The Effect of Change in Body Mass Index on Volumetric Measures of Mammographic Density

Vicki Hart1,2, Katherine W. Reeves2, Susan R. Sturgeon2, Nicholas G. Reich2, Lynnette Leidy Sievert3, Karla Kerlikowske4, Lin Ma4, John Shepherd5, Jeffrey A. Tice4, Amir Pasha Mahmoudzadeh5, Serghei Malkov5, and Brian L. Sprague1

Abstract

Background: Understanding how changes in body mass index (BMI) relate to changes in mammographic density is necessary to evaluate adjustment for BMI gain/loss in studies of change in density and breast cancer risk. Increase in BMI has been associated with a decrease in percent density, but the effect on change in absolute dense area or volume is unclear.

Methods: We examined the association between change in BMI and change in volumetric breast density among 24,556 women in the San Francisco Mammography Registry from 2007 to 2013. Height and weight were self-reported at the time of mammography. Breast density was assessed using single X-ray absorptiometry measurements. Cross-sectional and longitudinal associations between BMI and dense volume (DV), non-dense volume (NDV), and percent dense volume (PDV) were assessed using multivariable linear regression models, adjusted for demographics, risk factors, and reproductive history.

Introduction

High mammographic density is a risk factor for primary breast cancer (1–4). Mammographic density is typically assessed by comparing the proportion of dense and non-dense area measured on a two-dimensional mammographic image. Recently, novel methods that incorporate the thickness of the breast have been proposed as enhancements to area assessment (5–8). Single X-ray absorptiometry (SXA), which calculates breast volume using a calibrated phantom included in the mammographic image, has demonstrated equivalent breast cancer risk prediction to area methods (8). Some associations between breast cancer risk factors and mammographic density differ between area and volumetric methods. In particular, higher body mass index (BMI) has been associated with lower dense area (DA; refs. 2, 9, 10) but higher dense volume (DV; refs. 7, 11–13) in cross-sectional analyses.

Neither mammographic density nor BMI are static values. It is understood that percent dense area (PDA) decreases during aging, and that the rate of decline is greatest during the menopausal transition (14–16). It is unclear how simultaneous change in BMI influences the decline in density. A limited number of longitudinal studies have shown an inverse relationship between change in BMI and change in PDA (17, 18) and have reported either a null (17) or positive (18) association between change in BMI and change in absolute DA. To date, no studies have evaluated the longitudinal association of change in BMI on change in mammographic density using volumetric methods, and it is unclear if the difference between area and volumetric assessment seen in cross-sectional analyses will affect this longitudinal relationship. This association must be established to understand the impact of adjusting for changing BMI in longitudinal studies of volumetric density and breast cancer risk.

We examined the cross-sectional and longitudinal associations between BMI and mammographic density using the SXA volumetric density measurement method. Our analysis was conducted in the San Francisco Mammography Registry.
a decrease in percent dense volume (PDV).

Certiﬁcation of Conﬁdentiality and other protections for the identities of women, physicians, and facilities.

At the time of screening mammogram at an SFMR facility, women completed a self-administered, one-page questionnaire providing basic demographic, risk factor, and reproductive history information. Women were given the option to opt out of participating in research, and the opt-out rate for SFMR facilities averages 1.8% (range, 0.8%–3.3%). Women were eligible for the current analysis if they were aged 18 and older with two or more mammograms in 2007 to 2013 spaced at least 9 months apart. Women with a history of breast cancer, mastectomy, breast implants, or breast surgery were excluded. Mammograms that were performed within 6 months of a breast cancer diagnosis were also excluded.

The eligible study sample consisted of 30,000 women who contributed 75,489 mammograms. A total of 1,149 mammograms were removed due to poor placement of the SXA phantom in the mammographic image, resulting in volumetric density measurement error. As a result, 368 women had only one mammogram to contribute to the analysis and were further excluded. Women were excluded if their reported height between mammograms varied by more than 3 inches (470 women, 1,197 mammograms). These exclusions resulted in a study population of 24,556 women who contributed 61,653 mammograms.

BMI assessment

Women self-reported their current height in inches and weight in pounds at the time of their screening mammogram. These data were used to calculate BMI (weight in kg divided by the square of the height in meters). BMI was analyzed both in its original continuous form and categorized according to World Health Organization guidelines: <18.5 kg/m² for underweight, 18.5–<25 kg/m² for normal weight, 25–<30 kg/m² for overweight, and ≥30 kg/m² for obese.

