THE IMPACT OF AGE & BMI ON TRUNK CENTER OF MASS IN MALES

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INTRODUCTION
Nearly 26% the United States population is over the age of 55, a number that is consistently rising [1]. Unfortunately, adults over 55 years old are more at risk of falling, which can be detrimental to both a person’s health and finances. In 2000, the average cost of a hospital visit as a result of a fall injury was $35,000 [2]. Biomechanical research and gait analysis greatly assist in understanding the mechanism of falls. With adequate research and understanding, measures can be taken to reduce risk and prevent falls in older adults. However, the complex analysis of such biomechanical research is done using anthropometric tables which provide approximations for body segment parameters (BSPs), including mass, center of mass (COM), and radius of gyration of the head, torso, upper arm, lower arm, thigh, and shank. These tables are often derived from young, healthy subjects and are not accurate in applications with person of varying age and body mass index (BMI) [3]. BMI is a value derived from the mass and height of an individual and a gauge used to determine whether a person is overweight.

An alternative to anthropometry tables, dual energy x-ray absorptiometry (DXA) is a safe method to obtain in-vivo subject-specific BSPs. This technology is able to determine the differences between bone, muscle, and fat [4], and calculate masses based on assumed densities for each tissue type. A specific BSP, segment COM, is the point around which the segment’s mass is equally distributed in all directions and was the focus of this study. Previous research done by Pearsall et al. as well as Chambers et al. has demonstrated that BSP values, such as COM, significantly change with factors such as age, gender, and BMI [5,6]. However, these studies were comprised of a very limited subject pool, both in terms of size and diversity. Thus, this study aimed to expand the analysis of factors effecting BSPs with an increased subject pool with more extensive variability in age and BMI.

The goal of this study was to investigate age and BMI effects in the torso COM with the ultimate purpose of eventually developing new anthropometric models that incorporate such factors. For brevity purposes, we conducted our analyses on the torso due to the significant large inertial effects of this segment.

OBJECTIVE
The objective of this study was to process the DXA scans of the 126 adult male subjects and assess how changes in age and BMI affect torso COM.

HYPOTHESIS
Statistical significance was hypothesized in COM calculations for age, BMI, and the interaction of the two conditions. Furthermore, as age and BMI increase, torso COM was expected to transfer lower in the body (i.e. more inferior). These predictions were derived according to the findings of previous studies with smaller, less diverse subject pools [5,6].

METHODS
One hundred and twenty-six working males were recruited to participate in this study with ages ranging from 21 to 70 years old and BMIs from 18.5 to 50 kg/m². BMI and eligibility were validated for each participant after weight and height were recorded. A full body frontal image for each person was take with the Hologic Discovery DXA System (Hologic, Bedford, MA, USA), and then processed to establish body segments and sub-regions used to calculate BSPs. In the DXA scans, certain bony landmarks defined each body segment (Fig. 1). For the torso, these boundaries were from the shoulder joint center through the superior acromion to the hip joint center at the superior trochanter and the ischial tuberosity of the pelvis. Between these landmarks, the segment was split into sub-regions that were 2-3 pixels (2.6-3.9 cm) tall.

![Figure 1: Full body DXA scan with segment boundaries marked by red lines](image-url)

DXA-based measures of the mass of each sub-region were derived and used in MATLAB to calculate COM for the entire torso segment as a percent of total segment length. A mixed linear regression was done to analyze the data. More specifically, the outcome variable of interest was the torso COM (as a percent of segment length) and the following fixed effects were used in the model: age, BMI, and their interaction. In addition, subject
was included as a random effect in the model. Statistical significance was set at 0.05.

RESULTS

Statistical analysis found that age (p < 0.01), BMI (p<0.01) and age*BMI (p<0.05) had a significant effect on the torso COM assessed as a percent of total segment length (Figure 2). These results show that as age or BMI increases, the COM migrates significantly lower in the torso segment.

Furthermore, BMI was found to be the strongest influencing factor on torso BMI with a statistically significant standardized regression coefficient of β=0.08, followed closely by age with β=0.03. The age*BMI interaction had a significant beta value of 0.002 signifying a weak influence of the interaction on torso COM.

DISCUSSION

The torso COM results support the hypothesis in that age, BMI, and their interaction were all found to have a statistically significant effect of male torso COM. Furthermore, previous research has shown that a more distal torso COM is common as age and BMI increase. This research supports the findings of a direct correlation between age/BMI and torso COM (when presented as a percent of segment length) reported in this study [5,6]. According to the results, older individuals and those with a higher BMI are more likely to have a lower COM as weight gain is usually observed in the hips and lower stomach.

The findings of this study display the stark differences in BSPs of individuals of varying ages and BMIs and further emphasize the need to develop new models with conditional inputs such as age, BMI, and gender. Overall, the results validate the resources and research personnel being utilized to analyze an extensive subject pool and derive modified anthropometry models for more accurate biomechanical research.

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REFERENCES