# Volumetric Differences in Body Shape Among Adults with Different Body Mass Index Values: An Analysis Using 3D Body Scans

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## Abstract

### Introduction

It is difficult to quantify and assess body shape using traditional one-dimensional anthropometry. Three-dimensional (3D) whole body scanning provides a powerful tool to characterise shape according to two-dimensional and three-dimensional measurements such as volumes, surface and cross-sectional areas.

### Objective

To characterise the differences in body shape of people differing in body mass index (BMI), using segmental body volumes extracted from 3D whole body scans.

### Method

Eight segmental volumes were measured on 340 young adults (169 males, 171 females) aged 18–30 years, using the *Vitus* Smart 3D whole body scanner. Participants were purposively chosen to represent a wide range of BMI values, defined by four different BMI categories: <20 (thin); 20–24.99 (normal weight); 25–29.99 (overweight); and ≥30 (obese). Two-way (sex by BMI category) analysis of variance was used to determine the differences in mean absolute and relative body volumes (segmental and whole body). Body volumes were also expressed as a ratio of the sex-specific mean volume (segmental or whole body) and compared to BMI using simple linear regression, multiple-segment-linear regression and Lowess curves.

### Results

Mean absolute and relative body volumes typically varied significantly by sex and BMI. While all segmental volumes increased significantly as BMI increased, the BMI-related patterns of increase were not always consistent among different body segments. Pelvis and abdomen volumes increased at a significantly greater rate than whole body volume (WBV), with the rates of increase greatest in the overweight and obese. In contrast, lower arm + hand, lower leg + foot, and head + neck volumes increased at a significantly smaller rate than WBV. While smaller, these increases were consistent in males from different BMI categories, yet were smallest (and even negative in direction for head and neck volume) in overweight and obese females. Thorax, upper arm, and thigh + “flap” volumes increased at a similar rate to WBV, with rates of increase for the upper arm and thigh + “flap” volumes smallest in the overweight and obese.

### Conclusion

Variations in the distribution of segmental and whole body volumes for BMI and sex could have important implications in areas focused on shape analysis, such as ergonomics, sports science and health sciences. Thresholds in the shift of volume between segments may provide accurate measures that can be used for risk factors associated with health issues such as cardiometabolic disease and mortality. Further research is required to determine whether the changes in segmental body volumes accurately reflect subcutaneous and visceral adipose tissue.