Volumetric breast density assessment

DV and NDV were measured using the SXA technique and software developed by UCSF investigators (version 7.1). Total breast volume was computed by adding DV and NDV, and PDV was calculated by dividing DV by total breast volume. A complete description of the specific SXA imaging methods, development, and calibration processes has been previously published (19, 20). Briefly, a specialized SXA phantom was inserted in the corner of the x-ray ﬁeld during the mammography examination. The phantom was designed to conform to the same thickness of the breast and was composed of materials mimicking known fat/glandular content. The placement of the phantom was speciﬁcally designed to not interfere with standard screening procedures and to account for tilt of the compression surfaces during the examination (8, 20). Grayscale values for the pixels in the breast image were then compared with the grayscale values in the phantom, and unique volumes of adipose (non-dense) and ﬁbroglandular (dense) breast tissue were determined from the two-dimensional mammographic image (20).

SXA deﬁnes the total lack of dense breast tissue (i.e., 0% density) as pure fat as opposed to adipose, which contains fat and water. Therefore, in the division of breast tissue into dense and non-dense content, the SXA method includes water from adipose tissue in the ﬁbroglandular (dense) content. This is analogous to fat-saturated MRIs that have been used to measure breast density in young women (21), but in contrast with other volumetric and area techniques. However, direct comparisons demonstrate that SXA measures are highly correlated with area density measures (13) and with other volumetric density techniques (22). The mean difference in PDV measurements between repeat readings using the SXA technique has been demonstrated to be less than 2.5% (8). Further, SXA has been monitored over time using a quality control phantom to ensure stability of measurements with no systematic changes observed (13, 23).

Covariate assessment

Data on demographics, reproductive history, family history, and other breast cancer risk factors were obtained via the one-page questionnaire administered at the time of the screening mammogram. The covariates selected as potential confounders or effect modiﬁers were based on known predictors of mammographic density and availability within the SFMR data. Covariates assessed at the time of the ﬁrst screening mammogram and considered unchanging included age at ﬁrst mammogram, race, ever given birth, age at ﬁrst birth, education, ﬁrst-degree family history of breast cancer, and prior history of breast biopsy. Time-varying covariates included age at current mammogram, menopausal status, postmenopausal hormone therapy (HT) use, and hormonal birth control use. Consistent with previous analyses using BCSC deﬁnitions, women were considered postmenopausal if they reported that menstrual periods had stopped for more than 12 months, if they reported a bilateral oophorectomy, or if they were 55 years of age or older. Women were otherwise considered premenopausal. Current use of postmenopausal HT and hormonal birth control were assessed at the time of the screening mammogram. The questionnaire did not include speciﬁc formulations of HT or history of prior use.

Statistical analysis

There were no statistically signiﬁcant differences in distributions of density, BMI, or covariates between women who were excluded from the analysis and those who were retained (data not shown). We calculated descriptive statistics for demographic and reproductive characteristics. We assessed the cross-sectional association between BMI at ﬁrst mammogram and volumetric density...
measures at first mammogram using a generalized linear regression model adjusted for all covariates. For the longitudinal analyses, we estimated the annual change in BMI and volumetric density measures as \( \Delta \text{value}/\Delta \text{time, days} \times 365.25 \text{ days/year} \) to account for varying time lapse between mammograms. We categorized BMI change over the study period based on change from initial BMI (at first mammogram): \( \geq 10\% \) loss, \( 5\% \) to \( 10\% \) loss, stable within \( \pm 5\% \), \( 5\% \) to \( 10\% \) gain, and \( > 10\% \) gain. We used ANOVA to compare the percent gain/loss based on initial BMI, using the underweight or normal range \(<25 \text{ kg/m}^2\) as the reference. We summarized the annual change in each volumetric density measure over the study period and calculated adjusted means and confidence interval (CI) using generalized linear regression.

We assessed the association between annual change in BMI and annual change in DV, NDV, and PDV using a random intercept mixed effects model. The mixed effects model is appropriate for data in which each subject may contribute a varying number of observations, and the random intercept allows for individual subject variation in baseline density measures \(24\). The model was adjusted for all covariates listed above, and time-varying factors were updated at each successive mammogram. We stratified all analyses by menopausal status because the association between BMI and breast cancer risk has been shown to vary between pre- and postmenopausal women \(25,26\). Because previous analyses have shown that declines in PDA over the menopausal transition may be modified by initial BMI and postmenopausal HT use \(14,15\), we tested for effect modification by BMI at first mammogram and by HT use, consistent user, initiated use during the study period, discontinued use during the study period). We further considered effect modification by race/ethnicity, since BMI and the distribution of breast density have been shown to differ by race/ethnicity \(27\).

