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

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Introduction:
Identified osteological collections

Green: contemporary (born after 1920)

Purple: non-contemporary (born before 1920)

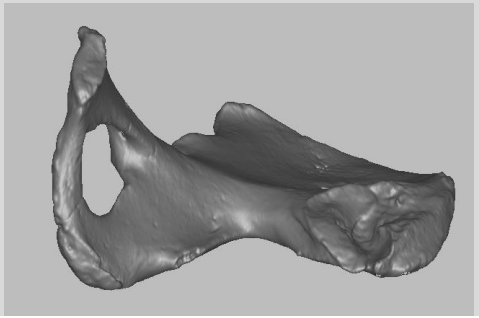
Orange: uncertain temporal status

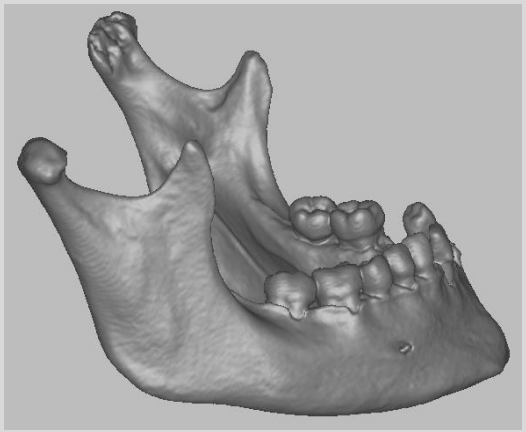
Source: forensicanthropology.eu

Introduction:
Virtual osteological collections

- The New Mexico Decedent Image Database (NMDID, 1972) with 15'000+ individuals, Albuquerque (Edgar & Berry, 2019)
- Subadult Virtual Anthropology Database (SVAD, 2015) with ~5000 individuals, Reno (Stull & Corron, 2022)
- Bakeng se Afrika (BsA, 2019) based, among others, on the Pretoria Bone Collection (PBC) with ~1000 individuals, Pretoria (L'Abbé et al., 2021)

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





Sources: Büren Chilchmatt 5293 (pelvis), Twann St. Petersinsel 3375 (mandible), photos: S. Braun

Introduction: Published research

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)
- …modality comparison with sample sizes <100 (Abegg et al., 2021; Abegg, Hoxha et al. 2023; Chapman et al., 2014; Corron, Marchal, Condemi, Chaumoître, & Adalian, 2016; Colman et al., 2019)
- …interchangeability with narrow anatomical focus (Braun, Ridel, L'Abbé, Theye, & Oettlé, 2022)

Rationale and research question

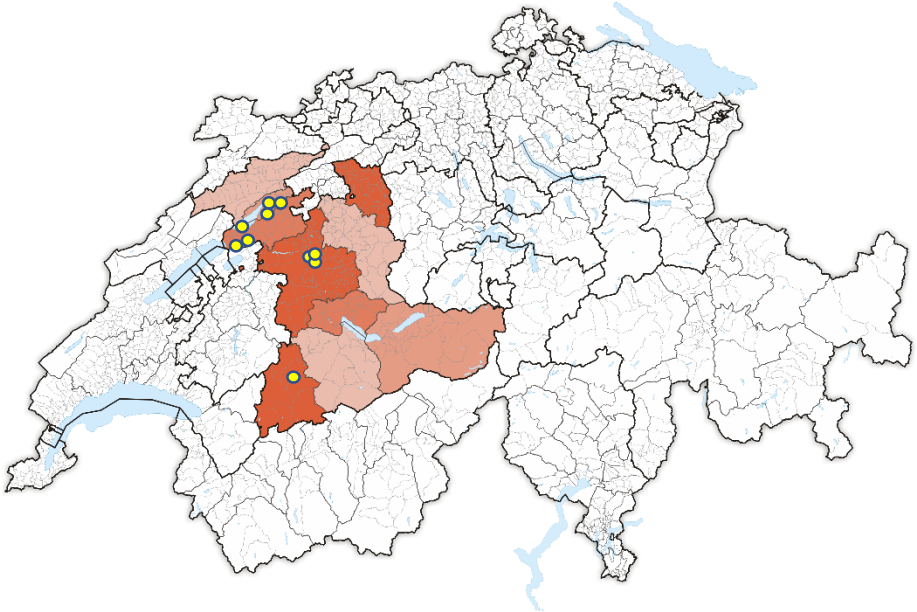
Summarizing rationale:

