Letter to the Editor

Estimating breast mass-density: A retrospective analysis of radiological data

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To the Editor:

Radiological breast density has been widely investigated within the literature due to the reported association with breast cancer risk (1). However, measurements of radiological density do not directly correspond to the mass-density of the breast, which is difficult to assess *in vivo* (2). The lack of an established mass-density estimate for the female breast has led to the wide approximation of this variable within the literature, with estimates ranging from 780 $kg.m^{-3}$ (3) to 2250 $kg.m^{-3}$ (4).

Technological developments within medical imaging have enabled detailed quantitative information to be obtained regarding breast composition, specifically the proportions of fat and glandular tissue within the breast (1). Quantitative radiological data on breast composition could be combined with density values for the breast's constituent tissues to estimate the mass-density of the breast as a whole. The reported mass-densities of human body fat and cellular matter (representing glandular tissue) are 900 $kg.m^{-3}$ (5) and 1057 $kg.m^{-3}$(6) respectively. It follows that the mass-density of the breast as a whole should lie between the mass-densities of these tissues, and that previously published estimates that lie outside of this range may not be appropriate. Potentially inaccurate breast mass-density estimates may have implications for several areas of breast research. For example, incorrect mass-density values may limit the accuracy of mathematical breast models used to predict breast deformation during medical imaging or surgery (7). Additionally, calculation of dependant biomechanical variables, such as breast mass, momentum, or force, may be affected by the value used to represent breast mass-density (3). This study represents the first attempt to calculate an improved breast mass-density estimate based on a retrospective analysis of radiological data.

Quantitative radiological breast density data was collated from studies published in English using the Medline database. Studies were excluded if measurements were made qualitatively or using categories; if assumptions regarding density were made; if insufficient data were presented; or if data were obtained on females aged less than 18 years. For longitudinal studies that presented more than one measurement on the same participant, the baseline data values were used for the calculation of mass-density within this study. Estimates of breast mass-density (ρ_B) were calculated using equation 1, where A is the proportion of fat in the breast (8). It was assumed that the breast is composed entirely of fat and glandular tissue (fat: ρ_F = 900 kg.m^{-3}; glandular tissue: ρ_G = 1057 kg.m^{-3}) (5,6).

$$\rho_B = A\,\rho_F + (1 - A)\rho_G \qquad 1$$

For each selected study, breast mass-density was calculated using the mean reported radiological breast density. Linear regression was used to investigate the presence of a trend in breast mass-density values calculated from radiological data published over the specified data collection time span.

Ninety nine studies met the inclusion criteria, with data spanning a 26 year period and incorporating 111,123 measurements on women aged between 18 and 90 years. The calculated mass-density of the breast from each study ranged from 911 kg.m^{-3} to 999 kg.m^{-3} with an overall mean mass-density value of 945 kg.m^{-3} (Fig. 1). Results demonstrated a decreasing trend in breast mass-density over the 26-year data sample (R^2 = 0.181).

