Quantification of fat in a rodent model of obesity

David H. Johnson[1], Chris Flask[2], Dinah Wan[3], Paul Ernsberger[3], David L. Wilson[1,2]

[1]Dept. of Biomedical Engineering, Case Western Reserve University
[2]Dept. of Radiology , University Hospitals of Cleveland
[3]Dept. of Nutrition, Case Western Reserve University

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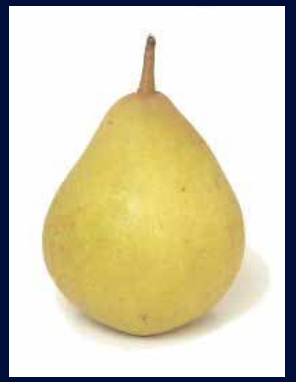
Outline

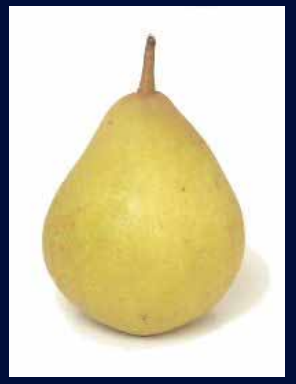
- Metabolic Syndrome X
  - The overlapping diseases
  - Spontaneously hypertensive rat
- MRI acquisition
  - Image processing
  - Semi-automatic segmentation
- Obesity phenotyping
  - Volume of fat
  - Percent lipid
- Discussion