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

Aim:

- Consistency of pelvic and cranial sex estimation traits on dry bone, CT and 3D surface scans

Materials: 200 pelves and 223 skulls from archaeological sites in Switzerland



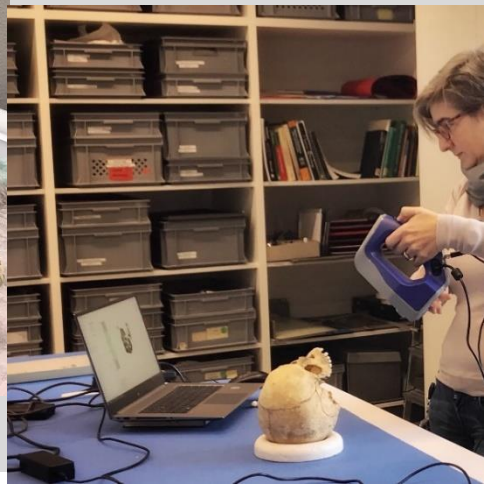
Sites:
Bern franz. Kirche
Bern Grosse Schanze
Biel-Mett Kirche
Büren aA Chilchmatt
Ins Kirchgemeindehaus
Kallnach Bergweg 95
Köniz Kirche
Nidau
Twann St. Petersinsel
Zweisimmen

Materials: Dry bone (gold standard) / CT (n=200/223); 3D surface scans (n=39/50)

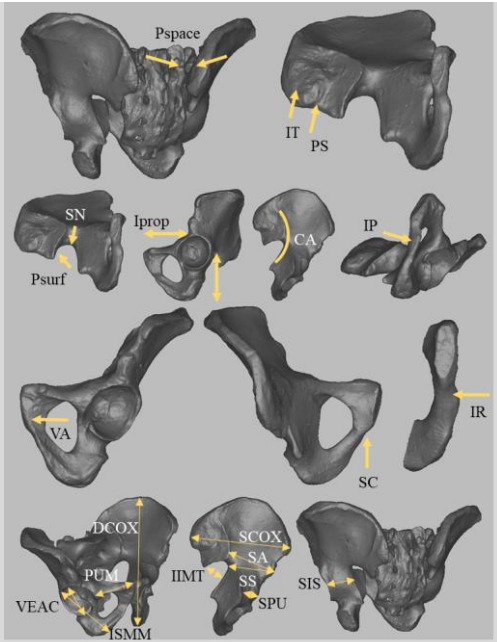
Dry bone (**B**), CT (**C**)

Photos: S Braun, J Ryan

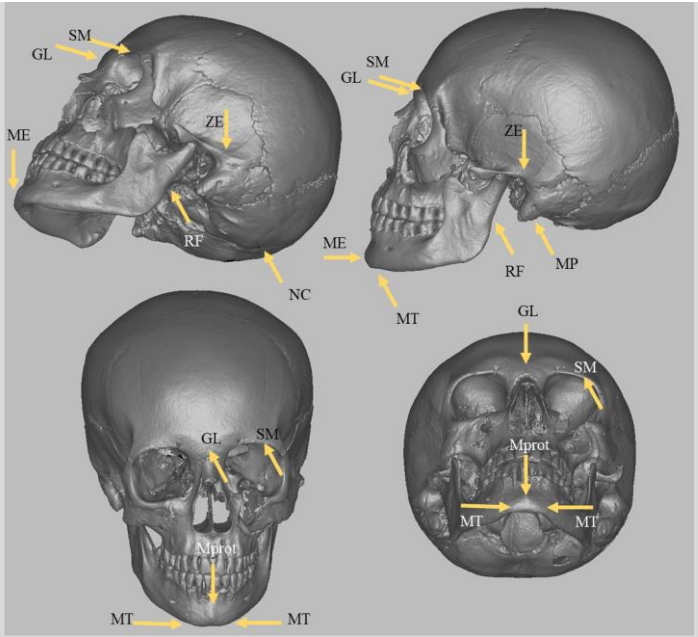
Artec 3D surface scans (**A**)



