Body composition analysis using the Quantum GX3 microCT.

Highlights

- The Quantum™ GX3 microCT enables rapid, non-invasive body composition analysis
- Quantify visceral (VAT) and subcutaneous (SAT) fat volumes
- Ideal for longitudinal metabolic studies, this low-dose imaging system allows for non-invasive, label-free measurements to be taken in live animals across the course of a disease

Introduction

Obesity and metabolic disorders are major contributors to cardiovascular disease, type 2 diabetes, and other chronic conditions and there is a significant need for reliable preclinical tools to investigate disease mechanisms and evaluate therapeutic interventions. Preclinical animal models are widely used to study metabolic disease progression and treatment response. In these studies, accurate and non-invasive assessment of body composition, particularly the quantification of fat and lean mass, is essential for characterizing metabolic phenotypes and monitoring longitudinal changes.

Several techniques are used to assess body composition in animal models; however, many provide only indirect measurements or limited spatial information. Micro computed tomography (microCT) offers a powerful alternative by providing high-resolution, three-dimensional imaging that allows direct visualization and quantification of adipose and lean tissues based on X-ray attenuation differences. Importantly, microCT imaging can be performed without the need for exogenous contrast agents and enables repeated imaging of the same animals over time.

In this technical brief, we demonstrate the use of the Quantum GX3 microCT instrument for quantitative whole-body composition analysis in a diet-induced obesity (DIO) mouse model. The study highlights the system's ability to differentiate lean and obese phenotypes and to quantify adipose tissue distribution through non-invasive *in vivo* imaging.

Animal model & experimental design

Male mice from a C57BL/6J diet-induced obesity (DIO) strain (Strain #: 380050, RRID: IMSR_JAX:380050) were used to evaluate the body composition analysis capabilities of the Quantum GX3. Animals were maintained on a high-fat diet (Research Diets D12492) for 26 weeks to induce obesity. Age-matched C57BL/6J mice fed a standard control diet served as lean comparators. At the time of imaging, lean control mice weighed approximately 28 g, while diet-induced obesity (DIO) mice weighed approximately 58.8 g, reflecting a substantial increase in adiposity associated with long-term high-fat diet exposure.

MicroCT imaging and acquisition parameters

Whole-body scans were performed using the Quantum GX3 microCT system. Animals were anesthetized and positioned in a prone orientation to ensure consistent positioning and reproducibility across scans. This acquisition protocol enabled clear differentiation between adipose and lean tissues while maintaining relatively low radiation exposure, making it suitable for longitudinal metabolic studies that require repeated imaging.

Scan parameters:

Field of View (FOV): 86 mm
Acquisition time: 4 minutes
Voltage: 50 kV
Current: 200 µA
Filter: 1.0 mm Aluminum

Image processing and segmentation

Following image reconstruction, body composition analysis was performed using Analyze 15 (AnalyzeDirect®, Inc.). Adipose tissue was identified from the CT data using X-ray attenuation values together with anatomical information to distinguish fat from surrounding tissues. Because adipose tissue can have similar attenuation values to other soft tissues and air-filled structures, thresholding alone is often insufficient for accurate segmentation. Therefore, a combination of thresholding, anatomical region definition, and morphological image processing was used to isolate adipose tissue.

The body was first segmented from the background, followed by segmentation of the ventral (thoracic and abdominopelvic) cavity using semi-automatic thresholding and manual refinement where required. Morphological operations, including erosion and hole filling, were applied to improve the segmentation mask and remove small artifacts. Defining the ventral cavity enabled separation of adipose tissue located inside the abdominal cavity from adipose tissue beneath the skin.

Adipose tissue was then classified into two compartments:

- **Visceral adipose tissue (VAT):** Fat located within the abdominal cavity surrounding the internal organs.
- **Subcutaneous adipose tissue (SAT):** Fat located beneath the skin and outside the abdominal cavity.

