# Variability in the distribution of Intermuscular Adipose Tissue

## Investigating IMAT distribution of the abdominal musculature on CT scans

Maastricht University · Maastricht UMC+ · NUTRIM School of Nutrition and Translational Research in Metabolism · eurostars

Verdonschot SELJ[1,2], Peltzer JN[1], Ackermans LLGC[1,2], Wee L[3], Verkoulen G[1], Martens B[4], Blokhuis TJ[1], Ten Bosch JA[1]

1. Division of Trauma Surgery, Department of Surgery, Maastricht University Medical Center+, Maastricht, The Netherlands
2. NUTRIM, School for Nutrition and Translational Research in Metabolism, Maastricht University, Maastricht, the Netherlands
3. Department of Radiation Oncology (MAASTRO), GROW Research Institute for Oncology and Reproduction, Maastricht, The Netherlands
4. Department of Radiology, Maastricht University Medical Centre+, Maastricht 6229 HX, the Netherlands

### Introduction

Body Composition Analysis (BCA) using CT enables precise quantification of muscle and fat compartments, including visceral adipose tissue (VAT), subcutaneous adipose tissue (SAT), and intermuscular adipose tissue (IMAT). IMAT, defined as adipose tissue beneath the muscle fascia, has emerged as a key marker of muscle quality and is linked to insulin resistance, poor cancer outcomes, increased COVID-19 mortality, and higher overall mortality.
While single-slice CT measurements at the third lumbar (L3) level are accepted surrogates for total body VAT, SAT, and skeletal muscle mass (SKM), no consensus exists for IMAT due to its heterogeneous distribution.
This study examines IMAT distribution across lumbar levels (L1–S1) in the rectus abdominis, psoas major, erector spinae, and multifidus muscles to assess whether single-slice IMAT measurement reliably reflects total abdominal IMAT.

### Study design

This retrospective study analyzed a subpopulation from a trauma cohort. (The original dataset included 9699 patients admitted to a level 1 trauma center between 2015–2021, of whom 616 met inclusion criteria (≥18 years, Injury Severity Score >15, arterial phase abdominal CT).For this study, patients with conditions potentially affecting body composition (e.g., diabetes, cancer history, metabolic or muscular disorders, COPD, alcohol or drug abuse) were excluded, resulting in a “pseudo-healthy” population.
To ensure diversity, subjects were stratified by BMI, age, and sex, forming nine subgroups (3 BMI × 3 age categories), with two males and two females randomly selected from each. After exclusion for CT artefacts, 35 patients were included.

### Imaging and analysis

Abdominal CT scans in the arterial phase were analyzed for each patient using sliceOmatic software (v5.5b, TomoVision). A total of 16 axial slices, spanning L1 to S1, were selected per patient to capture variation along the lumbar spine. Three muscle groups were segmented: the rectus abdominis, psoas major, and the combined erector spinae/multifidus complex. Segmentation followed the Alberta protocol, applying standardized Hounsfield unit (HU) thresholds to differentiate tissue types:

- Intermuscular adipose tissue (IMAT): –190 to –30 HU
- Skeletal muscle (SKM): –29 to +150 HU

For each muscle and vertebral level, the surface area (cm²) of IMAT and SKM was measured to quantify regional body composition.

