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Quantification of abdominal subcutaneous and visceral fat by magnetic resonance imaging of the proton at 3T: application to an overfeeding protocol

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Introduction

Overweight and obesity are a major worldwide health problem increasing the risk to develop pathologies such as diabetes and cardiovascular disease. Obesity is a complex multifactorial disease combining genetic factors still misunderstood as well as environmental factors mainly related to diet and physical inactivity. Although obesity is defined as a body mass index (BMI) greater or equal to 30 kg/m², the spatial distribution of adipose tissue is decisive for the assessment of cardio metabolic risk factors.

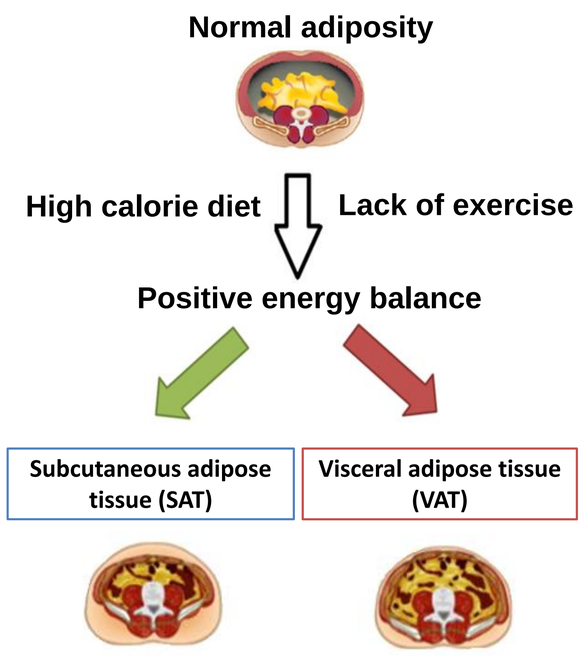
People with abdominal fat accumulation have commonly an altered metabolic profile. The increase of visceral adipose tissue [2] (VAT) is associated with a higher risk to develop insulin resistance and type 2 diabetes unlike the expansion of subcutaneous adipose tissue (SAT). While 1H MRI is well suited to evaluate SAT and VAT volumes, Magnetic Resonance Spectroscopy (MRS) is able to provide **saturated (SFA)**, **monounsaturated (MUFA)** or **polyunsaturated (PUFA) fatty acids proportions.**

Recent studies demonstrated the feasibility of assessing the composition of fat based on multiple gradient echo imaging [3]. MRI methodology to assess the fatty acid composition is still little used but has a high potential in the study of overweight and obesity.

World adult population in 2014 [1]

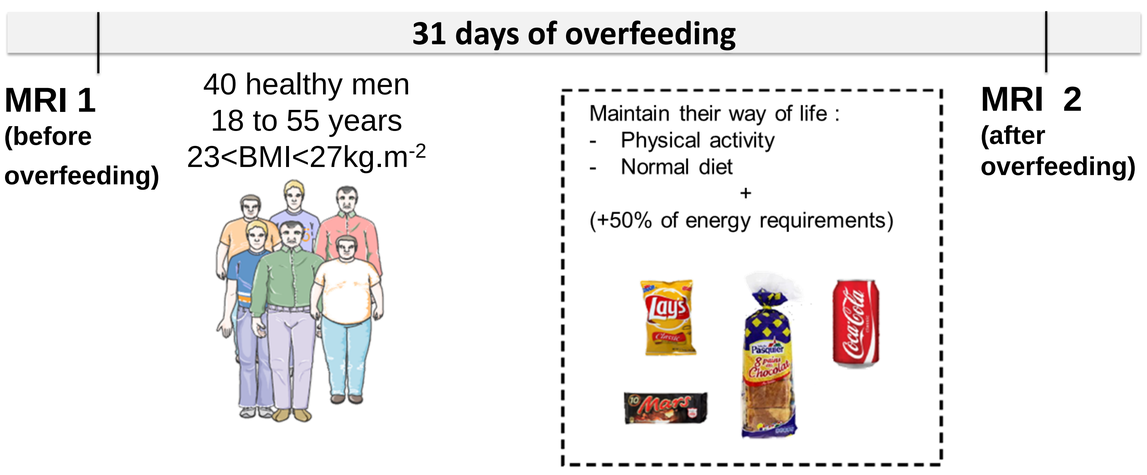
39% overweight (BMI>25 Kg/m²)