Shapes of Obesity



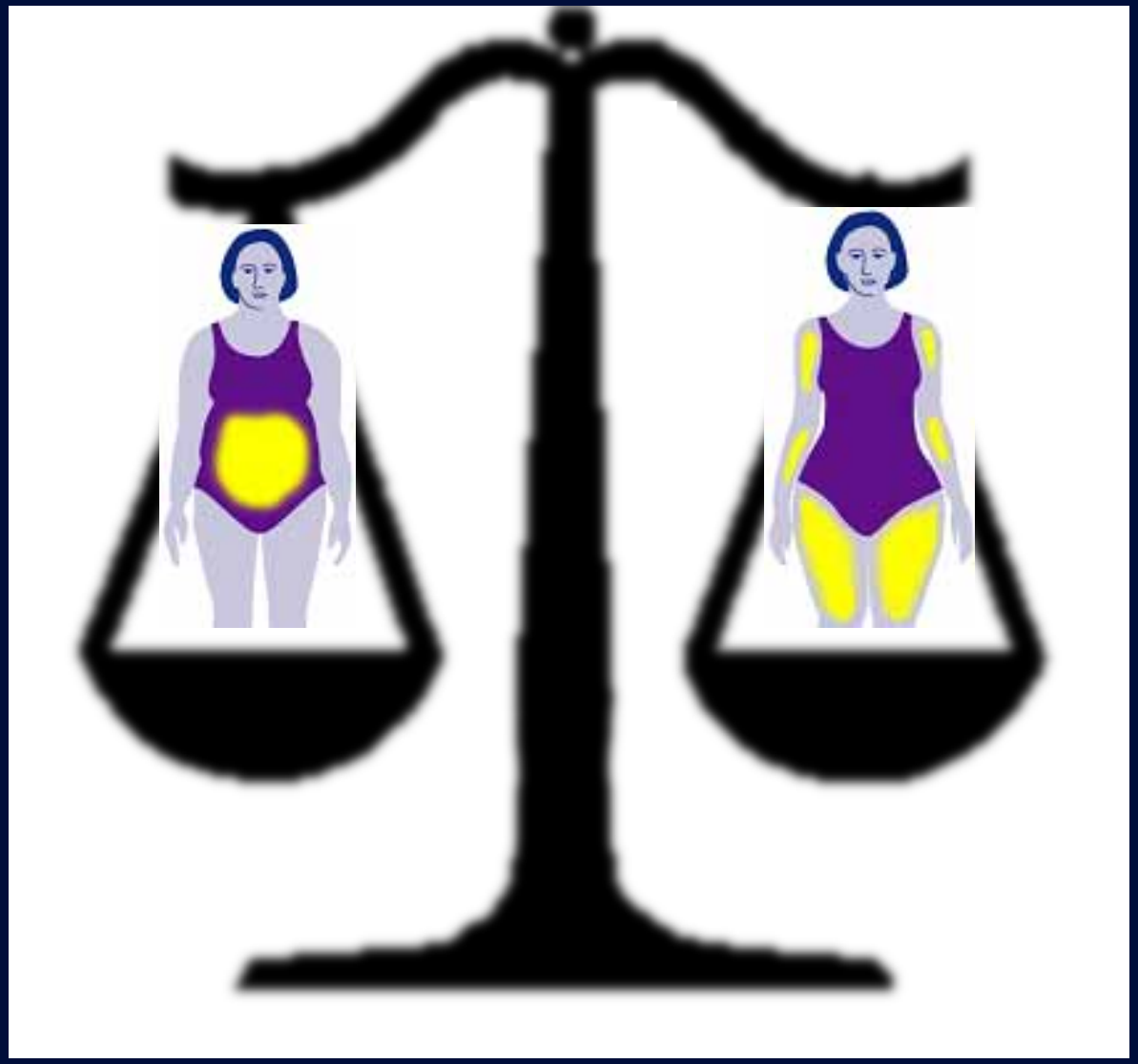
Obesity Phenotypes and Health

Visceral fat



Subcutaneous and intramuscular fat

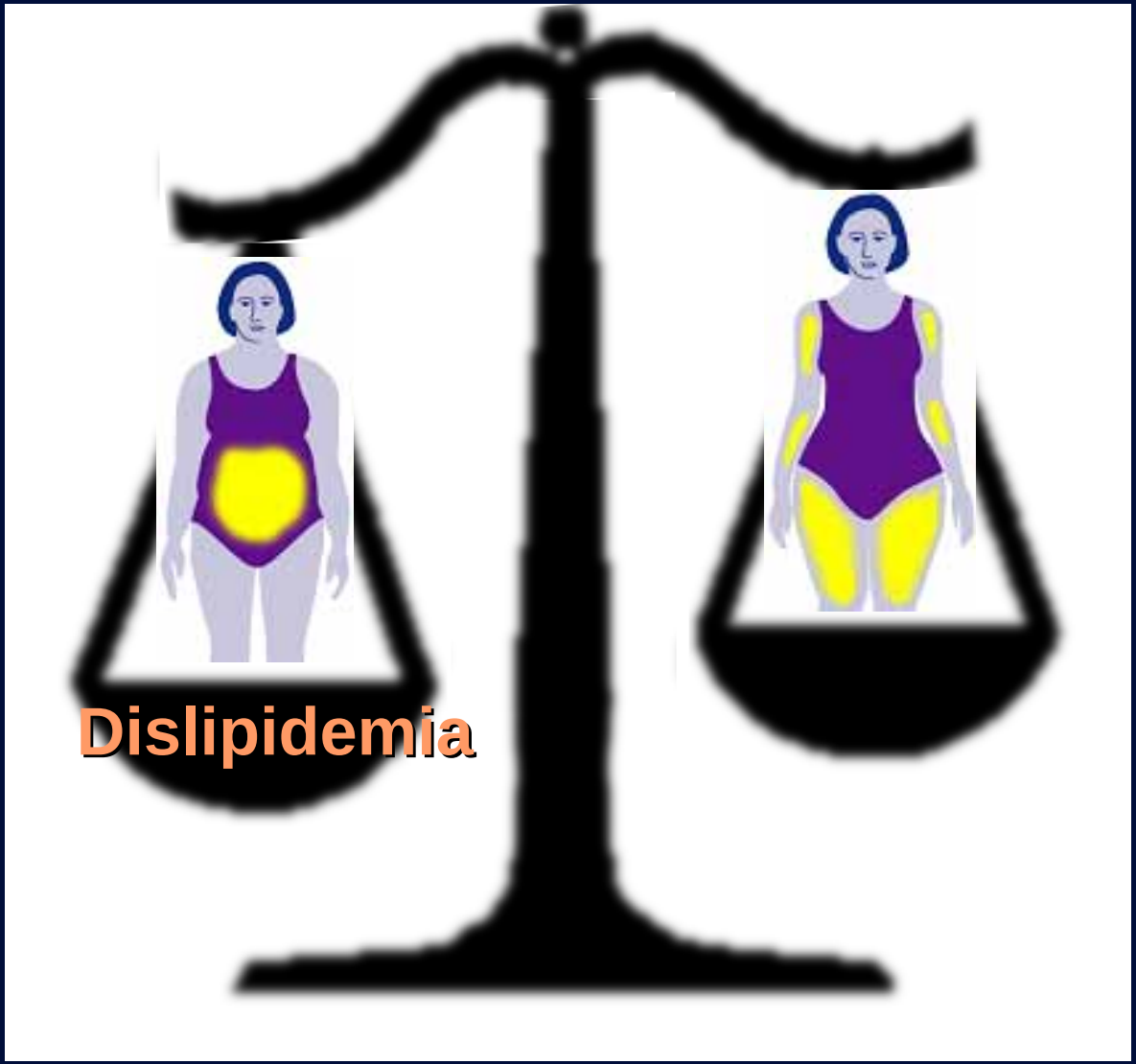
Development of Syndrome X



Visceral fat

Subcutaneous and intramuscular fat

Obesity Phenotypes and Health



Visceral fat

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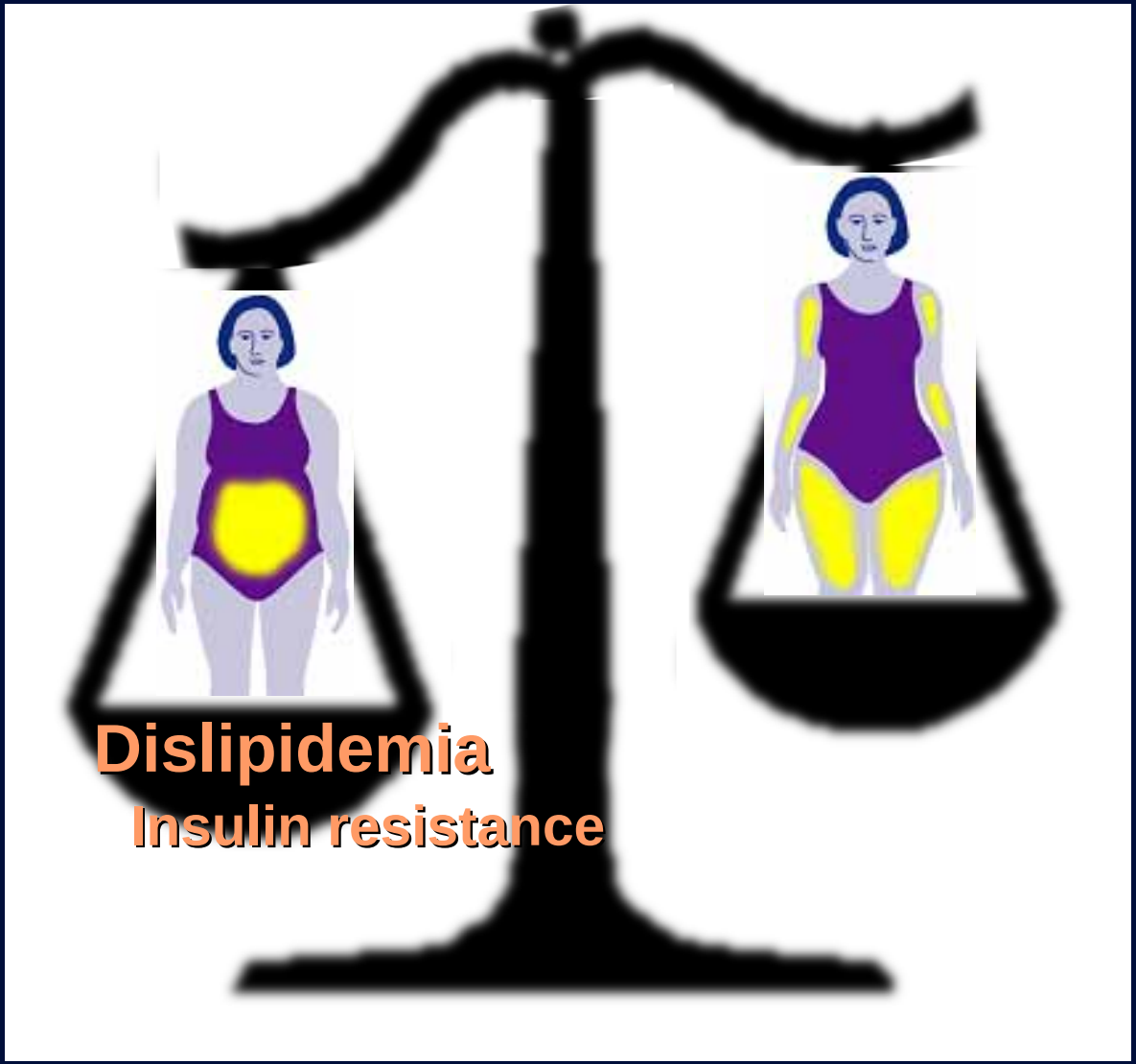
Obesity Phenotypes and Health