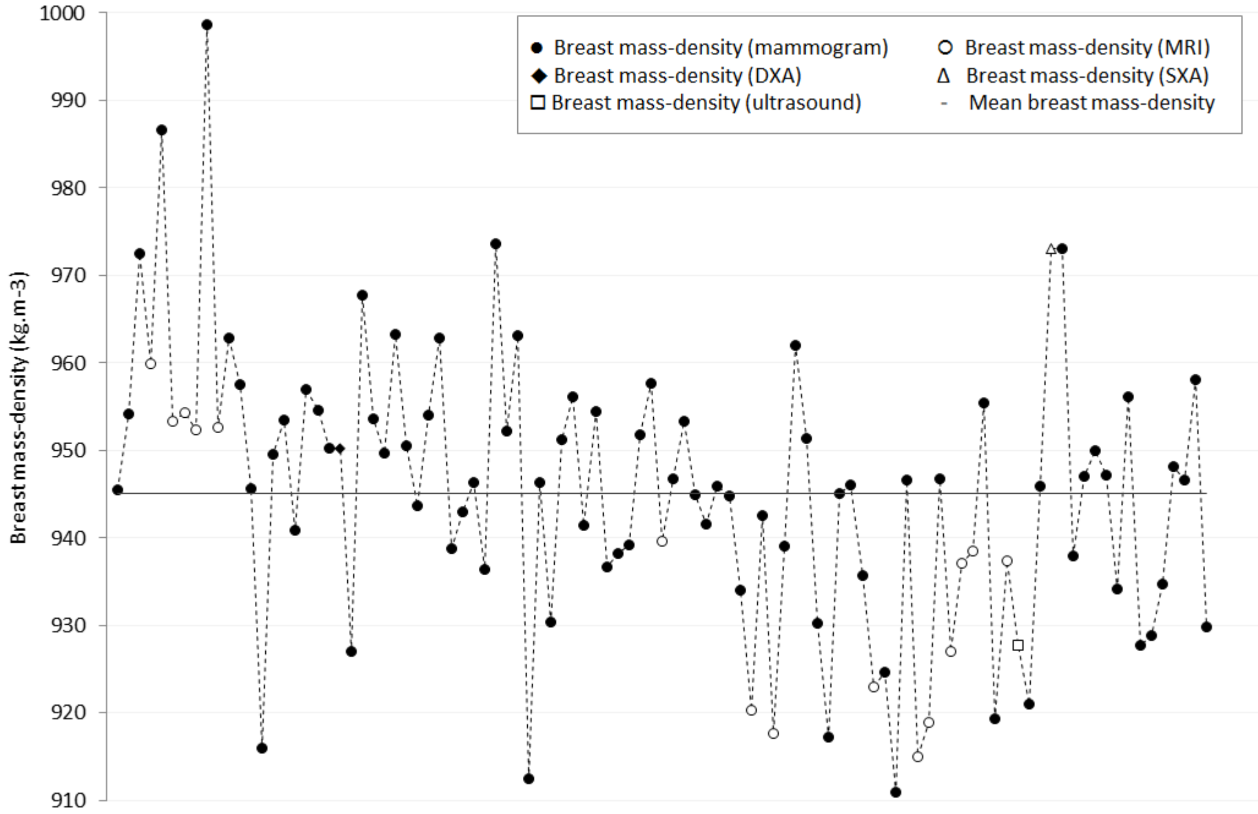

Figure. 1. Mean breast mass-density calculated from published quantitative radiological data, in chronological order, compared to the overall mean breast density.

Since these results encompass data from a large sample of women, spanning a wide age range, it was proposed that most women's breast mass-density would lie within the reported range, and that the mean calculated mass-density provides a more accurate approximation than previously published estimates. The trend for decreasing breast mass-density over the 26-year sample may have been caused by two contributing factors. Initial attempts to quantify radiological breast density from mammographic images used hand-drawn analysis techniques, whereas recent analysis methods have become increasingly computerised leading to improved precision and reduced human error in radiological breast density measurements (1). The semi-automated nature of modern radiological assessment methods may produce lower estimates of radiological breast density due to improved segregation of the breast tissue in regions where fat and glandular tissue are interspersed. Higher breast mass-densities calculated from early studies may therefore have been influenced by increased measurement error. On the other hand, a genuine trend for decreasing breast density may have been present in the 26-year sample due to increasing worldwide obesity rates (9). Increasing obesity levels may have led to higher percentages of fatty tissue in the modern breast, resulting in lower estimates of breast mass-density from the more recent breast data.

Although it was proposed that the mean breast mass-density value calculated in this study represents an improvement on the values currently available within the literature, it was acknowledged that two key assumptions were employed during the calculation process. Firstly, that the breast was entirely composed of fat and glandular tissue. Disregard for other tissues within the breast (e.g. breast skin) may have resulted in inaccuracies when calculating breast mass-density. Secondly, that the results presented in each selected study provided accurate quantitative data for the breast. Concerns have previously been raised regarding the validity of using 2D mammographic images to assess the 3D composition of the breast (2). However, comparison between breast mass-density values calculated from mammographic and MRI (3D) data demonstrate that both data sets produced results that lay either side of the overall mean breast mass-density value.

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