THE UNIVERSITY OF TEXAS MD Anderson Cancer Center | UTHealth The University of Texas Health Science Center at Houston
Graduate School of Biomedical Sciences

Investigation On the Use of 3D Age-Scaling Functions (ASF) to Scale Whole-Body Regions to Any Arbitrary Age

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Introduction

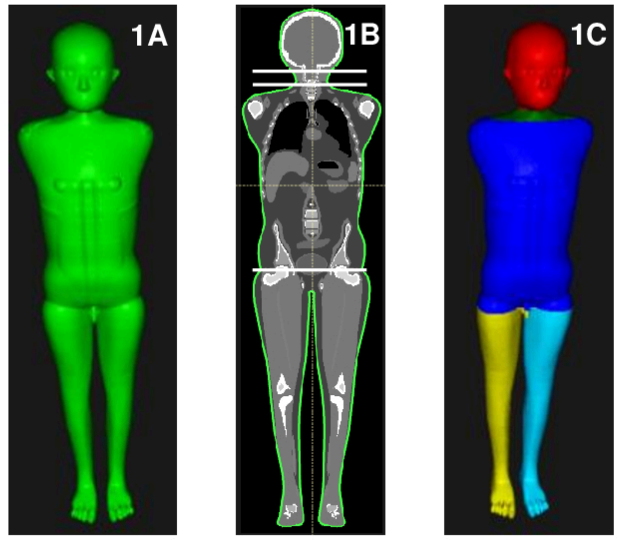
Purpose: Our in-house computational phantom uses age-scaling functions (ASF) that account for non-uniform growth by uniquely scaling each body region to any age (newborn-to-adult) in 3D[1,2,3].

Our *goal* was to determine if these ASFs can be used to scale human anatomy computed tomography (CT)-images from one age to another and evaluate if age-scaled anatomy is representative of growth between ages. The scaled phantom can be used for late effects studies in which dose reconstructions vary with patient's age and anatomy.

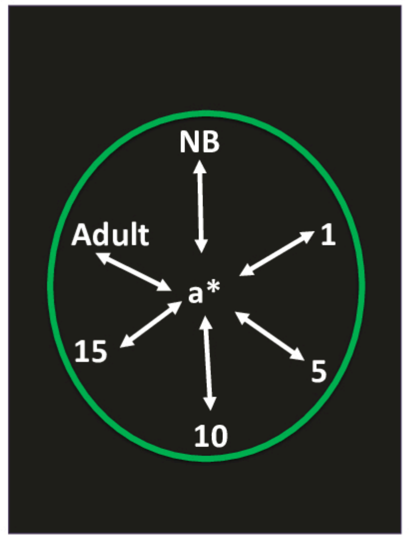
Specific Aims

1. Separate the whole-body contours of the University of Florida/ National Cancer Institute (UF/NCI)[4] male and female phantoms of ages newborn (NB or 0.1), 1, 5, 10, 15 and 18 into body regions (i.e., head, neck, trunk, and legs)
2. Scale the body regions from one age to another using ASFs
3. Validate the scaling by calculating Dice similarity coefficients (DSCs) and Hausdorff distances (HDs) for each scaled structure

