EFFECT OF BODY SIZE ON THE QUANTIFICATION OF BONE MINERAL DENSITY FROM QCT IMAGES USING A NOVEL ANTROPHOMORPHIC HIP PHANTOM

Serena Bonaretti[1], Isra Saeed[1], Andrew J. Burghardt[1], Lifeng Yu[2], Micheal Bruesewitz[2], Sundeep Khosla[2], Thomas F. Lang[1]

[1]Musculoskeletal Quantitative Imaging Research Group, Department of Radiology & Biomedical Imaging, University of California, San Francisco; San Francisco, CA USA
[2]Division of Endocrinology, Metabolism and Nutrition, Department of Internal Medicine, College of Medicine, Mayo Clinic; Rochester, MN USA

Beam hardening associated with variations in body size and skeletal density affect the measurements of bone mineral density (BMD) from quantitative computed tomography (QCT) images. In this study we aimed at evaluating the effect of body size on BMD quantification using a novel anthropomorphic hip phantom, evaluating four CT scanners at two centers.

The hip phantom consists of anthropomorphic hips and pelvis of known amount of hydroxyapatite-equivalent material. The two hips have different neck compositions. One hip contains a *calibration* neck made of three concentric cylinders, with densities spanning typical values of integral, cortical and trabecular compartments. The other hip contains a *test* neck made of an outer ellipsoid for cortical bone, and an inner cylinder for trabecular bone. Two *test* necks were created, one representing the BMD of a young subject, and the other simulating the BMD of an old subject. Each *test* neck was associated to correspondent pelvis-shaped elements, i.e. with higher density for the young subject and with lower density for the old subject. Hips and pelvis are positioned in a tank filled with water, and which represents the dimensions of a small adult female. Two different girdles can be placed concentrically over the tank, creating a maximum body size that corresponds to a 95% adult female (Figure 1).

We scanned the phantom in four different scanners, two GE VCT 64 systems, one Siemens Biograph and one Siemens Definition. For each machine, the phantom was scanned in 6 different configurations, i.e. combining young/old neck with no/small/large girdle. Each acquisition was performed with a calibration standard underneath the phantom, used to calibrate the acquired image to units of hydroxyapatite concentration. We measured the cortical BMD of the test neck, and the linear slope relating the nominal BMD of the concentric rings of the calibration neck to the measured values.

For each scanner, we found that the BMD measures in the test femoral neck systematically decreased with increasing phantom size, and that the slope measured from the calibration neck systematically increased with increasing phantom size.

In conclusion, our phantom simulation shed light on the quantitative effects of beam hardening due to increasing body size. Methodological studies in this area will be important for using QCT to understand the effect of obesity and weight loss on skeletal health.

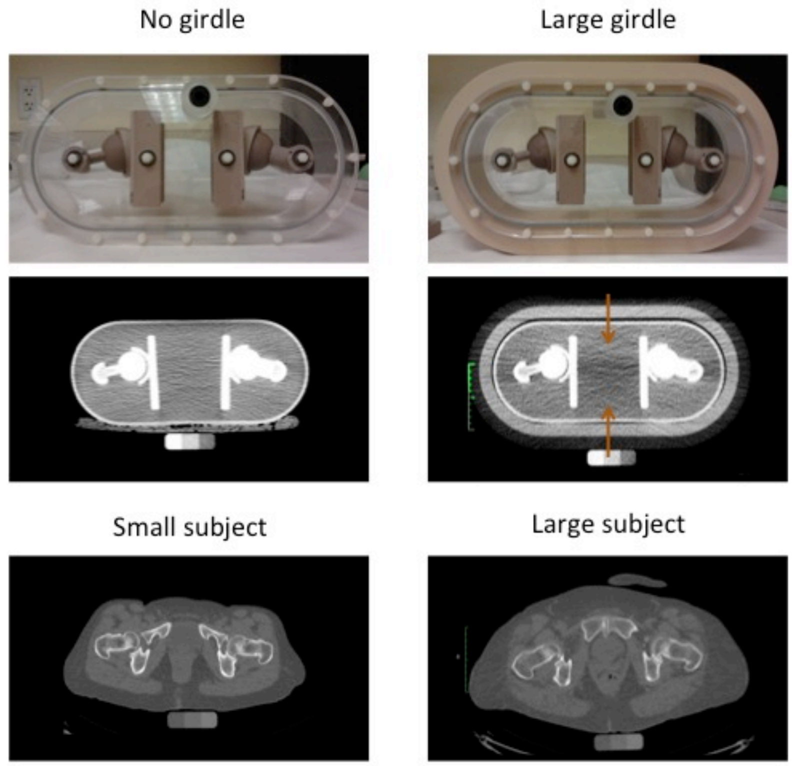

Figure 1. Beam hardening effects on phantom and subject images with different body size. The first row shows the phantom without and with large ring, and the second row shows the corresponding CT images acquired for the two phantom configurations. The final row shows images of larger and smaller subjects. In the CT images of large girdle phantom and fat subject, the beam hardening effect is visible between the two hips.