Methods: Sex estimation protocols



Pelvic:
İşcan & Derrick 1984
Bruzek 2002
Klales et al. 2012
Bruzek et al. 2017

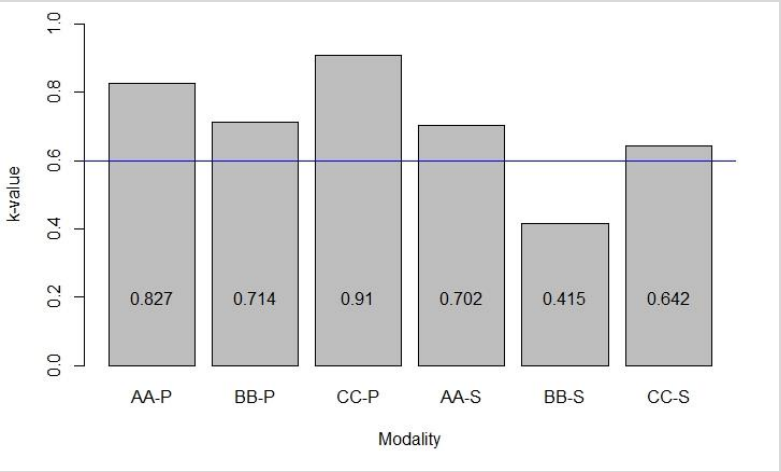


Cranial:
Loth & Henneberg 1996
Walker 2008
Langley et al. 2018

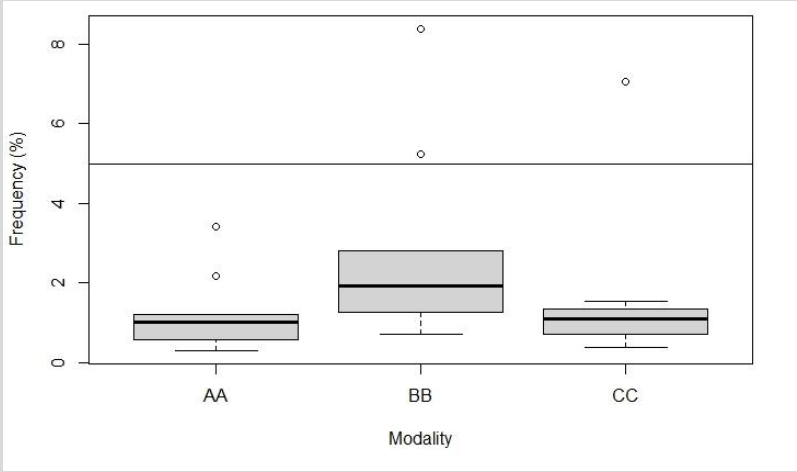
Methods: Statistical analyses

- Cohen's (weighted) kappa (Cohen, 1968)
  - **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: Intraobserver agreement



Legend:
A = 3D surface scans
B = dry bone
C = CT scans
P = pelvis
S = skull



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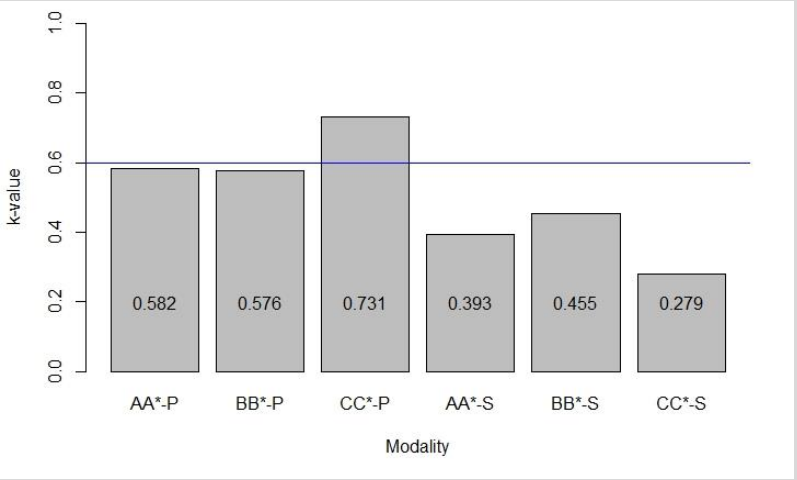

