Portable XRF validation and method to quantify bone lead in vivo

By Dr Aaron Specht, Assistant Professor, School of Health Sciences, Purdue University, USA
Photo from https://www.mpo-mag.com/breaking-news/purdue-researcher-develops-lead-detection-breakthrough-tech/

Pilot work to validate portable XRF:

Over the last few years, principal investigator Specht's lab (see biosketch) made substantial progress in validating a portable XRF machine for quantifying metals in bone *in vivo*.[170-172]
As shown in Figure 7a, conventional KXRF and portable XRF measurements of Pb are highly correlated (R^2=0.95) in four goat bones covered by 3 mm of soft tissue. To further validate the portable XRF against the standard KXRF bone Pb measurement system, 76 human participants were recruited and their bone Pb content measured. This study confirmed that the average detection limit (sensitivity) of the portable XRF system (using 5 min measures) is equivalent to that of the conventional KXRF system (with a 30 min measurement). As shown in Figure 7b, there is a strong correlation of bone Pb measurements between the portable XRF and KXRF systems (more details are in a recent paper[172]).

Conclusion: the portable XRF is sensitive to detect bone Pb, is ideal for the proposed study.

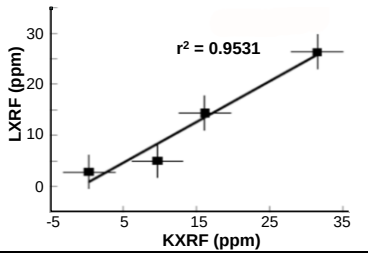


Figure 7a. Portable XRF vs. KXRF for bone Pb content in goat bones covered with 3 mm Lucite.

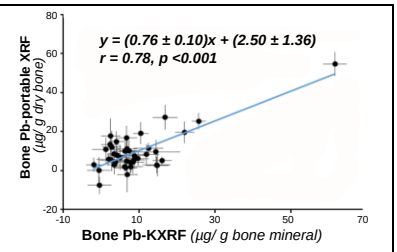
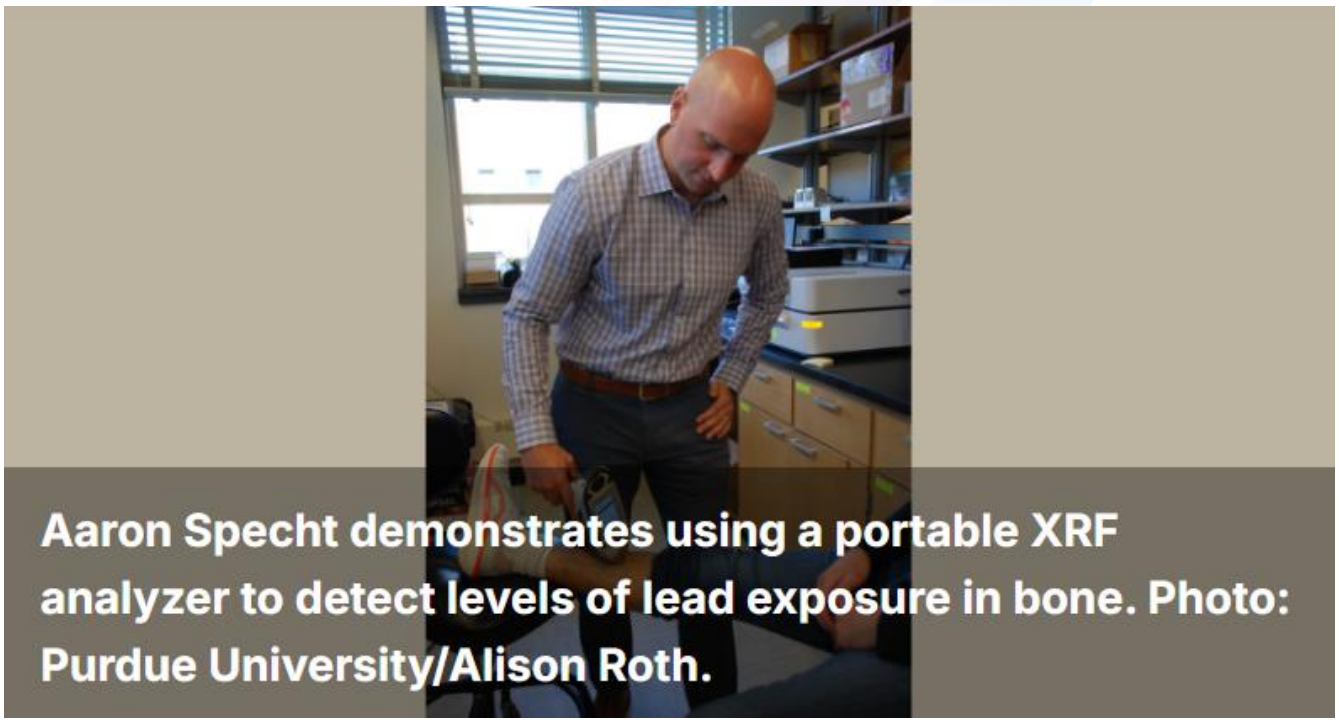


Figure 7b. Correlation of bone Pb measured by the portable XRF and KXRF (uncertainty bars shown).

A portable XRF method developed and validated in Dr. Specht's lab will be used to quantify bone Pb of participants *in vivo*. Details of the device and methodology were published previously,[171, 172, 214, 215] with the basics summarized here. The portable XRF device is a customized instrument manufactured by Thermo-Fisher Scientific (Thermo Niton XL3t GOLDD+, Billerica, MA). The x-ray tube has an energy span up to 50 kV and uses a thermoelectric-cooled silicon drift detector with 25 mm^2 area and 1 mm thickness. The tube was optimized for bone Pb measurement with a voltage of 50 kV, a current of 40 μA, and a silver and Fe combination filter. These settings provide the best sensitivity for bone Pb measurements.[214] In response to irradiation, Pb L x-rays are generated, detected, and used to estimate bone Pb concentration. Before *in vivo* measurements are performed, Pb-doped bone equivalent phantoms will be used to calibrate the system. Calibrations and QA/QC procedures will be performed periodically according to our standard protocols.[170] After collecting the spectra, characteristic Pb peaks will be fitted using a Gaussian function to quantify the net peak and an exponential function to quantify background. Least-squares algorithms will be used to extract the net counts of the Pb peaks. During

the *in vivo* measurement, participants will sit comfortably on a chair with his/her right leg placed on another chair. If it is not possible for the participant to place their leg on another chair, a measurement with the footrest on the floor can be performed. The pants of the participant will be pulled up, and a 50% alcohol swipe will be used to clean the skin above the tibia bone. A spot above the center of the tibia bone or toenail will be marked and a 5-minute measurement will be taken on the spot. The spectrum will be collected, stored, and analyzed later.



Aaron Specht demonstrates using a portable XRF analyzer to detect levels of lead exposure in bone. Photo: Purdue University/Alison Roth.

As the device makes use of low energy x-rays, there is a small and safe amount of radiation involved in the procedure. The whole-body effective dose from a 3-minute bone measurement is ~3.4 μSv.[216] We will take a 5-minute bone measurement for participants in this project and the effective dose will be <10 μSv. This dose is negligible compared to an AP chest x-ray of ~100 μSv and an annual background dose to the US population of ~3600 μSv.