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EFFECT OF AGE AND BODY MASS INDEX ON TORSO ANTHROPOMETRY IN FEMALES

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INTRODUCTION

Body segment parameters (BSPs), including segment mass, length, center of mass location, and moment of inertia are used in many ergonomic applications, such as design of tools, protective clothing, equipment and work space layout [1], as well as in biomechanical models used to estimate risk of musculoskeletal injuries.

Current anthropometry tables, which show the mass of each body part as a percent of total body weight (BW), and center of mass (COM) and radius of gyration (R_G) locations as percent of segment length were compiled using healthy, college-age adults, however these parameters have shown to be inaccurate in predicting BSPs in subjects with an increased body mass index (BMI), as well as in different age groups [2-5].

Several methods exist for determining BSPs including cadaver-based studies, magnetic resonance imaging, computed tomography, and measurements based on bony landmarks [6-9], however these methods have some issues as far as cost, time required, and high doses of radiation. Dual energy x-ray absorptiometry (DXA) is a validated method of determining BSPs in vivo that avoids these common problems. DXA scans are commonly used to determine bone density and body composition, as well as for mass calculations. The scan itself is an inexpensive, low radiation scan that differentiates between bone, muscle, and fat, and assigns mass values to each pixel based on assumed density for each classification.

The goal of this study is to use DXA scan-based BSP calculations in order to determine the impact of age and BMI on segment masses, COM's, and R_G's in working females, focusing specifically on torso parameters.

METHODS

The participants in this study were 138 females covering a continuous age range between 21 and 70 years old, with BMI between 18.5 and 53.3 kg m^{-2}.

During the single study visit, the height and weight of each participant were recorded in order to calculate BMI, then each participant was scanned using a Hologic Discovery DXA System (Hologic, Bedford, MA, USA) to collect a frontal plane, full body image. Predetermined anatomical landmarks were used to define the boundaries between BSPs in each scan. Specifically, the torso extended from the acromion to the superior border of the greater trochanter, with lateral boundaries defined by a line connecting the acromion through the axilla, and another line connecting the greater trochanter and ischial tuberosity.

In order to calculate segment COM and radius of gyration, the torso segment was separated into small slices. Each slice covered the width of the segment, and had a height of 2-3 pixels, corresponding to 2.6-3.9 cm tall. The analysis determined the mass of each sub-region, and used the masses and known slice height to calculate the segment parameters. COM and R_G were expressed as percent of the torso segment length (SL) from the superior border, and mass was expressed as a percent of the total body mass. A regression analysis was performed to determine the impact of age and BMI on the torso mass, COM, and R_G, using age, BMI, and their interaction as continuous predictors. Significance was set at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The analysis demonstrates significant effects of age on all three parameters, and BMI on COM and R_G (Table 1). More specifically, torso mass percentage increases with age, while the COM moves in the

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inferior direction, and the R_G decreases (Figure 1-left). COM location moved in the inferior direction and the R_G decreased with increasing BMI (Figure 1-right).

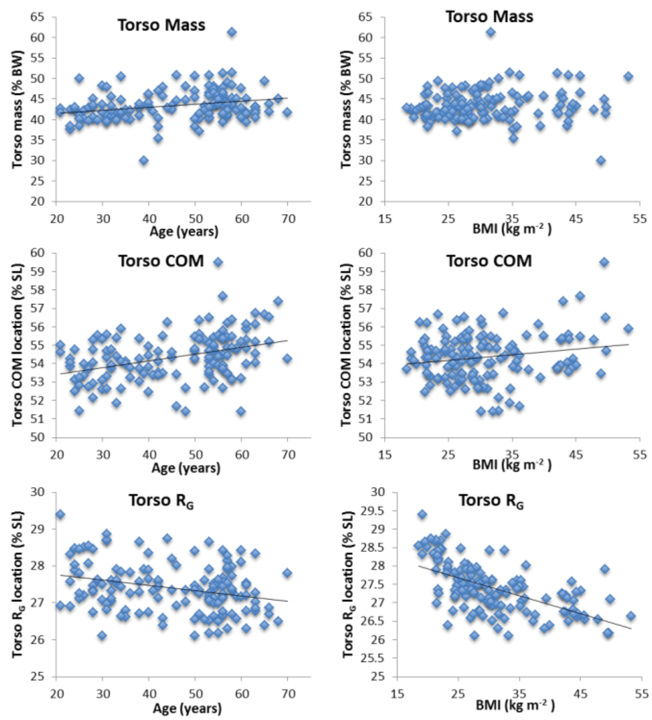

Figure 1: Torso mass (top), COM (middle), and R_G (bottom) vs age (left column) and vs BMI (Right column).

Accounting for the effects of age and BMI on torso segment parameters is necessary because of the impacts on static strength prediction [10] and inverse dynamics models [11] used to determine required muscle forces and joint contact forces. Both of these types of modeling are sensitive to BSP inputs such as mass, COM and R_G locations, especially during tasks involving larger degrees of dynamic motion.

CONCLUSIONS

This study demonstrated that torso segment parameters are impacted by both age and BMI. Using accurate parameters, such as those that account for differences in age and obesity levels, is important for static and dynamic modeling, as well as for ergonomic and occupational applications.

One of the limitations for this analysis is that only age, BMI, and their interaction were used as predictors. More accurate models could potentially be developed by including quadratic terms to account for nonlinear effects.

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ACKNOWLEDGEMENTS
Funding Source: NIOSH grant No. R01 OH01010

Table 1: Mean values for torso mass (as % body weight), and COM and R_G locations (as % segment length), p values for the age, BMI, and age x BMI interaction predictors, and β values for significant age and BMI effects.

	Mean ± SD	P_{Age}	β_{Age}	P_{BMI}	β_{BMI}	$P_{Age\ x\ BMI}$
Torso mass (%BW)	43.4 ± 3.7	0.0012	0.078	0.213	--	0.135
Torso COM (%SL)	54.4 ± 1.3	<0.0001	0.039	0.0143	0.031	0.063
Torso R_G (%SL)	27.4 ± 0.7	0.0002	-0.013	< 0.001	-0.048	0.176