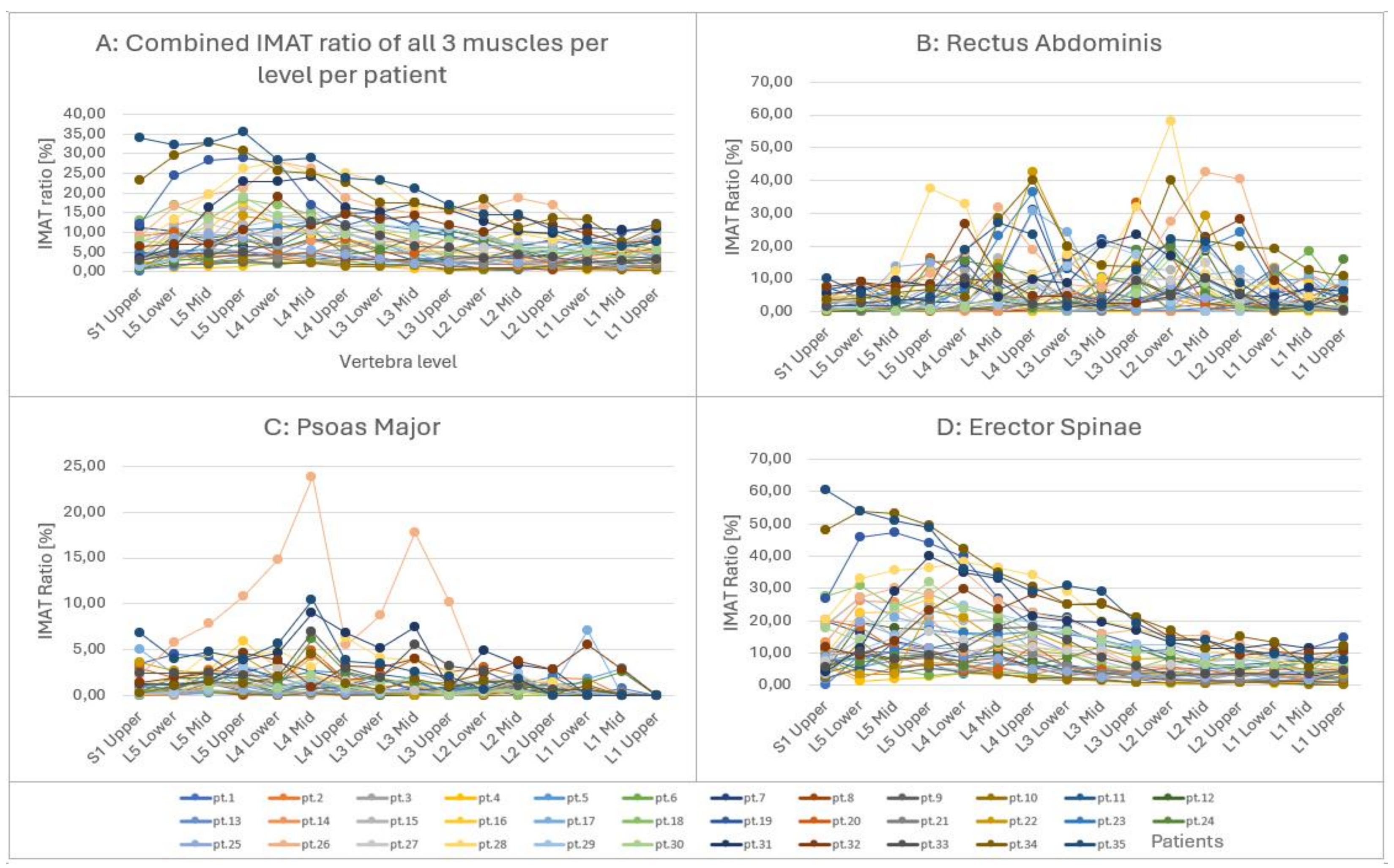


Figure 2: : IMAT ratio per vertebra levels of A: all 3 Muscle groups combined, B: Rectus Abdominis, C: Psoas Major and D: Erector Spinae. Each line represents 1 patient

### Study Population and Baseline Characteristics

The final study population included 35 patients (17 female, 48.6%), aged 18–79 years (mean ± SD = 50.5 ± 17.5 years). Mean BMI was 27.3 ± 4.9 kg/m² (range 18.7–42.9 kg/m²).
IMAT ratio was defined as the proportion of IMAT within each muscle (IMAT area / (IMAT + SKM area)), while the IMAT index represented IMAT area normalized by patient height². The IMAT ratio and index were used to evaluate inter- and intra-patient variation across vertebral levels and muscle groups.

### IMAT and SKM distribution

A broad range of skeletal muscle (SKM) and intermuscular adipose tissue (IMAT) surface areas was observed across patients and vertebral levels.

- IMAT: 0.07–24.32 cm² (mean ± SD = 5.77 ± 5.13 cm²)
- SKM: 22.54–151.87 cm² (mean ± SD = 71.50 ± 24.66 cm²)

The erector spinae/multifidus (ES) complex contained the largest proportion of both IMAT and SKM (≈ 63–94% and 42–66% of totals, respectively), followed by the rectus abdominis (RA) and psoas major (PM).