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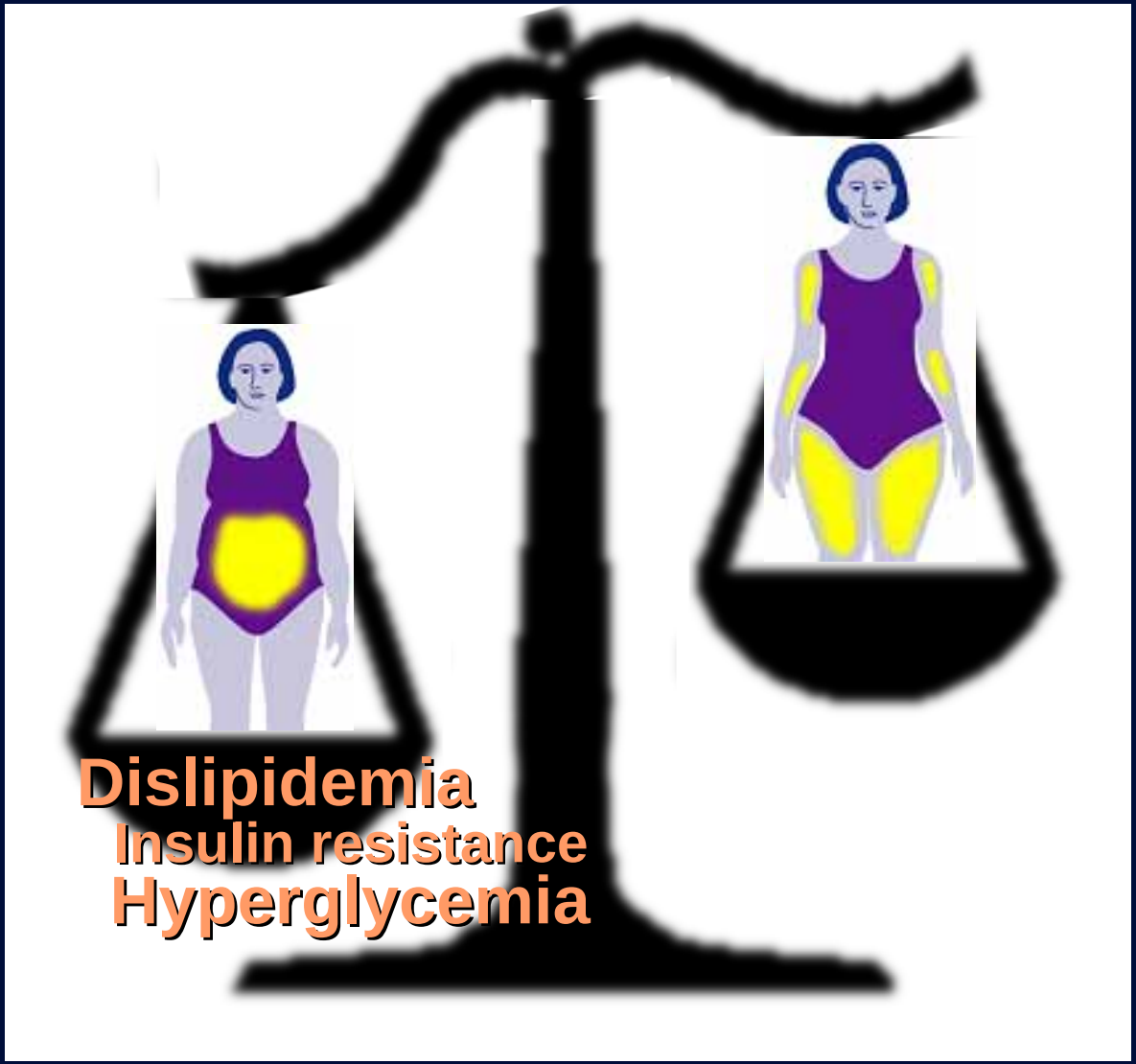

