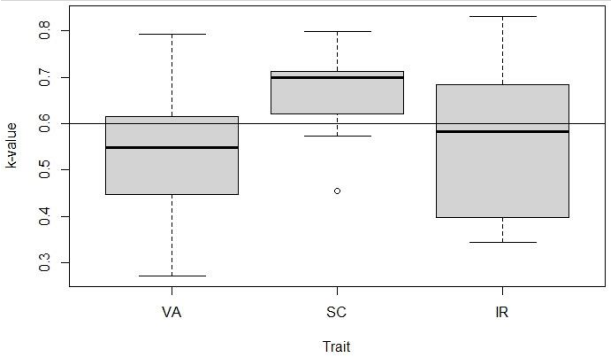
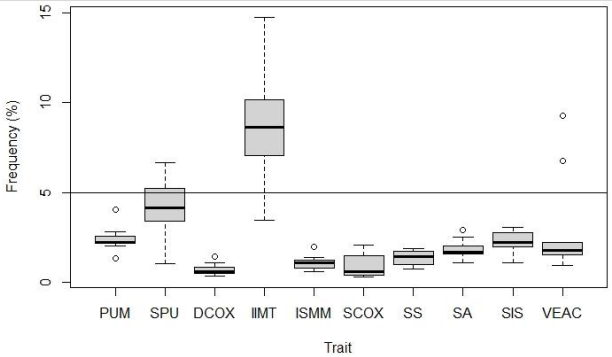
Dichotomous




Ordinal

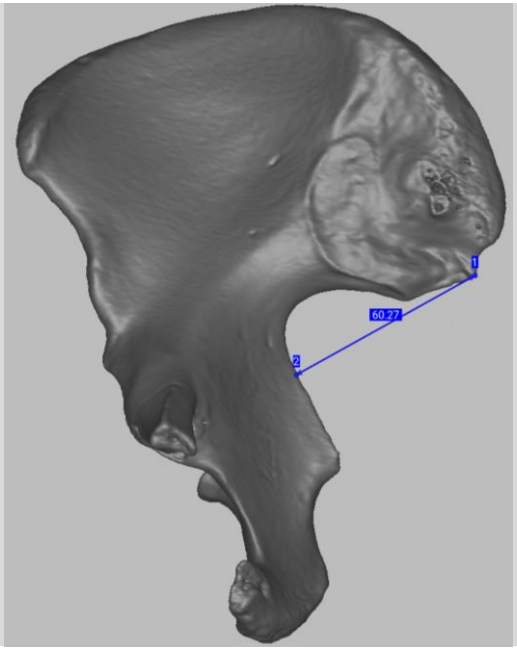


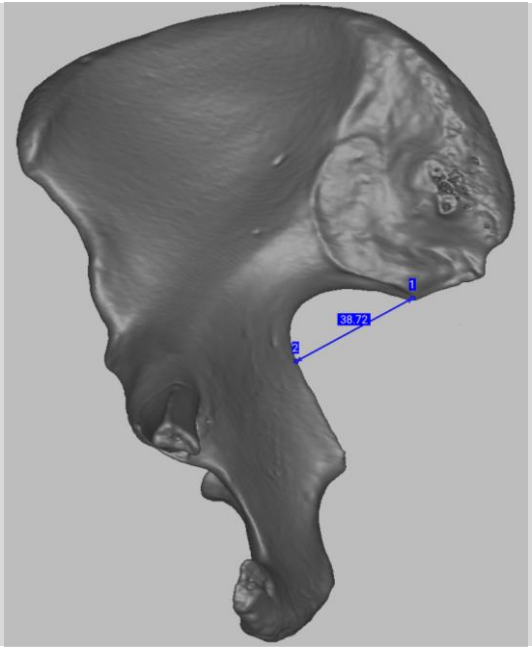

Metric

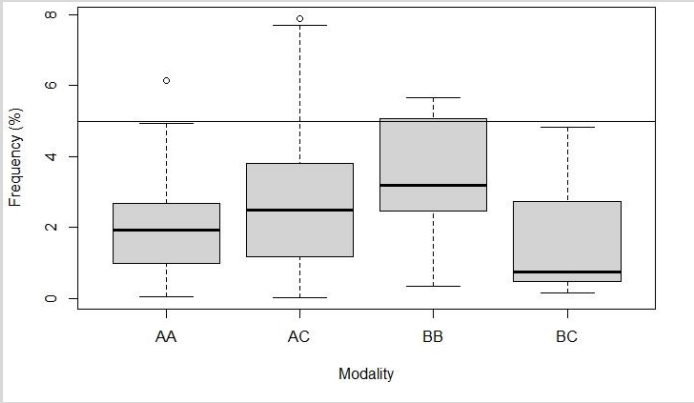



Dichotomous traits performed best, followed by metric and ordinal traits

# Results: Trait revision




rTEM below 5% with revised trait

# Discussion & Conclusion

- Modalities (**A**, **B**, **C**) are interchangeable for most of the analyzed sex estimation traits
- CT (**C**) and surface scans (**A**) yield even better results, both non-tactile
- Metric method (DSP2) best, dichotomous trait data intermediate, ordinal data poorest
- Trait definition more important than modality

# Limitations

- Other virtual modalities and devices (MicroScribe digitizer, micro-XCT, etc.)
- Other skeletal regions should be included, results based on pelvis only
- Observers without previous virtual modality experience

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# Thank you for your attention!

# Any questions?