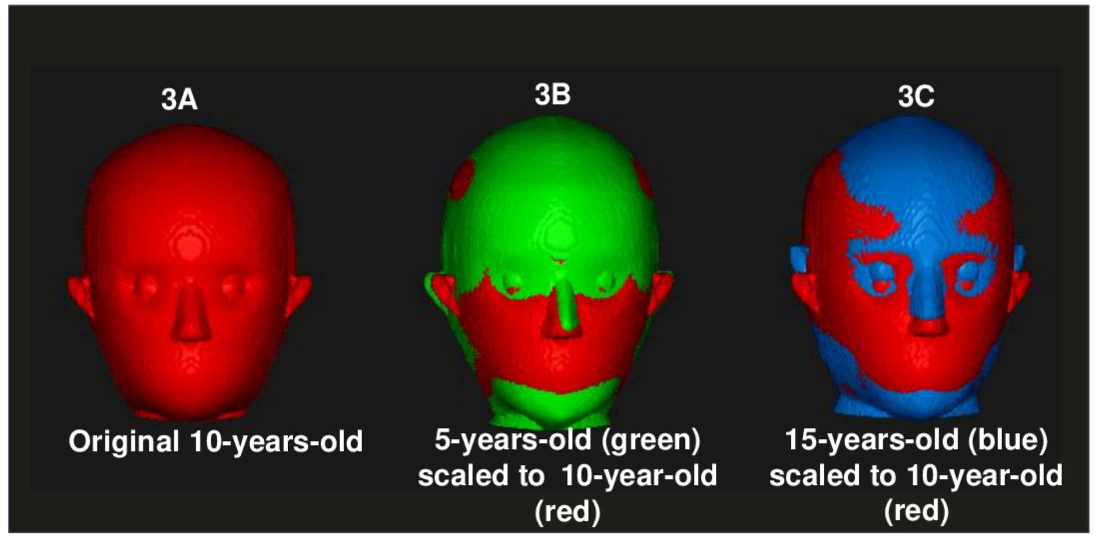
Methods



Step 1: Separation of whole-body contours (using bony anatomical landmarks (1A-B) of UF/NCI phantoms into head, neck, trunk, and legs as shown in 1C. This is performed for all ages*



Step 2: Each body region was scaled separately to all other ages and co-registered with their original contours.
**a (age) is NB, 1, 5, 10, 15, 18*



Step 3: Registration of scaled body regions with the original body regions. Head of a 10-year-old male phantom (A) co-registered with upscaled 5-year-old head (B) and downscaled 15-year-old (C) head.

Results: Dice Similarity Coefficients (DSC)

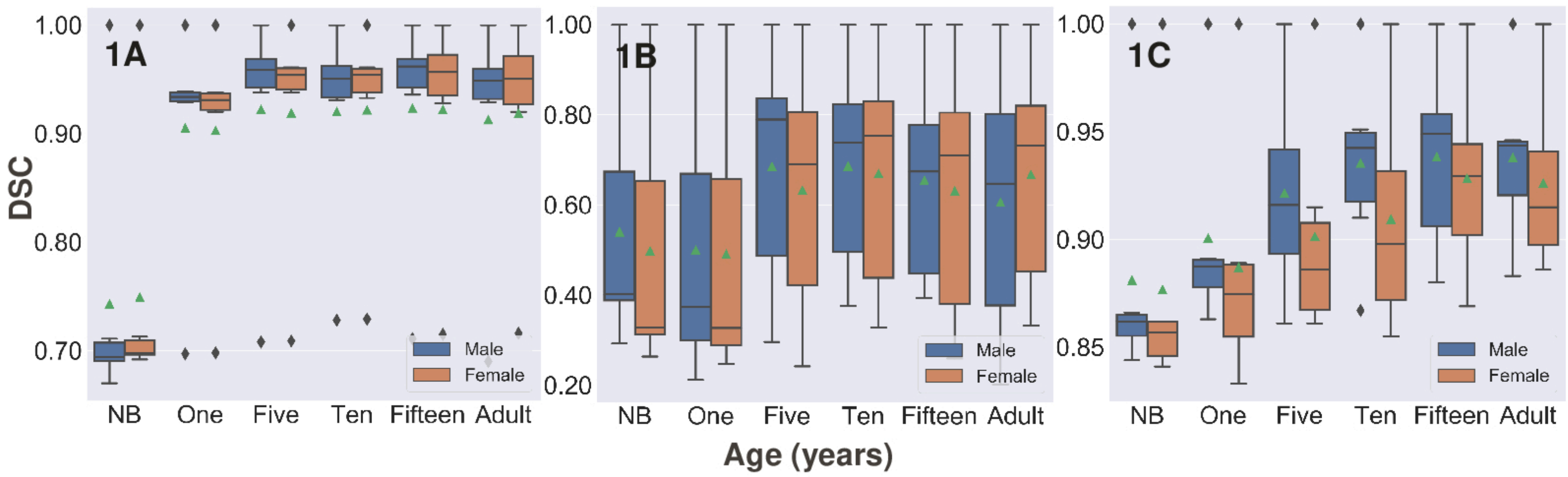


Figure 1. DSC distribution of head (1A), neck (1B) and trunk (1C). DSCs for males showed better agreement compared with females. The outliers in 1A and 1C correspond to scaling involving newborn. DSCs of necks are lower as necks of NB and 1-year-old are not well separated in superior-inferior direction.