Visceral fat

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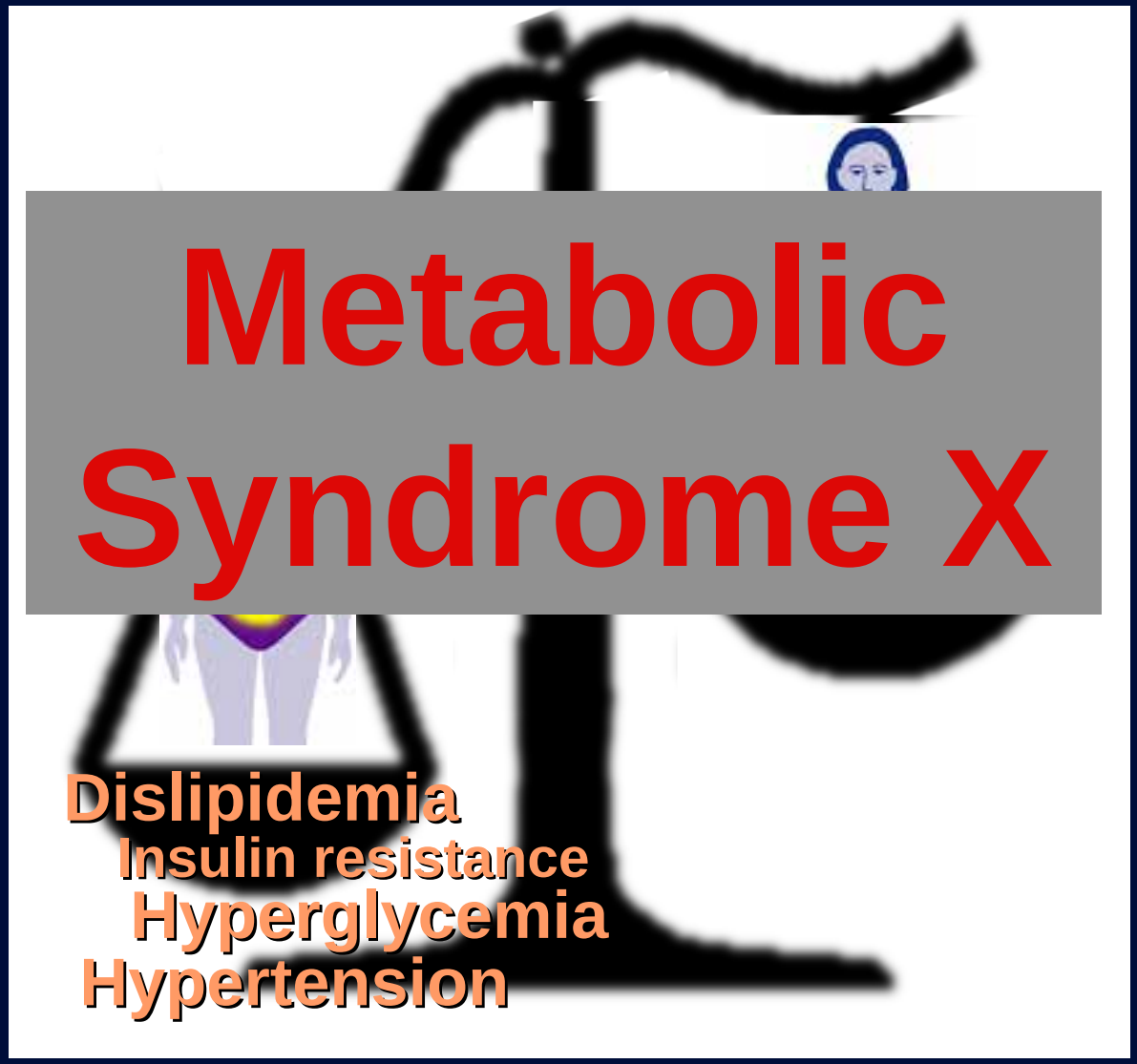
Obesity Phenotypes and Health



Visceral fat

Subcutaneous and intramuscular fat

Rodent model of Metabolic Syndrome X

SHR
294.5g

DSHR
427.5g

Insulin resistance
Hypertension
Dislipidemia
Hyperglycemia

SHROB
529.5g

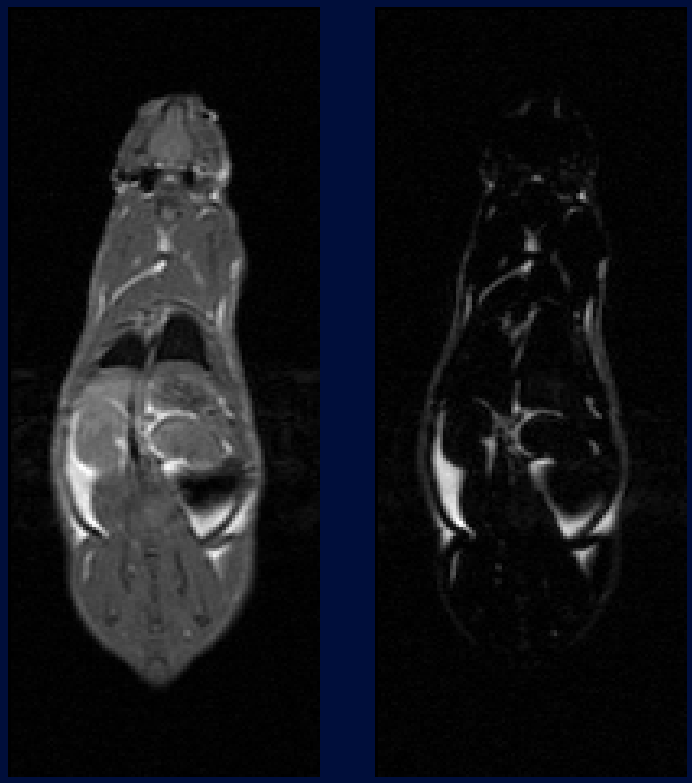
- Spontaneously Hypertensive Rat (SHR/Kol)
- Dietary obese variation (DSHR) -- SHR becomes obese on a cream and sugar dietary supplement
- Obese Spontaneously Hypertensive Rat (SHROB/Kol)

MR Imaging

- **T1-weighted images show a strong separation between lipids (fat) and water (muscle)**