All analyses were performed using SAS Version 9.2 (SAS Institute).

**Results**

A majority of the study population was Caucasian (66.3%) with 25.1% Asian or Pacific Islander (Table 1). The average age at the first mammogram was 56.6 years, and 41% of women were postmenopausal. Over half of the study population was classified as normal weight at the first mammogram (62.6%), whereas 24.2% were classified as overweight and 10.9% were classified as obese. About 12% of the study population was using postmenopausal HT at the time of the first mammogram. Women contributed an average of 2.54 mammograms, and the average time between first and last mammogram was 2.4 years (range, 0.8–5.9 years).

In the fully adjusted cross-sectional analysis, BMI at first mammogram was positively associated with both DV \( (\beta = 2.95 \text{ cm}^2; 95\% \text{ CI}, 2.69–3.21) \) and NDV \( (\beta = 51.03 \text{ cm}^3; 95\% \text{ CI}, 49.93–52.13) \) at first mammogram, and was inversely related to PDV at first mammogram \( (\beta = -2.03\%; 95\% \text{ CI}, -2.09, -1.98; \text{ Table 2}) \). The associations with NDV and with PDV were stronger among women who were premenopausal at first mammogram compared with those who were postmenopausal \(P\text{ value for interaction by menopausal status: } P = 0.79\text{ for DV, } P < 0.01\text{ for NDV, } P < 0.01\text{ for PDV})\). In cross-sectional analysis, no significant interaction by postmenopausal HT use \(P\text{ value for interaction by HT use: } P > 0.15\text{ for DV, NDV, and PDV})\) or by race \(P\text{ value for interaction by race: } P > 0.28\text{ for DV, NDV, and PDV})\) was observed.

A majority of women maintained stable weight within \( \pm 5\% \) of their initial BMI during the study period \(73.6\%; \text{ Table 3}\). A greater proportion of women who were initially overweight or obese lost over 5\% of their initial BMI compared with those who were initially underweight or normal BMI \(<25 \text{ kg/m}^2\) \(P < 0.01\). Among premenopausal women, a higher proportion of those who were initially overweight or obese gained over 5\% of their initial BMI compared with those who initially had BMI <25 kg/m\(^2\) \(P = 0.01\). No difference in weight gain by initial BMI was observed among postmenopausal women \(P = 0.86\).

The mean annual change in DV, NDV, and PDV over the study period was \(-0.56 \text{ cm}^2\text{/year}, 6.09 \text{ cm}^3\text{/year}, and -0.81\%\text{/year}, respectively\). A 1 kg/m\(^2\) annual increase in BMI was associated with a statistically significant decrease in DV \( (\beta = -1.01 \text{ cm}^2\text{/year}; 95\% \text{ CI, } -1.59, -0.42) \), increase in NDV \( (\beta = 26.2 \text{ cm}^3\text{/year}; 95\% \text{ CI, } 23.5–28.9) \), and decrease in PDV \( (\beta = -1.17\%\text{/year}; 95\% \text{ CI, } -1.31, -1.04; \text{ Table 4}) \). These associations remained significant after adjustment for change in total breast volume (Supplementary Table S1). When stratified by menopausal status and initial BMI, the significant annual decrease in DV with increasing BMI was observed among premenopausal women who were initially overweight or obese, but not among those who were initially underweight or normal BMI \(P\text{ value for interaction by initial BMI: }
NOTE: Stratified results exclude 467 women with unknown menopausal status at first mammogram. P value for interaction by menopausal status: \( P < 0.07 \) for DV, \( P < 0.01 \) for NDV, and \( P < 0.01 \) for PDV.

Discussion

Consistent with our expectations, we observed positive cross-sectional relationships between BMI and both DV and PDV, and an inverse cross-sectional relationship between BMI and PDV. We further observed that DV and PDV declined on average over the study period, and that a longitudinal increase in BMI was associated with an accelerated decrease in PDV. However, contrary to our expectations, we found that a longitudinal increase in BMI was also associated with an accelerated decrease in DV. This finding was consistent among pre- and postmenopausal women and was strongest among premenopausal women who were initially overweight or obese.

