# Liver and muscle lipid stores and their association with abdominal fat distribution in healthy elderly individuals

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## Introduction

Obesity is associated with insulin resistance, type 2 diabetes and vascular risk. However, the distribution of body fat is an important confounder of the metabolic effects of obesity, such that visceral or central obesity is more strongly associated with the metabolic derangements. Magnetic resonance imaging and spectroscopy offer non-invasive methods of measuring visceral, subcutaneous and total abdominal fat, as well as intrahepatic lipid (IHL) and intramyocellular lipid (IMCL) levels. The correlations between these lipid stores have been investigated in 'normal' [1] adults and also those prone to type 2 diabetes [2]. However, these studies involved younger people, with a mean age of 44 years, and these relationships have not yet been described in older individuals. Therefore here we investigate the correlations between different abdominal fat stores, IHL and IMCL in a cohort of healthy elderly individuals.

## Method

70 healthy volunteers (38 male, 32 female), aged between 67 and 76 years, undertook a magnetic resonance scan the morning after an overnight fast. They were asked to avoid vigorous exercise for two days prior to the scan. Measurements of IHL and IMCL, together with measures of visceral (VAT), subcutaneous (SCAT) and total abdominal adipose tissue (TAT) were acquired on a Siemens 3T Tim Trio scanner, enabling the swift acquisition of all data in one forty minute scan session.

*IHL measurement:*

A $^1$H spectrum was obtained from a voxel, of cube length 1.5cm, located within the posterior aspect of the right lobe of the liver, using the PRESS sequence. During this measurement volunteers were given breathing instructions with a seven second cycle, which was designed and gated such that participants were at the end of expiration during the localisation and subsequent acquisition. Non-water suppressed data was acquired with TR=7s, TE=35ms, NR=64. The voxel was positioned to avoid blood vessels and the gall bladder using $T_2$-weighted HASTE transaxial images, that were also acquired in the same phase of respiration.

*IMCL measurements:*

A $^1$H spectrum was obtained from a voxel, of cube length 1.3cm, in the soleus of the right leg using PRESS. The voxel was positioned to avoid fasciae lines and visible fat. Water suppressed data was acquired with a TR=5s, TE=35ms and NR=64.

All spectra were analysed in jMRUI [3,4] and fitted using the AMARES [5] algorithm and then IMCL and IHL ($CH_2$ peak) were quantified relative to creatine and water respectively.

*Abdominal fat measurement:*

17 $T_1$-weighted turbo spin echo, water suppressed, transaxial slices were acquired through the abdomen. Slice thickness 10mm (2mm gap between slices), in-plane resolution was 1.3x1.3mm, FOV 500x500mm, TR=400ms, TE=21ms, 2 averages, 3 concatenations. Volumes of VAT and SCAT were calculated using a semi automated method, using a theshold map in combination with manual input to distinguish between the VAT and SCAT compartments. TAF and VAT/SCAT ratios were then calculated and data on the distribution of the VAT (eg. number of clusters, maximum volume of the largest cluster and the mean volume of the clusters in the visceral compartment) was tabulated.

## Results

Participants tolerated the scan and breathing instructions well. IMCL was not acquired in 6 people as an abundance of fasciae lines meant there was no viable voxel location. IHL data from 7 volunteers was excluded due to insufficient shim, with the remaining data having a mean line width of (28.9±5.6) Hz for the $CH_2$ resonance. Statistical analysis was performed using SPSS. The values shown here for abdominal adiposity represent the results from one slice, that is located at the L4 vertebral level.

| | Male | | Female | |
|---|---|---|---|---|
| Age (yrs) | 71.6±2.3 | [67.5-75.4] | 71.1±2.6 | [67.4-76.2] |
| Weight (kg) | 83.3±14.6 | [55.2-107.7] | 68.0±8.6** | [55.0-86.2] |
| BMI (kgm$^{-2}$) | 27.6±3.6 | [21.0-37.4] | 25.9±3.4 | [20.7-35.2] |
| IHL/wtr (%) | 6.2±6.8 | [0.3-28.9] | 5.4±8.5 | [0.1-36.7] |
| IMCL/Cr | 17.8±15.5 | [1.8-77.2] | 14.5±10.0 | [4.2-48.7] |
| VAT (cm$^3$) | 164±73 | [57-394] | 100±61** | [29-246] |
| SCAT (cm$^3$) | 240±76 | [104-437] | 267±89 | [129-435] |
| TAT (cm$^3$) | 404±138 | [190-671] | 367±131 | [165-703] |
| VAT/SCAT (%) | 69±23 | [30-114] | 38±19** | [9-72] |

**Table 1.** *Mean±SD and [Range] values for anthropometric data and measures of adiposity. Gender differences in mean *p<0.05, **p<0.001.*

A Shapiro-Wilk test revealed that IHL, IMCL, VAT and VAT/SCAT were not normally distributed and therefore these measurements were $\log_e$ transformed (to give a normal distribution) prior to evaluating gender differences in means by t-test, and also prior to linear regression analysis. The mean values for males and females are shown in Table 1, with the only significant difference in mean due to gender being higher weight, VAT and VAT/SCAT in males.

| | | BMI | VAT | SCAT | TAT | VAT/SCAT |
|---|---|---|---|---|---|---|
| IHL | *male* | 0.58** | 0.61*** | 0.55** | 0.62*** | 0.29 |
| | *female* | 0.53** | 0.79*** | 0.46* | 0.68*** | 0.52** |

**Table 2.** *Correlation coefficients for the linear regression analysis of IHL against BMI and different measures of abdominal adiposity.*p<0.05, **p<0.01, ***p<0.001.*

IHL, VAT, SCAT and TAT were all associated with weight and BMI (p<0.01). Results shown in Table 2 imply IHL is associated with all abdominal measures, though not with VAT/SCAT in males. IHL was also shown to correlate with the mean and maximum volume of the visceral clusters (p<0.01), but not to the no. of clusters. IMCL did not correlate with any measure of abdominal lipid nor IHL. After correcting for age and BMI (Table 3) it appeared that IHL is more linked to VAT and VAT/SCAT rather than SCAT. Adjusting for age also revealed a correlation of IMCL with VAT and TAT.

| Adjustment | | VAT | SCAT | TAT | VAT/SCAT |
|---|---|---|---|---|---|
| None | IHL | 0.72*** | 0.43*** | 0.65*** | 0.47*** |
| | IMCL | 0.13 | 0.21 | 0.20 | 0.02 |
| Age | IHL | 0.68*** | 0.25 | 0.55** | 0.48** |
| | IMCL | 0.46** | 0.26 | 0.44* | 0.28 |
| BMI | IHL | 0.59** | -0.15 | 0.32 | 0.53** |
| | IMCL | 0.27 | -0.13 | 0.09 | 0.28 |

**Table 3.** *Correlation coefficients of IHL and IMCL with abdominal measures in the whole group, both before and after adjusting for age and BMI. *p<0.05, **p<0.01, ***p<0.001.*

## Discussion

Our results suggest that IHL is closely related to VAT in healthy elderly individuals, consistent with recent reports in younger healthy adults [1, 6-7]. The increased VAT noted in the males compared to the females is in agreement with [2] in younger adults, and the lack of correlations with IMCL is consistent with [1]. The change in correlation coefficients after adjusting for age may imply that even within a relatively narrow range of nine years, age may be an important confounder of the relationship between body fat distribution and tissue fat accumulation.

## References

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