- **Chemical shift selective (CHESS) pulses suppress the water signal**

MRI of SHR



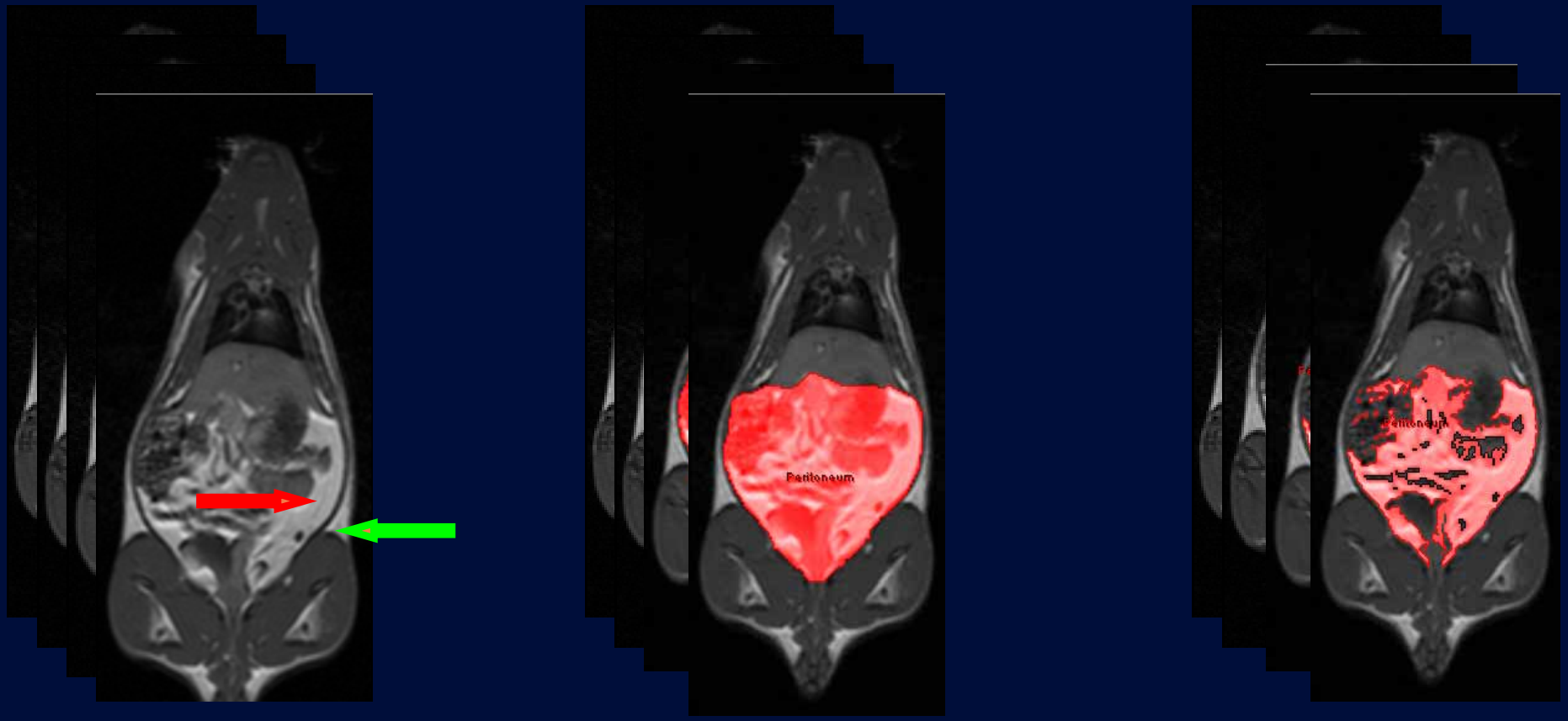
T1W

Fat + H_2O

CHESS

Fat only

Semi-automatic segmentation



Measurement of visceral fat in the abdomen by tracing the abdominal wall (peritoneum) and then applying a threshold.

Coil Sensitivity Inhomogeneity

- **Receive coil inhomogeneity in this image confounds analysis**

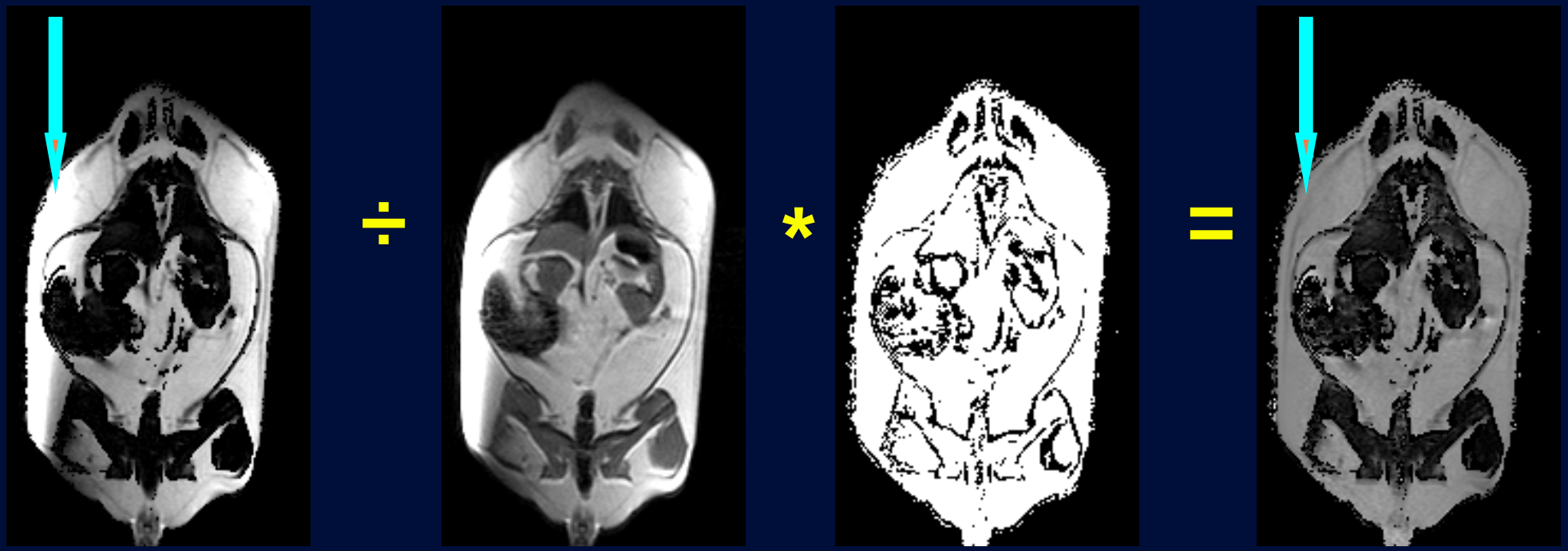
T1W

CHESS

- **The pixel values are not meaningful unless this is corrected.**

Percent Lipid Ratio Image

- Divide the two images
- Apply a mask



Fat only

Fat+Water

% Lipid

CHESS

T1W

Mask

Ratio Image

Derivation of Percent Lipid

T1W image

$$\rho_1 = \Lambda\ \rho_{0,\,fat}\left(1 - e^{-\frac{T_R}{T_1,\,fat}}\right) + \Lambda\ \rho_{0,water}\left(1 - e^{-\frac{T_R}{T_1,water}}\right)$$