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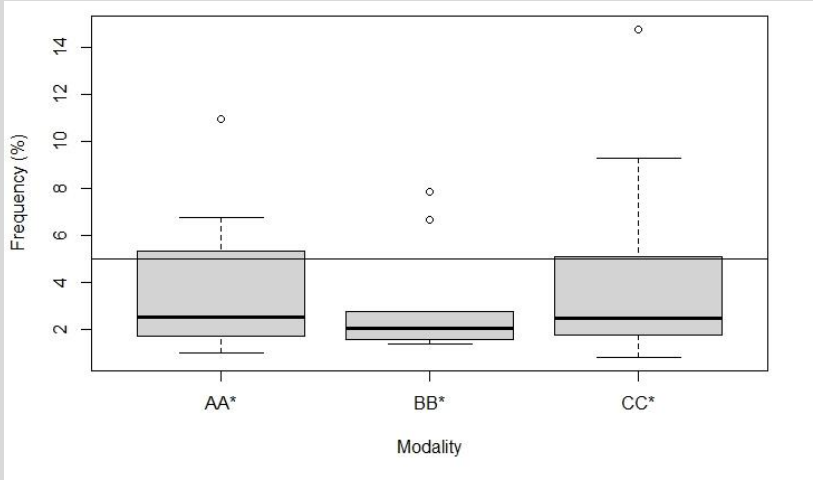
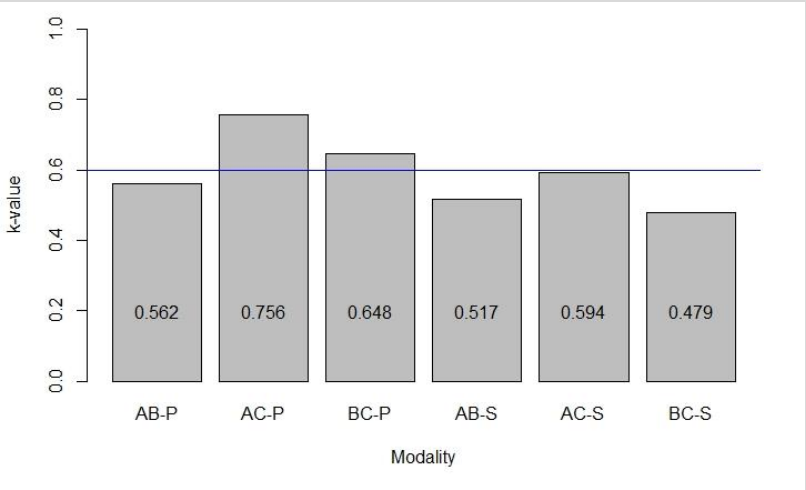


Results: Intermodality agreement



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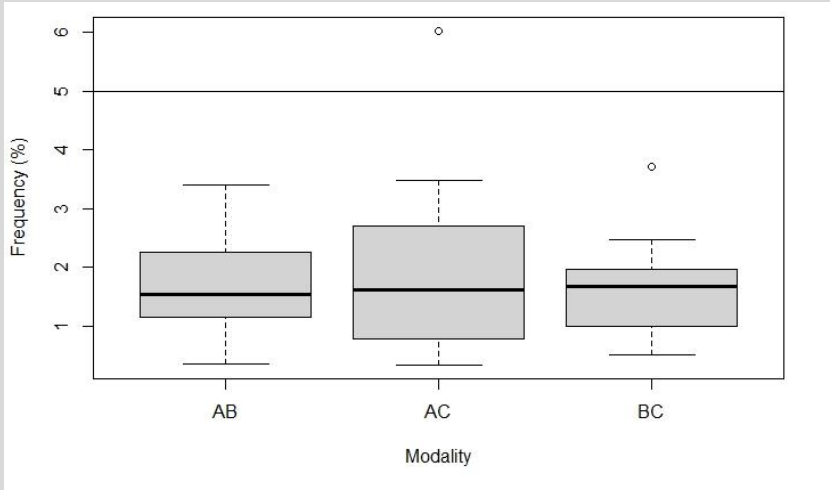

Discussion & Conclusion

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- Metric data more consistent than nonmetric data
- Pelvic sex estimation traits more consistent than cranial traits
- Modalities (**A**, **B**, **C**) are interchangeable for most of the analyzed sex estimation traits
- CT (**C**) and surface scans (**A**) yield better results than the combination with dry bone (**B**)

Limitations

- CT and 3D surface scans only
- Pelvis and skull only
- Observers with previous imaging experience only
- Selection of sex estimation methods

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ORIGINAL ARTICLE

What we see is what we touch? Sex estimation on the pelvis in virtual anthropology

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Thank you for your attention!
Any questions?

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