Effect of Osteoporosis on Latent Bone Models to Estimate Plutonium Activity Concentration in Human Skeleton

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he recently developed latent bone modeling (LBM) approach applies principal components regression (PCR) to estimate plutonium activity concentration in the human skeleton from measurements of a limited set of bone samples. The analytical bone dataset contains plutonium concentrations for 90 individual bone samples from 19 whole-body donors to the United States Transuranium and Uranium Registries. These samples were divided into 6 groups by bone type: skull (11 samples), long bone end (15), long bone shaft (14), cortical bone (29), trabecular bone (18) and other bones (3). Five of 19 studied individuals were diagnosed with osteoporosis. This study evaluated the effect of osteoporosis on LBMs for estimation of skeleton plutonium activity concentrations. For each bone group (except for the mixed bones), the PCR was performed with and without the 5 osteoporotic cases. The PCR models were fitted for 2 to 6 bones randomly sampled from each group, and 10,000 simulations were run for a given number of sampled bones. Regression residual standard error (RSE) for the PCR simulation was used to evaluate model performance. Excluding 5 osteoporotic cases from analyses significantly improved the PCR models in terms of relative RSE reduction compared to those obtained from the analyses of all 19 cases. The average RSEs for 2 to 6 bones were reduced by 60.2±0.4% for trabecular bone, 56.1±5.1% for long bone end, 53.2±1.8% for cortical bone, 48.4±2.4% for long bone shaft, and 22.4±1.9% for skull. Therefore, separate models should be used for non-osteoporotic and osteoporotic individuals when possible. The RSEs of PCR models for non-osteoporotic individuals were 1.9±0.4 for long bone end (epiphysis), 2.5±0.1 for trabecular bone, 2.8±0.1 for cortical bone, 2.8±0.2 for long bone shaft (diaphysis), and 4.2±0.1 for skull. The non-osteoporotic PCR model, accounting for all bone types, was developed by selecting 3 'best' bones with the lowest RSE in each of 5 bone groups. When the analytical dataset for 14 non-osteoporotic cases was reduced from 90 to 18 bones (15 'best' bones plus 3 others), a further improvement of the PCR model fit was achieved with RSE of 1.4±0.4. Due to the limited number of cases, the model to estimate plutonium concentration for osteoporotic individuals was not proposed.

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