Our findings of a positive cross-sectional relationship between BMI and DV are consistent with studies using the SXA method (13) and other volumetric techniques (11, 12, 7), but in contrast with studies using area assessment (10, 28). Differences in study populations may contribute to the difference in the association of BMI and DV between area and volumetric methods; however, two studies (7, 13) compared this association using area and volumetric density measured from the same mammographic images and confirmed this contrasting result. This indicates that measurement method may be largely responsible for the difference. Unlike area methods, which rely on a dichotomous separation of dense and non-dense area, the volumetric SXA method calculates a continuous value for DV based on the comparison of each pixel on the mammographic image to a known phantom (20). Continuous assessment of DV may provide a more accurate measurement of dense tissue than dichotomous area methods. Further, the SXA method includes water in adipose tissue in its calculation of DV (8). A recent study comparing area and SXA volume measurements reported that correlations between DA and DV were stronger among lean women than among obese women as a result of this inclusion (13). The contribution of water from adipose tissue may partially account for the positive cross-sectional association between BMI and DV.

Our observed 1.17% annual decline in PDV associated with a unit annual increase in BMI is similar in magnitude to the two previous studies of change in BMI and PDA over time, which reported annual declines of 0.36% (17) and 1.44% (18). However, our observation of a decrease in DV with increasing BMI does not support their findings of no association (17) or positive

Table 2. Cross-sectional association between BMI and volumetric density measures at first mammogram; BCSC SFMR 2007-2013

<table>
<thead>
<tr>
<th>N (women)</th>
<th>Mean (SD) at first mammogram</th>
<th>( \beta ) (SE)</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All women</td>
<td>24,556</td>
<td>142.3 (76.7)</td>
<td>2.95 (0.13)</td>
<td>2.69–3.21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>416.8 (331.0)</td>
<td>51.03 (0.56)</td>
<td>49.93–52.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td>32.5 (99.5)</td>
<td>−2.03 (0.03)</td>
<td>−2.09, to −1.98</td>
</tr>
<tr>
<td>Premenopausal at first mammogram</td>
<td>8,355</td>
<td>166.7 (83.7)</td>
<td>3.05 (0.27)</td>
<td>2.51–3.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>327.1 (305.2)</td>
<td>53.64 (0.98)</td>
<td>51.72–55.55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>42.3 (21.3)</td>
<td>−2.88 (0.06)</td>
<td>−3.00, to −2.77</td>
</tr>
<tr>
<td>Postmenopausal at first mammogram</td>
<td>15,734</td>
<td>129.1 (69.1)</td>
<td>2.97 (0.16)</td>
<td>2.67–3.28</td>
</tr>
<tr>
<td></td>
<td></td>
<td>465.6 (336.2)</td>
<td>49.96 (0.69)</td>
<td>48.61–51.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27.3 (96.2)</td>
<td>−1.67 (0.03)</td>
<td>−1.75, to −1.61</td>
</tr>
</tbody>
</table>

NOTE: Stratified results exclude 467 women with unknown menopausal status at first mammogram. P value for interaction by menopausal status: \( P < 0.07 \) for DV, \( P < 0.01 \) for NDV, and \( P < 0.01 \) for PDV.

Table 3. Change in BMI from first mammogram to last mammogram, stratified by menopausal status and by BMI at first mammogram (kg/m²; N = 24,556); BCSC SFMR 2007-2013

<table>
<thead>
<tr>
<th>N (women)</th>
<th>&gt;10% loss, N (%)</th>
<th>5%–10% loss, N (%)</th>
<th>Stable, N (%)</th>
<th>5%–10% gain, N (%)</th>
<th>&gt;10% gain, N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All women</td>
<td>24,556</td>
<td>839 (3.4)</td>
<td>2,177 (8.9)</td>
<td>18,059 (73.6)</td>
<td>2,584 (10.5)</td>
</tr>
<tr>
<td>Premenopausal (all exams)</td>
<td>7,266</td>
<td>520 (7.2)</td>
<td>45 (0.9)</td>
<td>271 (5.2)</td>
<td>4,163 (80.0)</td>
</tr>
<tr>
<td>Underweight or normal: &lt;25</td>
<td>5,203</td>
<td>1,487 (27.1)</td>
<td>71 (4.8)</td>
<td>172 (11.6)</td>
<td>985 (66.0)</td>
</tr>
<tr>
<td>Overweight: 25–&lt;30</td>
<td>576</td>
<td>57 (9.9)</td>
<td>65 (11.3)</td>
<td>536 (61.8)</td>
<td>35 (6.3)</td>
</tr>
<tr>
<td>Obese: 30+</td>
<td>15,715</td>
<td>9,682</td>
<td>168 (1.7)</td>
<td>735 (7.6)</td>
<td>7,489 (77.4)</td>
</tr>
<tr>
<td>Underweight or normal: &lt;25</td>
<td>4,093</td>
<td>259 (5.0)</td>
<td>513 (12.5)</td>
<td>2,787 (68.3)</td>
<td>417 (10.2)</td>
</tr>
<tr>
<td>Overweight: 25–&lt;30</td>
<td>1,940</td>
<td>191 (9.9)</td>
<td>272 (14.0)</td>
<td>1,224 (63.1)</td>
<td>181 (9.3)</td>
</tr>
</tbody>
</table>

