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PREDICTION OF THE RIB CAGE VOLUME AND THORAX DENSITY FROM ANTHROPOMETRIC DATA.

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INTRODUCTION

Rib cage volume and thorax density are useful both for clinical issues (Sverzellati et al. 2013) and for multi-segmental body modeling. In the latter case mean density is generally assumed, using data from Dempster et al (Dempster 1955), which could be over-evaluated due to the lack of consideration of lung density. Bi-planar X-Ray system (Dubousset et al. 2010) combined with 3D reconstruction allows to get both the rib cage and the external body shape. The aim of this study is to estimate the rib cage volume compared to the thorax volume and to propose a refined thorax density estimation.

METHODS

55 asymptomatic volunteers were considered (35 males, 20 females); mean age: 38.3 y.o. [20-85] and mean body mass index (BMI): 22.9 kg/m² [15.4-29.5]. Head to feet low dose bi-planar X-Rays were acquired using the EOS system (EOS Imaging, Paris, France) followed by performing the 3D reconstructions of the spine, rib cage and external body shape (Humbert et al. 2009; Aubert et al. 2014; Nérot et al. 2015) (Figure 1). Bone, Rib cage and thorax volumes (TV) were computed (from T1 to T12 levels). Lung volume was estimated as the inner rib cage volume (RCV) minus the heart volume computed from the literature (Badouna et al. 2012). Multi-linear regression was considered to search for correlation between RCV and regressors such as TV, BMI, Age and Gender. Gender was set to 1 for Male subject and 0 for Female subject. Criteria to determine the ideal number of regressors were: the leave-one-out-error (LOOE), the R-squared statistics (R²), the p-value (pval) and the standard error of estimate (SEE). Moreover, global thorax density was calculated using literature reported densities of each component (bone, lung, heart and soft tissues), and their respective calculated volumes.

RESULTS

Mean RCV was 7793 cm³ (SD: 1675) and mean reconstructed TV was 18020 cm³ (SD: 4528). The most relevant predictive equation was: $RCV (cm^3) = 0.336 \cdot TV (cm^3) + 151.4 \cdot Gender + 1609.2$.

Prediction of the RCV was significant with $p < 0.05$ and $R^2 = 0.88$. SEE and LOOE were respectively 7.33 and 7.83 of the mean RCV. Mean density was 0.80 g/cm³ (SD 0.007).

DISCUSSION

This study brings a new evolution of the rib cage volume from anthropometric parameters. This could serve as a reference when studying rib cage variability for pathological population.

It also allows providing a refined value of global thorax density, which is lower than the one proposed by Dempster et al. (0.92 g/cm³), and could be more relevant for multibody human models.

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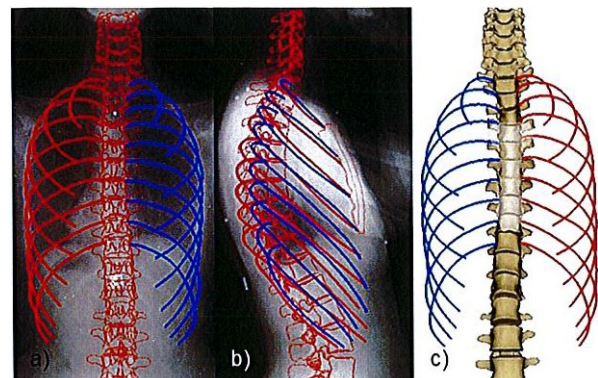


Figure 1: a) & b) Bi-planar radiographies with reconstructed spine and rib cage. c) 3D reconstruction of the spine and rib cage.