Once the anatomical regions were established, VAT and SAT were segmented and quantified independently to calculate their respective tissue volumes. Three-dimensional renderings and segmentation overlays were generated to visualize adipose tissue distribution throughout the animal. For a detailed step-by-step description of the segmentation workflow, including recommended thresholds, morphological operations, and user guidance, please refer to the Analyze 15 User's Guide.

Results

MicroCT imaging clearly differentiated lean and obese phenotypes, revealing substantial increases in adipose tissue in the diet-induced obese mouse compared with the control animal. Whole-body CT scans and three-dimensional reconstructions showed widespread fat accumulation in the obese mouse, while the lean mouse exhibited minimal adipose tissue (Figure 1).

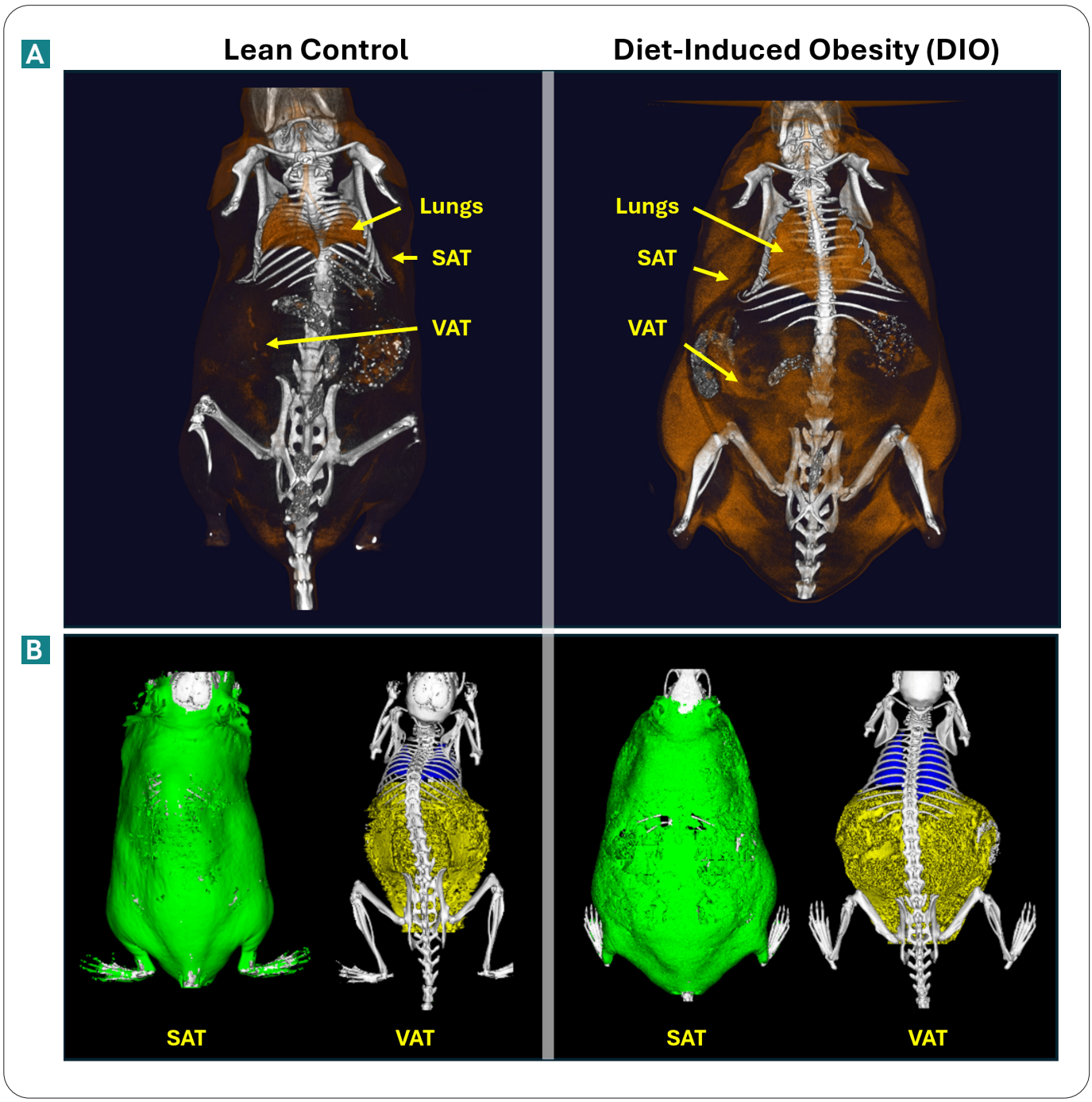

Figure 1: Representative whole-body microCT scans and adipose tissue segmentation of lean control and diet-induced obesity (DIO) mice. A) Three-dimensional view of skeletal and fat volumes from the Quantum Viewer software. B) Reconstructions and compartmental segmentations generated in Analyze 15. The DIO mouse shows substantially increased visceral adipose tissue (VAT) and subcutaneous adipose tissue (SAT) compared with the lean control mouse. Adipose and anatomical structures are color-coded as follows: SAT in green, VAT in yellow, lung tissue in blue, and bone in white.

Quantitative segmentation analysis using Analyze 15 enabled volumetric measurement of adipose tissue compartments (Table 1). The control mouse showed markedly lower adipose volumes, with a visceral adipose tissue (VAT) volume of 2.2 cm^3 and a subcutaneous adipose tissue (SAT) volume of 5.7 cm^3. In contrast, the obese mouse exhibited substantially higher adipose tissue volumes, with a VAT volume of 11.1 cm^3 and a SAT volume of 23.3 cm^3.

These results demonstrate a pronounced expansion of both visceral and subcutaneous fat deposits in the obese animal, consistent with its higher body weight and diet-induced metabolic phenotype. Representative CT images and segmented overlays further illustrate the anatomical distribution of adipose tissue, with extensive visceral fat surrounding abdominal organs and increased subcutaneous fat along the body wall in the DIO mouse.