NOTE: Stratified results exclude 467 women with unknown menopausal status at one or more mammogram(s) and 1,089 women who transitioned from pre- to postmenopausal during the study period.
association (18) between change in BMI and DA. The association between change in BMI and change in DA observed by Reeves and colleagues (17) was in the same direction as our findings, despite adjustment for total breast volume in the model did not change the association between change in BMI and change in DV. It is unlikely that the inclusion of adipose water in the SXA technique has been shown to be consistent over time (18, 19). The inverse association between BMI and DV was seen among postmenopausal women, but this association was stronger among women who were associated with increased breast cancer risk in a case-control analysis of 864 women using SXA (8). Women in the highest quintiles of DV (192 ± cm³) had significantly higher risk compared with those in the lowest quintile (<122 cm³).

We observed that the longitudinal association between BMI and DV was strongest among premenopausal women who were initially overweight or obese. These women were more likely to gain more than 5% of their initial weight during the study period than their lean counterparts. It is possible that the association between change in BMI and DV was easiest to observe among women who gained more weight, since a larger change in BMI may allow us to see the associated small change in DV. Further, water has been estimated to account for only 8% (21) to 20% (31) of adipose tissue volume. The inclusion of adipose water in the SXA technique has been shown to be consistent over time (18, 19). However, future studies using SXA are necessary to confirm our findings. Our study is strengthened by the large number of participants and the concurrent collection of height and weight data at the time of the screening mammogram. In addition, volumetric density was assessed using a validated method that has been found to similarly predict breast cancer risk compared with area assessment (8). Our results must be interpreted in context of the study limitations, however. First, height and weight were self-reported. Although we observed a significant annual decrease in DV, it is understood that the number and size of breast lobules decrease with increasing age, known as breast tissue involution (29, 30), which is consistent with a decrease in DV over time. Age remained a significant factor in our multivariable models for DV that included change in BMI as well as menopausal status and parity, both of which have been associated with the rate of breast involution (29). Thus, breast involution with age may partially explain our longitudinal findings, despite adjustment for total breast volume in the model did not change the association between change in BMI and change in DV. It is unlikely that the inclusion of adipose water in the SXA technique has been shown to be consistent over time (18, 19). However, future studies using SXA are necessary to confirm our findings.

The associations between change in BMI and change in volumetric mammographic breast density, stratified by menopausal status and BMI at first mammogram (kg/m²), BCSC SFMR 2007–2013

Table 4. Association between annual change in BMI and annual change in volumetric mammographic breast density, stratified by menopausal status and BMI at first mammogram (kg/m²), BCSC SFMR 2007–2013

