EFFECT OF AGE ON BODY SEGMENT PARAMETERS IN NORMAL WEIGHT FEMALES

Molly Knewtson, Zachary Merrill, Rakie Cham, April Chambers

University of Pittsburgh, Pittsburgh, PA, USA
email: mek122@pitt.edu, web: http://www.engineeringx.pitt.edu/hmbl/

INTRODUCTION

The population of adults over 55 years old in the United States increased over 15% from 2000 to 2010 [1]. Adults in this age group are more susceptible to injuries resulting from falls, including over 10,300 fatal fall-related injuries in 2000 [2]. In order to understand the mechanisms of falls and resulting injuries in the older adult population, biomechanical research is required. Biomechanical gait analysis and injury prevention research relies on anthropometric tables to give accurate approximations of body segment parameters (BSPs) of subjects. These parameters include mass, center of mass, and radius of gyration of the common body segments: upper arm, lower arm, torso, thigh, shank, and head.

Current anthropometric tables were developed with college-aged adults and are proven to be inaccurate in predicting BSPs of other age groups [3, 4, 5]. There are many proven ways to create predictive models such as cadaver-based studies and imaging [3, 6], but each method has disadvantages such as monetary cost, time-intensiveness, and/or delivery of high doses of radiation to the participant. Dual energy X-ray absorptiometry (DXA) is a validated in-vivo method of determining BSPs [7]. It is a quick, inexpensive, low-radiation, full-body scan that can differentiate densities of bone, muscle, and fat tissue, allowing for accurate mass calculations. This study uses DXA scanning and analyzing techniques to compare BSPs of normal-weight, young females against those of normal-weight, old females, focusing on the largest segments of the body: the torso and the thigh.

METHODS

The young subgroup corresponds to ages 21 to 40, while the old subgroup corresponds to ages 55 to 70. Thirteen young and thirteen old females, with BMI 18.5-25 kg m^{-2}, were recruited for participation in this study. Height and weight of each participant was recorded to confirm BMI and eligibility. Each participant was scanned with a Hologic Discovery DXA System to gather a full body, frontal plane image.

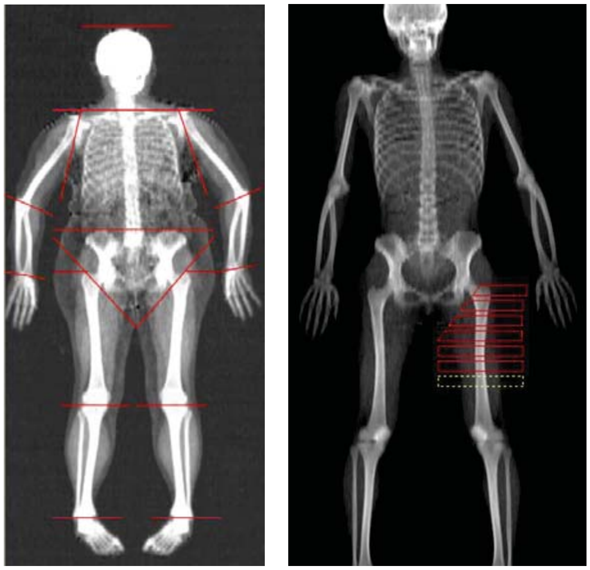

Figure 1: *left:* Whole body DXA scan with segmental boundaries designated by red lines *right:* sub-regions of the thigh segment indicated with red boxes.

Bony landmarks were used to define boundaries between body segments in analysis of each DXA scan (Fig. 1). The segments of interest were the torso and the thigh. The torso extended from the acromion to the greater trochanter. The torso's lateral boundaries were defined with a line through the medial acromion to the axilla and a line just lateral to the anterior superior iliac spine and the ischial tuberosity of the pelvis. The thigh segment began at the greater trochanter and extended to the center of the knee joint.

Each body segment was then divided into sub-regions that spanned the width of the segment and were 2-3 pixels (2.6-3.9 cm) tall (Fig. 1). Masses were calculated for each sub-region and used to determine BSPs for the whole segment.

Sub-region and segment measurements were used to determine segment mass as a percent of body mass (SM), longitudinal distance from the proximal end to the center of mass of the segment as a percent of segment length (COM), and frontal plane radius of gyration as a percent of segment length (RG). A two-tailed t-test was run to compare BSPs between the two age groups. Statistical significance was set at 0.05.

RESULTS AND DISCUSSION

Age was found to significantly affect SM for both the torso and thigh segment and RG for the torso. Thigh and torso parameters for the young and old age groups are presented in Table 1. Thigh SM was smaller in the older age group, while torso SM was larger in the older age group. Torso RG was smaller in the older age group. These differences represent a variation in mass distribution across age groups. Young females have a higher percent of overall body mass in the thigh segment, and old females have a higher percent of overall body mass in the torso. This trend continues in old and elderly populations as well, as examined in Chambers et al. [8]. Elderly subjects were found to have a significantly higher torso SM than old subjects [8], confirming the finding that torso SM increases with age. The torso segment was found to have a more concentrated mass for the older subgroup, as indicated by a smaller RG. No significant differences in COM locations in any of the segments were found.

CONCLUSIONS

Current anthropometric tables were developed using measurements of young, normal weight adults. However, significant differences were found in the torso and thigh segments between normal-weight, young females and normal-weight, old females, indicating the commonly-used tables do not accurately model subjects in every age category. The difference in thigh SM and torso SM are of particular interest as these segments are commonly used in gait analysis and other biomechanical research. This study underlines a need for age-specific anthropometry tables.

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Table 1. Mean and standard deviation of torso and thigh segment parameters of young and old females. * indicates statistically significant values ($p<0.05$)

	Segment Mass (% of total body mass)		Center of Mass Location (% of segment length)		Radius of Gyration (% of segment length)	
Age	**Torso***	**Thigh***	**Torso**	**Thigh**	**Torso***	**Thigh**
Young	41.5 ± 1.5	11.9 ± 1.0	54.0 ± 0.8	45.6 ± 1.0	28.4 ± 0.5	25.6 ± 0.3
Old	43.4 ± 2.7	11.1 ± 1.0	54.8 ± 1.1	45.6 ± 2.0	27.5 ± 0.7	25.8 ± 0.7