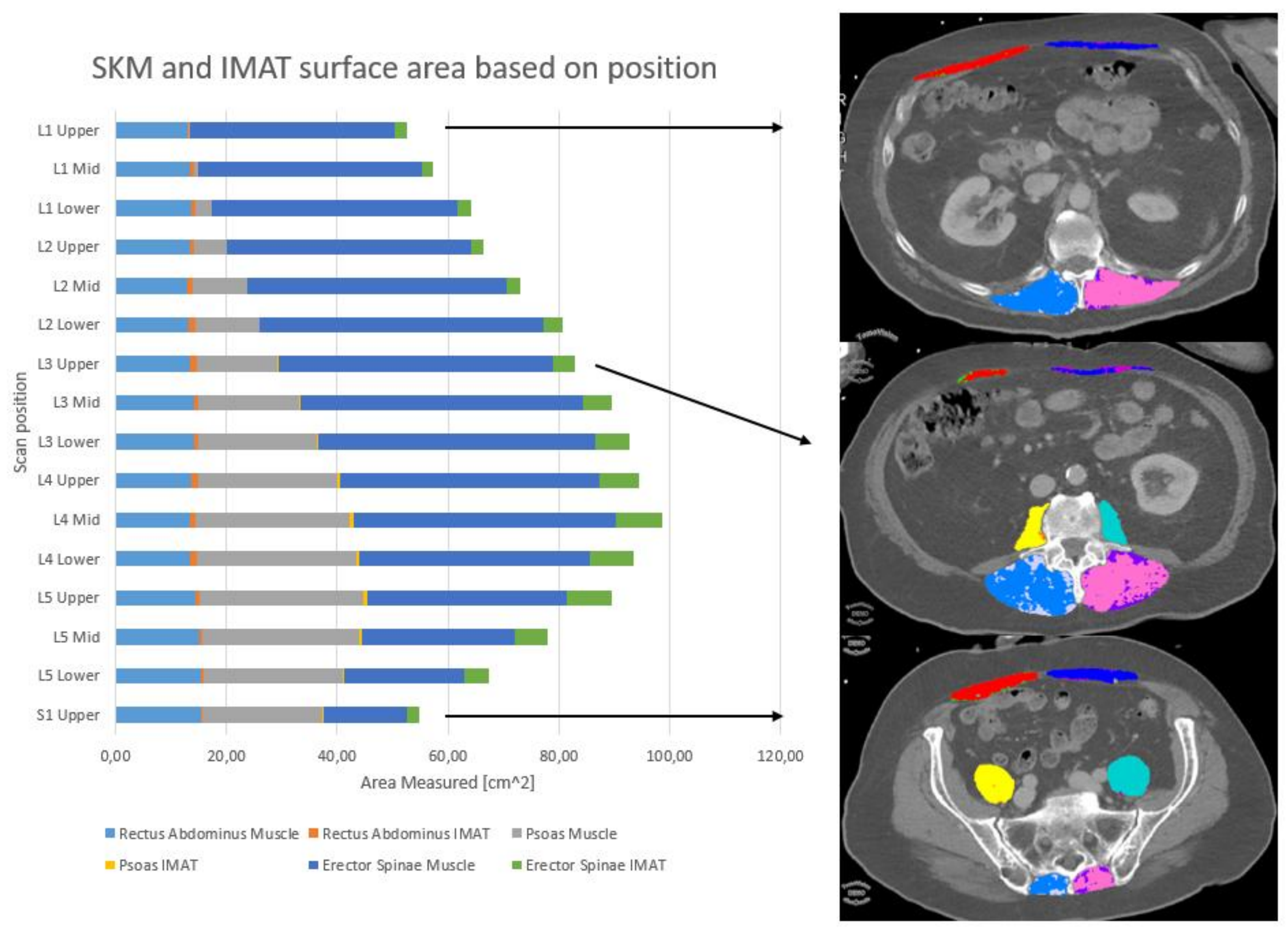


Figure 1: Muscle and IMAT Surface area based on vertebra levels with samples of segmented CT scans

### Inter- and intra-patient variation

IMAT increases with age (IMAT index $r = 0.755$, $p < 0.001$), while BMI shows no significant correlation.

Within patients, IMAT and skeletal muscle vary across vertebral levels: RA is most consistent (~14 cm²), PM shows the largest variation (0.07–21.5 cm²), and ES peaks at L2 before decreasing cranially.

### IMAT variation

The combined IMAT ratio of all three muscles showed wide inter- and intra-patient variation. The highest inter-patient IMAT ratio was 1.45–35.39% at L5 Upper, and the lowest was 0.36–10.64% at L1 Mid. By muscle, RA and ES reached IMAT ratios up to 60%, with RA showing more variability and ES decreasing with higher vertebral levels. The PS remained under 10% for most patients.

Comparison to L3 Mid: IMAT ratios at other vertebral levels showed substantial differences compared to L3 Mid. The greatest variation occurred at S1 Upper and L5 Lower (ranges 23.07 and 23.68), while L3 Upper and L3 Lower showed the smallest variation (–4.80 to 4.09 and –3.17 to 6.25, respectively). Differences included both positive and negative values, with coefficients of variation (CV) ranging from 89.6% to 435.2%, highlighting the unreliability of single-slice measurements.

### Conclusion

Although small in scale, our study clearly shows that IMAT distribution has large inter- and intra-patient variation. This highlights the unreliability of single slice IMAT measurements and suggests that a single slice approach using abdominal CT scans is not suitable in the quantification of IMAT.

**Correspondence to:**
S.E.L.J. Verdonschot

sven.verdonschot@maastrichtuniversity.nl
https://www.mumc.nl/

Dept. of Trauma Surgery
MUMC+ Maastricht, The Netherlands

T +3143 387 6543

Maastricht University

P.O. Box 616
6200 MD Maastricht, The Netherlands