13% obese (BMI>30 Kg/m²)



Methods

High-carbohydrate and high-fat overfeeding protocol

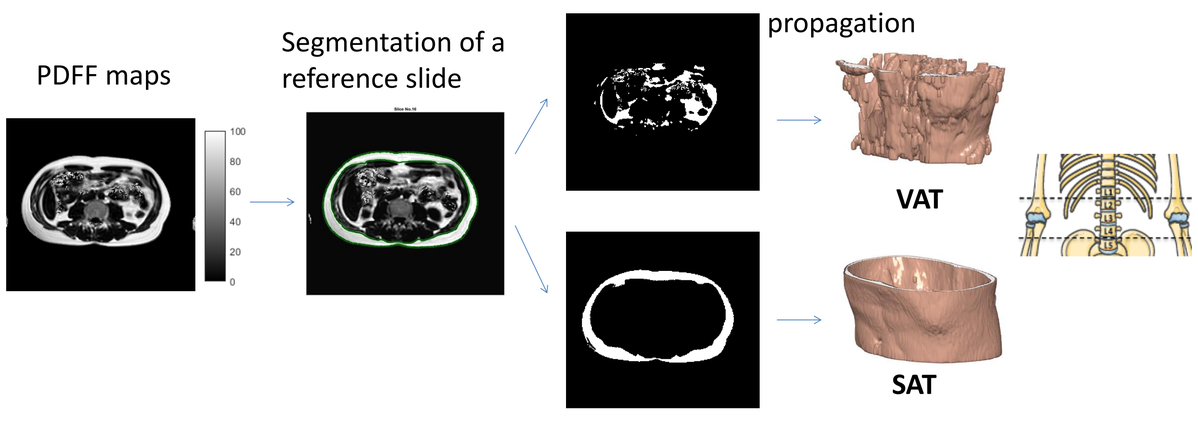


MRI protocol

- Subjects underwent a MRI examination of the **abdominal region** (encompassing levels L1 to L5 and liver) before and after overfeeding on a Philips Ingenia 3T.
- 3D MRI acquisitions parameters were:
  - 8 echoes (n x 1.15 ms TE with n=1, …,8),
  - TR = 10.3 ms;
  - FOV = 384x320x420 mm3;
  - matrix size = 256x256x80 after interpolation;
  - scan duration = 20.8 s.
- Fat and water only images, PDFF and fatty acid composition (i.e SFA, MUFA and PUFA fractions) parametric maps were obtained using the method described in [3].

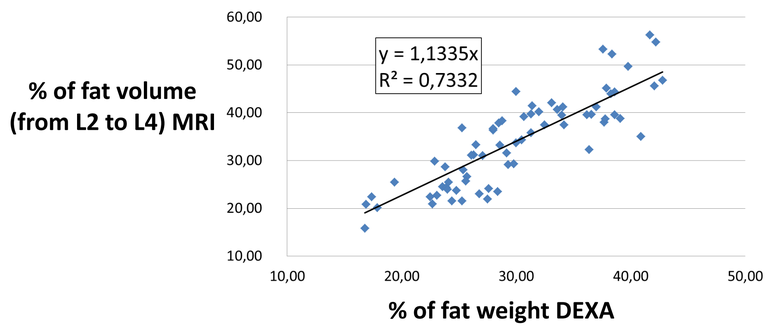
Segmentation

The PDFF maps and the 2 first echoes (in and out of phase) were then used for the segmentation of subcutaneous and visceral fat volumes (between L2 and L4). Automatic segmentation was based on the method of Lankton [4] (figure 1). Derived volumes were compared to fat mass measurements by DEXA (measured on the trunk). The PDFF map can also quantify the levels of fat in the liver. Paired t-test was used for statistical analysis.