Results: Hausdorff Distance (HD)

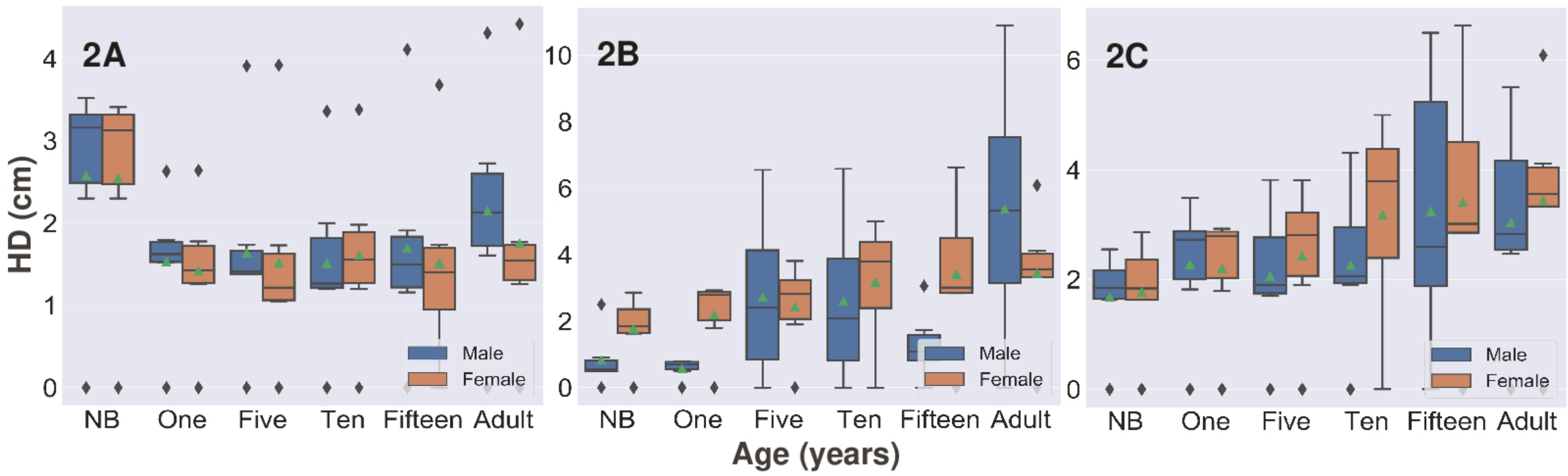


Figure 2. HD distribution of head (2A), neck (2B) and trunk (2C). A larger separation between 1st and 3rd quartiles are due to shift in the nose and ear position after scaling 2A. Higher values of neck HD is explained by the error in the neck structures. This is also reflected in 1B and 2B.

Results: Tabulated Averages

Table 1: Average DSCs and HDs of male and female with their range for head, neck and trunk

	DSC	HD (cm)
Head	0.89 (0.67-1.00)	1.79 (0.0-4.31)
Neck	0.60 (0.20-1.00)	2.28 (0.0-10.86)
Trunk	0.91 (0.84-1.00)	2.59 (0.0 – 6.50)

Discussion and Conclusion

We demonstrated that our ASFs can be used to scale human anatomy CT-images from one age to another and that age-scaled anatomy is representative of growth that occurs between ages

- Head and neck discrepancies are attributed to:
  - Inadequate separation/delineation of those regions from the adjacent regions
  - Flexion of NB neck towards chest

References

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4. Lee C et al. 2010 The UF family of reference hybrid phantoms for computational radiation dosimetry *Phys Med Biol* 55 339–63 10.1088/0031-9155/55/2/002

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