<table>
<thead>
<tr>
<th>BMI at first mammogram</th>
<th>N (women)</th>
<th>Annual change in dense breast volume (cm³ per year)</th>
<th>Annual change in non-dense breast volume (cm³ per year)</th>
<th>Annual change in percent dense breast volume (% per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (SE)</td>
<td>95% CI</td>
<td>P value</td>
<td>β (SE)</td>
</tr>
<tr>
<td>All women</td>
<td>24,556</td>
<td>−1.01 (0.30) to −0.139, to −0.42 0.001</td>
<td></td>
<td>−1.17 (0.07) to −1.31, to −1.04 &lt;0.001</td>
</tr>
<tr>
<td>Premenopausal (all exams)</td>
<td>7,266</td>
<td>−1.73 (0.75) to −5.37, to −0.50 0.02</td>
<td></td>
<td>32.64 (2.65) to 27.47, to 77.80 &lt;0.001</td>
</tr>
<tr>
<td>Underweight or normal: &lt;25</td>
<td>5,203</td>
<td>0.92 (0.74) to −0.52, to 2.37 0.21</td>
<td></td>
<td>31.71 (2.65) to 25.97, to 36.37 &lt;0.001</td>
</tr>
<tr>
<td>Overweight: 25 &lt;30</td>
<td>1,487</td>
<td>−2.71 (0.98) to −4.63, to −0.80 0.01</td>
<td></td>
<td>33.56 (4.50) to 24.74, to 42.37 &lt;0.001</td>
</tr>
<tr>
<td>Obese: 30+</td>
<td>576</td>
<td>−3.29 (1.90) to −7.01, to 0.44 0.08</td>
<td></td>
<td>32.63 (6.48) to 19.93, to 45.32 &lt;0.001</td>
</tr>
<tr>
<td>Postmenopausal (all exams)</td>
<td>15,715</td>
<td>−0.74 (0.32) to −1.36, to −0.12 0.02</td>
<td></td>
<td>24.08 (1.63) to 20.89, to 27.27 &lt;0.001</td>
</tr>
<tr>
<td>Underweight or normal: &lt;25</td>
<td>9,682</td>
<td>−0.32 (0.32) to −0.95, to 0.31 0.32</td>
<td></td>
<td>22.93 (2.95) to 17.15, to 28.70 &lt;0.001</td>
</tr>
<tr>
<td>Overweight: 25 &lt;30</td>
<td>4,093</td>
<td>−0.94 (0.66) to −2.23, to 0.36 0.16</td>
<td></td>
<td>31.09 (1.73) to 27.70, to 34.47 &lt;0.001</td>
</tr>
<tr>
<td>Obese: 30+</td>
<td>1,940</td>
<td>−0.53 (0.61) to −1.73, to 0.67 0.39</td>
<td></td>
<td>20.57 (2.56) to 15.55, to 25.58 &lt;0.001</td>
</tr>
</tbody>
</table>

NOTE: Stratified results exclude 486 women with unknown menopausal status at one or more mammograms and 1,089 women who transitioned from pre- to postmenopausal during the study period.

P value for interaction by menopausal status: DV P = 0.43, NDV P = 0.01, PDV P = 0.01.
P value for interaction by BMI at first mammogram among premenopausal women: DV P > 0.05, NDV P = 0.87, PDV P < 0.01; postmenopausal women: DV P = 0.67, NDV P < 0.01, PDV P < 0.01.

*Adjusted for age at first mammogram, age at first birth, education, ever used med (yes/no), first-degree family history of breast cancer, hormone use during study period, menopausal status (all women), and race.

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measures over an average of 2.4 years of follow-up. Although short-term change in BMI may not be strongly associated with breast cancer risk, adult weight gain has been consistently associated with increased risk (33, 34). Thus, change in BMI may be a confounder in long-term longitudinal studies of volumetric density and breast cancer risk; and researchers should consider adjusting for change in BMI to fully understand the independent effect of change in volumetric density on breast cancer risk. Further, longitudinal studies using change in volumetric density as an indicator of changing breast cancer risk should carefully evaluate the potential for confounding by gain or loss in BMI and consider adjustment as necessary. The inverse association we observed between change in BMI and change in DV after adjustment for factors associated with breast involution is not easily explained, and confirmation is required to ensure that our results are not due to chance or an inherent manifestation of our measurement method.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Disclaimer

The content is solely the responsibility of the authors and does not necessarily represent the official views of the NCI or the NIH.

Authors’ Contributions

Conception and design: V. Hart, K.W. Reeves, K. Kerlikowske, B.L. Sprague

Development of methodology: V. Hart, N.G. Reich, K. Kerlikowske, S. Malkov

Acquisition of data (provided animals, acquired and managed patients, provided facilities, etc.): K. Kerlikowske, L. Ma, J. Shepherd, S. Malkov

Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): V. Hart, K. Kerlikowske, L. Ma, J. Shepherd, S. Malkov

Writing, review, and/or revision of the manuscript: V. Hart, K.W. Reeves, S.R. Sturgeon, N.G. Reich, L.L. Sievert, K. Kerlikowske, J. Shepherd, J.A. Tice, S. Malkov, B.L. Sprague

Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): V. Hart, K. Kerlikowske, A.P. Mahmoudzadeh, S. Malkov

Study supervision: B.L. Sprague

Other (analyzing images): A.P. Mahmoudzadeh

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References


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