Genetic obesity disorders:
Quantitating visceral fat as a predictor of cardiometabolic risk

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OBJECTIVES

- Develop a method to quantitate total visceral and total subcutaneous fat mass
- Determine the absolute amount and proportion accounted for by each layer

BACKGROUND

Body Composition

The human body can be modeled as a three compartment system: bone mass, fat mass and lean body mass (muscle, heart, liver and other organs). We know that an increase in a person's body fat is often associated with increased risk for severe diseases, but the *distribution* of body fat also affects one's risk level.

Fat may be classified into two categories: the subcutaneous and the visceral layer. Visceral fat breakdown leads to the release of low-density lipoproteins (LDL) and triglycerides into the bloodstream. Thus, the amount of visceral fat correlates strongly with serious diseases, namely hypertension, diabetes and coronary heart disease.

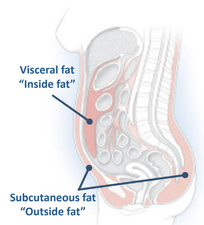


Figure 1: The distribution and accumulation of subcutaneous and visceral adipose tissue (Gather Health 2007).

Methods for measuring body composition

Many different techniques are used to measure body composition, in particular body fat percentage. However, these techniques are limited since they do not reliably distinguish visceral from subcutaneous fat. Whole-body MRI captures data on both layers, which must first be separated with computational methods.

METHODS

Whole-body MRI scan

↓ T1-weighted MRI scan in the "Superman" position

Adipose Tissue Isolation

↓ Isolate the adipose tissue

Adipose Tissue Layer Isolation

↓ Differentiate between subcutaneous and visceral fat

PixCount Analysis

Determine the proportion of each layer via pixel quantitation

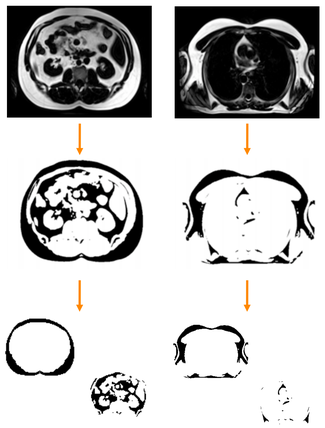
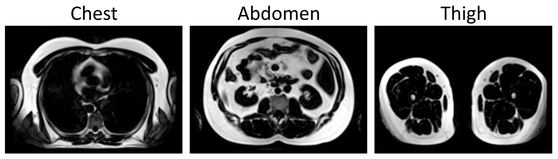


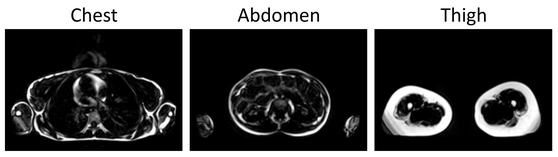
Figure 2: Images from each step of the complete procedure for the isolation of the subcutaneous and visceral layers from a T1-weighted axial MRI image.

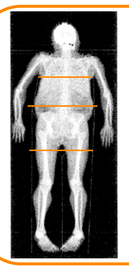
STUDY SUBJECTS

A012, Male
Normal control

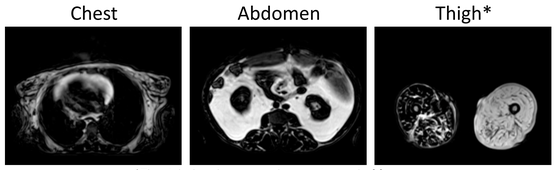


A058, Female
Lipodystrophy





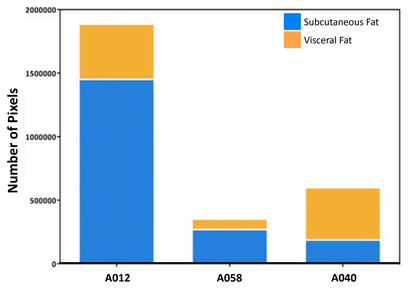
A040, Female
Acquired partial lipodystrophy



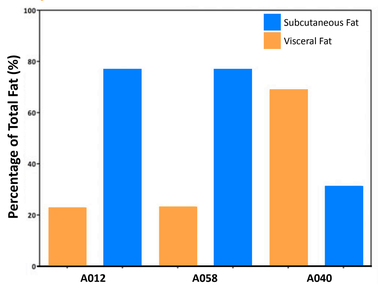
*The right leg shows muscle mass instead of fat mass

RESULTS

Total Fat Mass based on Number of Pixels



Proportion of Subcutaneous and Visceral Fat



Total Fat Mass

- A012, male normal control, is shown to have the greatest amount of total fat mass while both females have significantly lower levels of total fat.

Fat Distribution

- Men have a greater proportion of their total fat as visceral fat than do women. A058, female with lipodystrophy, has the same proportion of visceral fat as the male control which is different from the norm for a female.
- A040 has a significant decrease in her subcutaneous adipose tissue, but appears to retain normal amounts of visceral fat.

DISCUSSION & CONCLUSION

- Fat distribution varies between individuals
- Visceral fat percentage cannot be predicted from the total body fat mass among individuals with genetic obesity disorders
- Pixel quantitation of MRI images provides a potential means to segregate fat mass into two compartments

FUTURE DIRECTIONS & APPLICATIONS

Future Directions

- Use of multiple coronal slices, instead of axial slices, may provide the same amount of data with less processing time

Applications

- Genotype-phenotype correlation

  Identify novel determinants of visceral fat accumulation and the partitioning of fat into the subcutaneous and visceral depots.

- Rare genetic obesity disorders

  Improve understanding of how individuals with rare genetic obesity disorders, such as Prader-Willi syndrome, are affected by visceral adiposity.

Figure 3: An example of a T1-weighted whole body coronal slice image

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Figure 1: http://media-files.gather.com/images/d444/d147/d744/d224/d96/f3/full.jpg