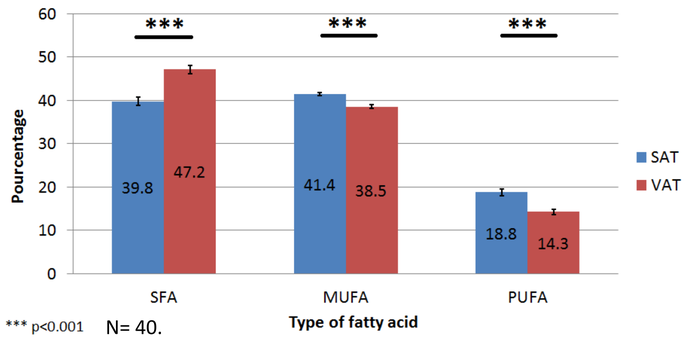
Results

Correlation between MRI and DEXA measurements



in abdominal region

Composition of adipose tissues

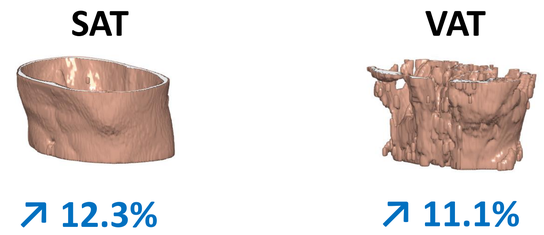


*** p<0.001 N= 40.

1. Difference in lipid composition between SAT and VAT

Graph on MRI 1 data, for MRI 2 remain line.

Effect of overfeeding on adipose tissues



↗ 12.3% From the initial volume (p<0.001)

↗ 11.1% From the initial volume (p<0.001)

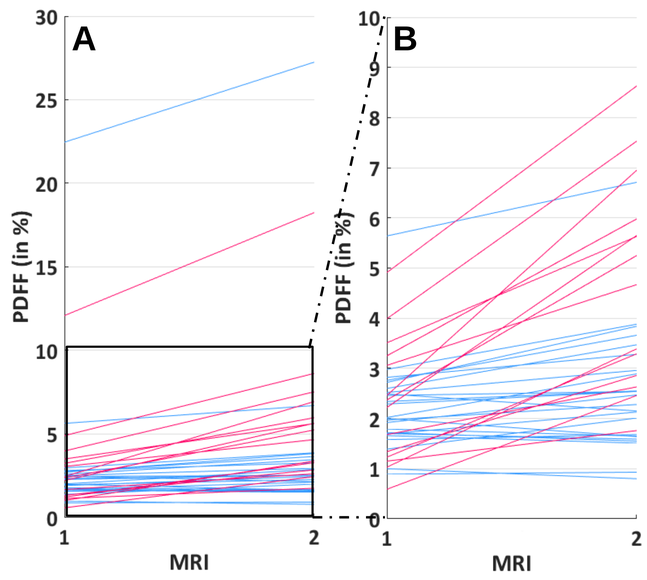
	SAT	VAT
SFA	↗ 0.19 p = 0.367	↘ -0.39 p = 0.044
MUFA	↗ 0.22 p = 0.334	↗ 0.26 p = 0.014
PUFA	↘ -0.41 p = 0.031	↗ 0.14 p = 0.250

2. Increase of adipose tissues volumes after overfeeding

3. Variation of lipid composition between MRI 1 and MRI 2

Effect of overfeeding on the liver

Variation of PDFF in liver between MRI 1 and 2



Mean of difference between MRI 1 and 2 (in %)		p-value
40 subjects	1.35 CI 95% [0.81 ; 1.82]	< 0.001

4. Significant increase of fat in the liver

Each line represents a subject. In our study, two subjects have an abnormal PDFF in the liver for healthy subject. Variation of PDFF between MRI 1 and 2 for all subjects; for subjects with a PDFF <10% (B).Some subjects have higher variation of PDFF (red lines represent subjects who have a relative variation >50%, blue lines <50%).

Discussion and Conclusion

To conclude, overfeeding has a significant effect on fat storage in the body with an increase of visceral and subcutaneous abdominal adipose tissues volumes and fat storage in the liver. Overfeeding also seems to have an effect on stored fat composition. All the results were assessed from a single imaging sequence and a suitable post processing. At the end of the study, analysis by gas chromatography will be made on biopsies of SAT to confirm the fatty acid composition results.

Références:

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4. Lankton S, Tannenbaum A. IEEE Trans Image Process. 17:2029-2039, 2008.

Acknowledgments:
LABEX PRIMES (ANR-11-LABX-0063), program "Investissements d'Avenir" (ANR-11-IDEX-0007), IHU Opera and PHRC-IR Visfatir.

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