CHESS (fat only) image

$$\rho_2 = \Lambda\ \rho_{0,\,fat}\left(1 - e^{-\frac{T_R}{T_1,\,fat}}\right)$$

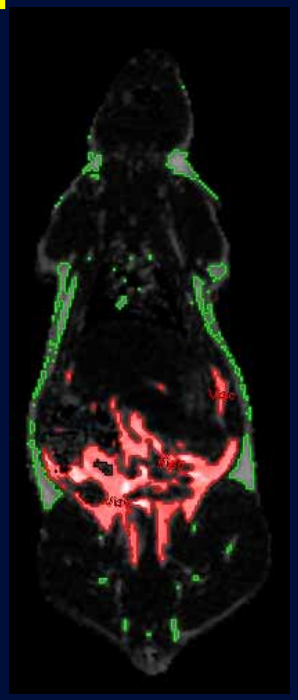
Ratio image

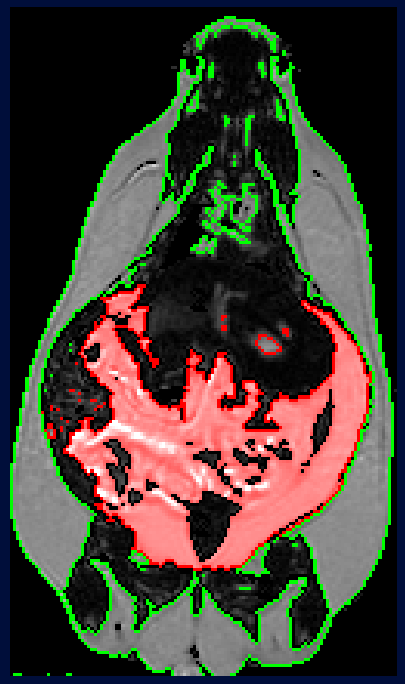
$$\alpha = \frac{1 - e^{-\frac{T_R}{T_1,\,fat}}}{1 - e^{-\frac{T_R}{T_1,water}}} \approx 1$$

$$\mathrm{R} = \frac{\rho_{0,\,fat}}{\rho_{0,water} + \rho_{0,\,fat}} = \frac{\rho_2}{\rho_2 + \alpha\left(\rho_1 - \rho_2\right)} \approx \frac{\rho_2}{\rho_1}$$

SHR/SHROB Phenotypes

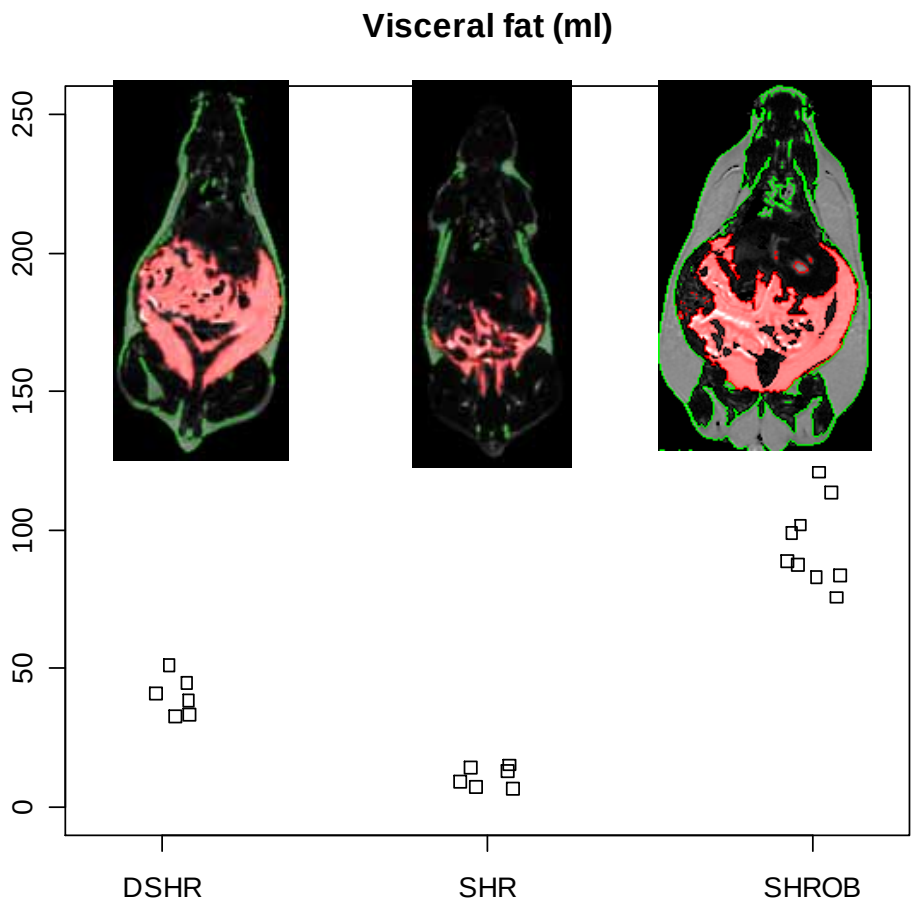
Apples and pears -- different amounts of fat in different places