Together, these findings confirm that the Quantum GX3 microCT system enables rapid, non-invasive visualization and quantification of adipose tissue, allowing clear differentiation between lean and obese animals using a single imaging session.

Table 1: Volumetric measurement of adipose tissue using the Analyze 15 software

	Visceral adipose tissue (VAT)	Subcutaneous adipose tissue (SAT)
Lean control	2.2 cm^3	5.7 cm^3
Diet-induced obesity	11.1 cm^3	23.3 cm^3

Discussion

The results presented here demonstrate that the Quantum GX3 microCT system provides a robust and quantitative approach for assessing body composition in preclinical obesity models. Unlike planar imaging methods or indirect techniques, microCT offers true three-dimensional volumetric measurement of adipose tissue and allows visualization of fat distribution across the entire body. The ability to distinguish and quantify specific adipose deposits, such as visceral and subcutaneous fat, is particularly valuable in metabolic research. Visceral adiposity is strongly associated with metabolic dysfunction and cardiometabolic risk, making accurate measurement of this compartment important for studying disease progression and therapeutic response.

Because the Quantum GX3 microCT imaging instrument is non-invasive, low-dose, and requires no contrast agents, the same animals can easily be scanned repeatedly throughout a study without concern for severe toxicity or adverse side-effects from the imaging process. This capability supports longitudinal experimental designs, can reduce the number of animals required for the study (following the 3Rs ethical framework for conducting more humane animal experiments), and improves statistical power when evaluating metabolic changes or treatment effects.

Conclusion

The Quantum GX3 microCT system enables high-resolution, non-invasive, whole-body imaging for quantitative body composition analysis in preclinical models. In this study, microCT imaging successfully distinguished lean and diet-induced obese mice and provided precise volumetric measurements of visceral and subcutaneous adipose tissue. These capabilities make the Quantum GX3 system an important tool for obesity research, metabolic phenotyping, and evaluation of therapeutic interventions, particularly in studies requiring longitudinal monitoring of body composition changes.