Automatic assessment of computed tomography muscle and adipose tissue metrics in 2,238 low back pain subjects

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Summary

Low back pain (LBP) is a major public health problem worldwide, but many previous investigations into body composition and musculoskeletal metrics–which can impact loading on the low back–suffer from low sample sizes. We analyzed a dataset of 23,547 clinical abdominal computed tomography scans and corresponding medical records. Automated tissue segmentation tools were used to study correlations between the tissue composition of the abdomen at L3 and low back pain diagnosis. When comparing a low back pain population (n=2,238) with an age, sex, and BMI matched control cohort, there were no differences in the muscle cross-sectional area normalized to height-squared or the visceral to subcutaneous fat ratios. There was a small difference in the ratio of muscle to total abdominal fat in the two groups; albeit with a low effect size. Our large-scale analysis provides normative values for future biomechanics studies involving body composition in the low back.

Introduction

Previous investigations into musculoskeletal health and body composition relationships in individuals with low back pain have produced contradictory results and often suffer from small sample sizes [1,2]. Medical imaging clinical datasets with automated image analysis and linked medical records present a unique opportunity to analyze musculoskeletal composition in large populations. However, few studies have accessed such large imaging datasets for low back pain [3].

We tested three hypotheses on musculoskeletal differences in large retrospective cohorts of subjects with and without LBP. Relative to matched controls, we hypothesized that at the third lumbar vertebrae (L3) patients with LBP have:

i. Lower muscle cross-sectional area (CSA) normalized to height-squared
ii. Higher visceral to subcutaneous fat ratio (VAT/SAT)
iii. Lower muscle to total abdominal fat ratio

Methods

We analyzed 23,547 abdominal computed tomography (CT) scans and electronic health records collected during clinical care at a tertiary care center. Patients with non-physiologic height, weight, and BMI values or a history of cancer, leukemia, and malignant tumors were excluded. The LBP cohort includes patients with an International Classification of Disease (ICD) code diagnosis for LBP. A control cohort with no LBP diagnosis was created by population-level matching the LBP cohort by sex, age (bin width: 5 years), and BMI (bin width: 2 kg/m^2). The LBP cohort had n=2,238 subjects (1,397 female), median age 53.4 years, and median BMI 27.6. The control cohort had n=2,192 subjects (1,378 female), median age 53.1 years, and median BMI 27.4.

We segmented muscle, visceral fat, and subcutaneous fat in the axial slice at the L3 vertebrae of each subject using Comp2Comp [4]. We compared muscle CSA normalized by height-squared, VAT/SAT ratio, and muscle to total abdominal fat (subcutaneous and visceral fat) ratio in the LBP and control cohorts with three-way ANOVAs (factors: diagnosis, sex, BMI (<25, ≥25kg/m^2), and their interactions). To meet normality of residuals assumptions, we applied log-transforms to the VAT/SAT and muscle to fat data. With Bonferroni correction, a $p<0.017$ was considered significant.

Results and Discussion

All three parameters had a significant effect of sex ($p<0.0001$), BMI ($p<0.0001$) and their interaction ($p<0.01$) supporting previous literature that muscle and fat distributions differ by sex and BMI. While the muscle to total fat ratio of the LBP cohort was statistically lower than the control cohort ($p<0.001$) (Figure 1), the effect size was very small (partial $\eta^2=0.005$). No significant differences were seen between the LBP and control cohorts when comparing the normalized muscle CSA ($p=0.07$) and VAT/SAT ratios ($p=0.24$) of the two cohorts. There were no two or three-way interaction effects between diagnosis and sex or BMI for any of the hypotheses tested in our matched cohorts.

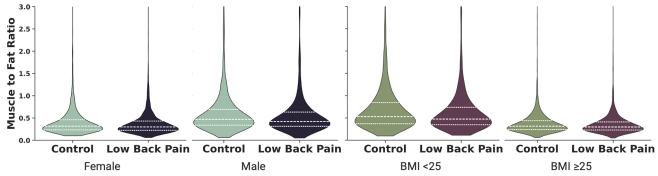

Figure 1: Muscle to total abdominal fat ratio was lower in LBP subjects compared to matched controls. Sex (F/M) and BMI (low/high) had no significant interaction effects with LBP diagnosis. Long tails truncated for visualization.

These results are limited by the cross-sectional nature of the data. Additionally, CT imaging is not optimized for soft tissue contrast, making individual muscle analysis difficult.

Conclusions

Our findings complement previous studies with low sample sizes and suggest that normalized muscle CSA and VAT/SAT ratio are not related to LBP diagnosis, but the ratio of muscle to total abdominal fat at L3 is associated with low back pain with a very small effect size. Future studies should investigate the causality of these associations.

Acknowledgments

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