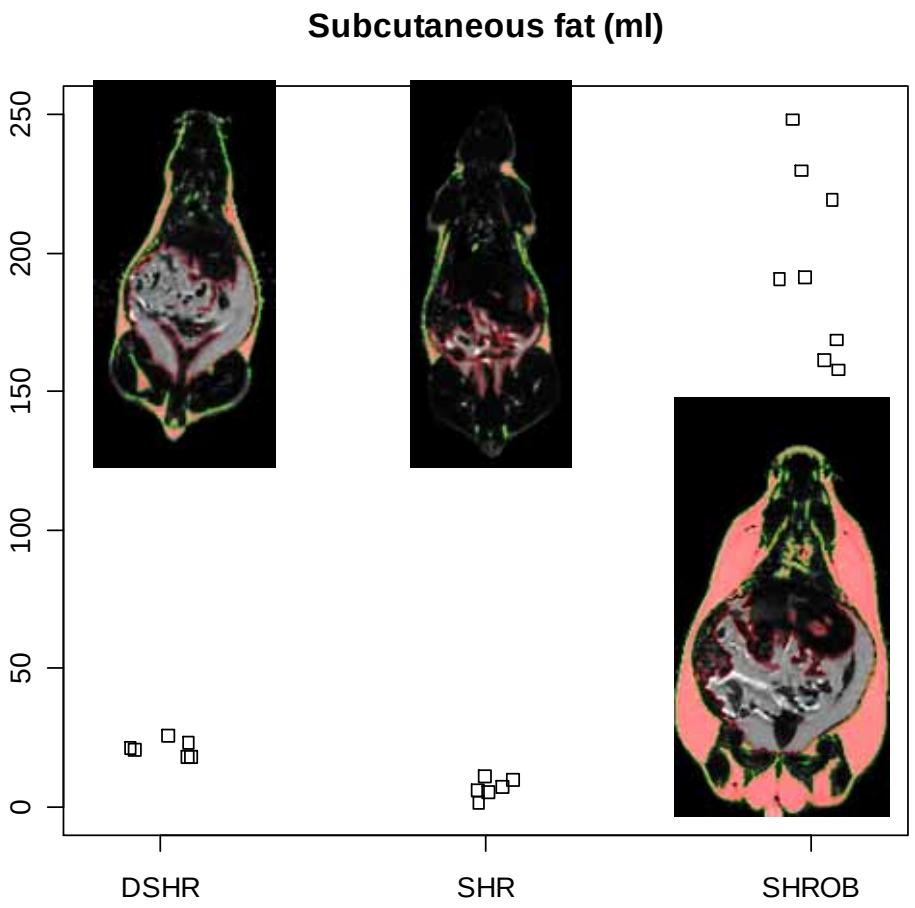




	SHR	DSHR	SHROB
Visceral fat	15 ml	51 ml	84 ml
Subcutaneous fat	11 ml	26 ml	166 ml

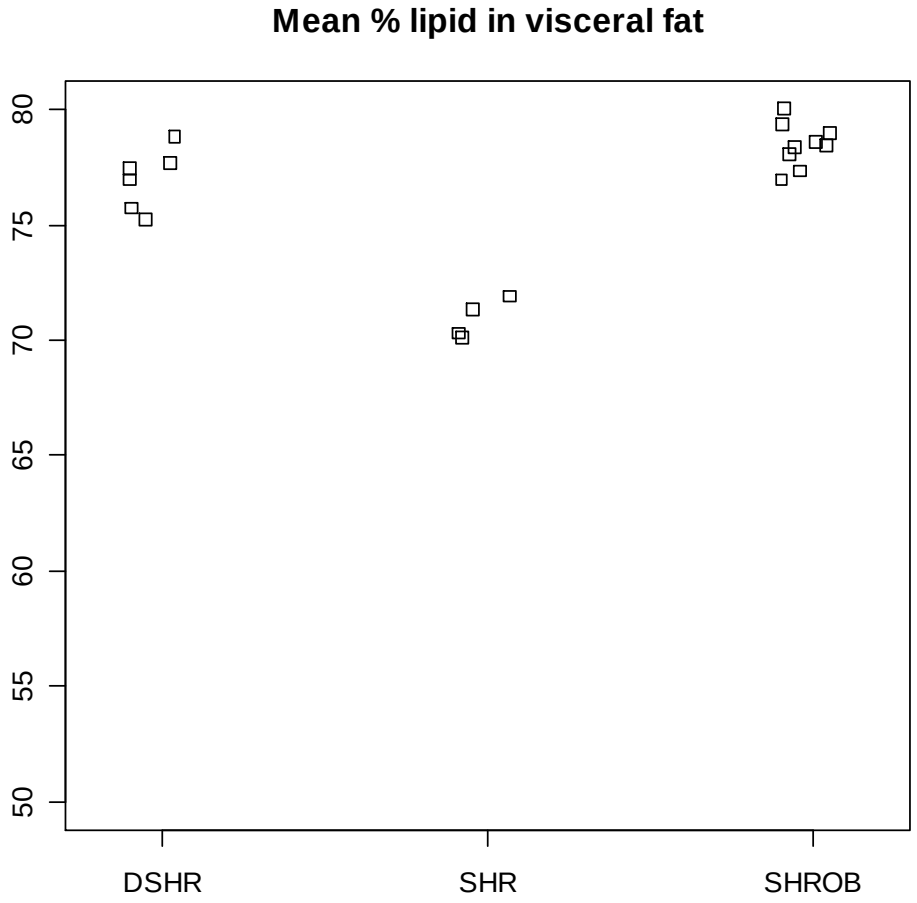
Volume fat as a phenotypes

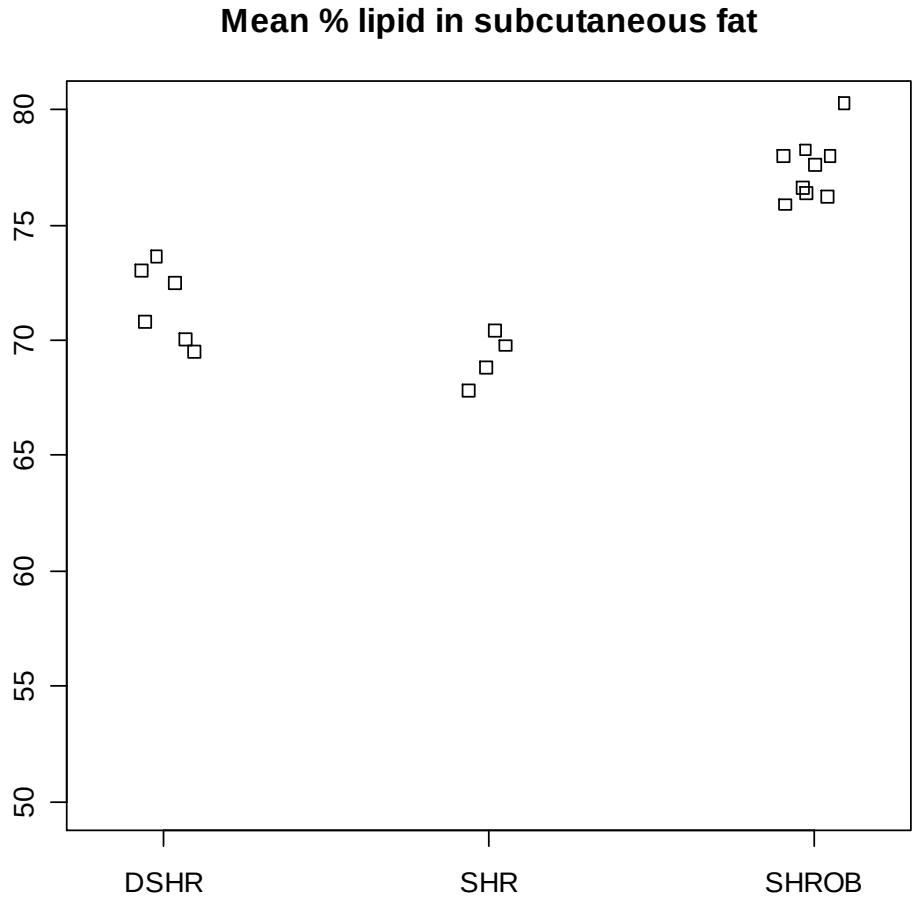




6 lean (SHR)
6 dietary obese (DSHR)
9 genetically obese (SHROB)

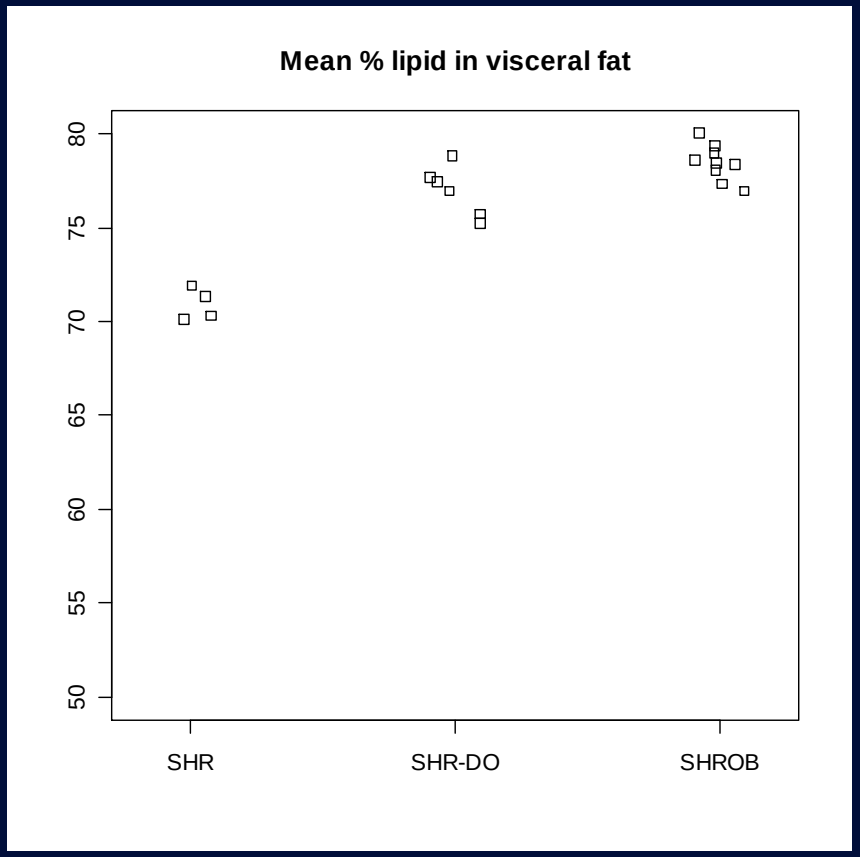
% Lipid as a phenotype

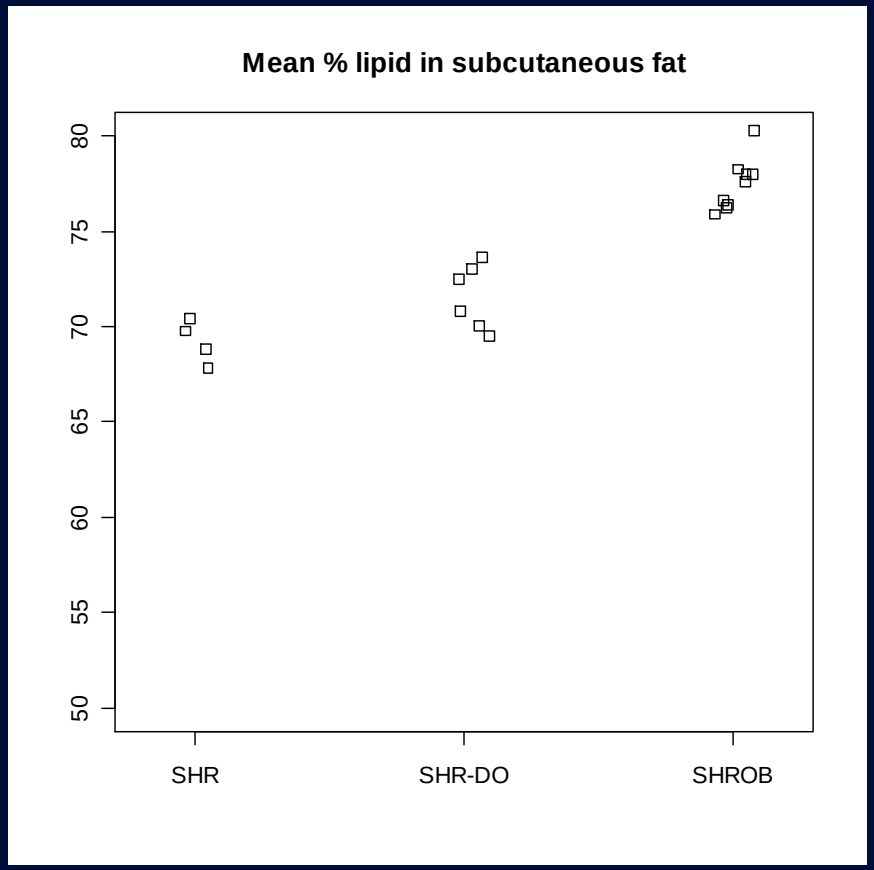




This method can estimate triglycerides in the fat cells (adipocytes) over the whole animal *in vivo*!

% Lipid as a phenotype





This method can estimate triglycerides in the fat cells (adipocytes) over the whole animal *in vivo*!

Discussion

- Useful for long term *in vivo* assessment of environmental effects, including stress, exercise, diet, and drugs
- Provides new insight into the underlying genetic factors, including other rodent models of obesity, such as C57BL/6 mice on the high fat, high sucrose (“Atkin’s”) diet.
- Future work includes comparisons to lipid content via MR spectroscopy

Thank you

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