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Original Contribution

Adult Body Size, Hormone Receptor Status, and Premenopausal Breast Cancer Risk in a Multiethnic Population

The San Francisco Bay Area Breast Cancer Study

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Large body size has been associated with a reduced risk of premenopausal breast cancer in non-Hispanic white women. Data on other racial/ethnic populations are limited. The authors examined the association between premenopausal breast cancer risk and adult body size in 672 cases and 808 controls aged ≥35 years from a population-based case-control study conducted in 1995–2004 in the San Francisco Bay Area (Hispanics: 375 cases, 483 controls; African Americans: 154 cases, 160 controls; non-Hispanic whites: 143 cases, 165 controls). Multivariate adjusted odds ratios and 95% confidence intervals were calculated using unconditional logistic regression. Height was associated with increased breast cancer risk (highest vs. lowest quartile: odds ratio = 1.77, 95% confidence interval: 1.23, 2.53; $P_{\text{trend}} < 0.01$); the association did not vary by hormone receptor status or race/ethnicity. Body mass index (measured as weight (kg) divided by height (m) squared) was inversely associated with risk in all 3 racial/ethnic groups, but only for estrogen receptor– and progesterone receptor–positive tumors (body mass index ≥30 vs. <25: odds ratio = 0.42; 95% confidence interval: 0.29, 0.61). Other body size measures (current weight, body build, adult weight gain, young adult weight and body mass index, waist circumference, and waist-to-height ratio) were similarly inversely associated with risk of estrogen receptor– and progesterone receptor–positive breast cancer but not estrogen receptor– and progesterone receptor–negative disease. Despite racial/ethnic differences in body size, inverse associations were similar across the 3 racial/ethnic groups when stratified by hormone receptor status.

African Americans; body size; breast neoplasms; Hispanic Americans; premenopause; receptors, estrogen; receptors, progesterone

Abbreviations: BMI, body mass index; CI, confidence interval; ER, estrogen receptor; OR, odds ratio; PR, progesterone receptor; WHR, waist-to-hip ratio; WHtR, waist-to-height ratio.

Body size is an important and potentially modifiable risk factor for breast cancer (1–4). Associations have been shown to vary greatly across population groups according to menopausal status, menopausal hormone therapy use, and tumor hormone receptor status. In premenopausal women, high body mass index (BMI) is associated with a decreased risk of breast cancer, although growing evidence suggests that the inverse associations are limited to women with tumors that are estrogen receptor– and progesterone receptor–positive (ER+/PR+) (5–10).

Given that most epidemiologic studies of associations between body size and premenopausal breast cancer risk have been conducted in non-Hispanic white women, it is unclear whether these associations hold among other racial/ethnic populations. Studies conducted in premenopausal African American (11–19) and Hispanic (20–22) women are limited and the results are mixed. Some studies found no association with adult obesity (11, 14, 15, 20–22), whereas others reported positive associations (12, 17). We present here the results for BMI and other body size measures in premenopausal women from the

San Francisco Bay Area Breast Cancer Study, which was conducted in Hispanic, African American, and non-Hispanic white women.

MATERIALS AND METHODS

Study population

The methods of this population-based case-control study have been described elsewhere (23, 24). Briefly, 17,581 women aged 35–79 years with incident invasive breast cancer were identified through the Greater Bay Area Cancer Registry. Eligibility was restricted to women residing in Alameda, Contra Costa, San Mateo, San Francisco, or Santa Clara county, California, at diagnosis. Of 15,573 cases contacted (those who were alive, had a valid address, and had no physician refusal), 89% completed a brief telephone screening interview that assessed study eligibility and self-reported race/ethnicity. A total of 2,571 cases were selected (all Hispanic cases diagnosed from April 1, 1995, to April 30, 2002, all African-American cases diagnosed from April 1, 1995, to April 30, 1999, and a 10% random sample of non-Hispanic white cases diagnosed from April 1, 1995, to April 30, 1999). Of these women, 2,258 (88%) completed an in-person interview, including 1,119 (89%) Hispanics, 543 (87%) African Americans, and 596 non-Hispanic (86%) whites.

Controls aged 35–79 years were identified through random digit dialing (23). Of 161,703 randomly generated telephone numbers, household enumeration (for age, sex, and race/ethnicity of each household member) was obtained for 61,576 (84%) of 73,380 phone numbers known to be residential. From the pool of potentially eligible women, 3,771 controls were randomly selected and frequency-matched based on race/ethnicity and the expected 5-year age distribution of cases. Of the 3,547 controls contacted (alive and with a valid address), 92% completed a telephone screening interview that assessed study eligibility (no history of breast cancer, self-identified race/ethnicity). Of 3,170 controls selected, 2,706 (85%) completed the in-person interview, including 1,462 (88%) Hispanics, 598 (82%) African Americans, and 646 (83%) non-Hispanic whites.

The analysis was restricted to premenopausal women. We excluded women who reported natural (805 cases, 995 controls) or surgical (337 cases, 366 controls) menopause, as well as women using hormone therapy (414 cases, 499 controls). Thus, 702 cases and 846 controls were included in the present analysis. All study participants provided written informed consent, and the study was approved by the institutional review board of the Cancer Prevention Institute of California (formerly the Northern California Cancer Center).

Data collection

Professional interviewers administered a structured questionnaire in English or Spanish at the participants' homes and collected information on breast cancer risk factors and body size, including adult height, weight in the reference year (defined as the calendar year before diagnosis for cases or before selection into the study for controls), and body build in the reference year relative to 9 figure drawings ranging from slim to heavy (25). For cases diagnosed from April 1995 to April 1998 and their matched controls, information was collected on average weight at ages 25–30 years. For cases diagnosed after April 1998 and their matched controls, information was collected on average weight at ages 20–29 years. The interviewers also took 3 repeated measurements of standing height, hip circumference, and waist circumference and 2 measurements of weight. Height was measured to the nearest millimeter using a stadiometer after study participants removed their shoes. Weight was measured to the nearest 0.2 kg using a portable scale, with study participants wearing light clothing. Waist and hip circumferences were measured to the nearest millimeter using a linen tape measure. Waist circumference was measured at the natural indentation of the waist; hip circumference was measured at the greatest protrusion of the buttocks.

The questionnaire also asked about lifetime history of physical activity, including sports and exercise, walking for transportation, strenuous indoor and outdoor chores, and occupational activity (23). For each activity, we assessed time spent per week and estimated average lifetime physical activity by multiplying the average annual hours per week by the number of years the woman engaged in that activity, summed those quantities across the period from menarche to the reference year, and then divided by the number of years from menarche to the reference year. A food frequency questionnaire adapted from the 106-item Block Health History and Habits Questionnaire, developed in 1995 (26, 27), was used to assess usual dietary intake and alcohol consumption during the reference year. Information on ER and PR status was available from cancer registry records for 85% and 84% of cases, respectively.

Definition of body size variables

Current BMI was calculated as weight (in kilograms) divided by height (in meters) squared. Calculations were based on measured height at interview (or self-reported height for 6% of cases and 5% of controls who declined measurement) and self-reported weight in the reference year (or measured weight for 1% of cases and 2% of controls without self-reported data). BMI in a woman's 20s (young-adult BMI) was based on reported average weight at ages 25–30 years (410 cases, 492 controls) or at ages 20–29 years (292 cases, 354 controls) (as described above) and height measured at interview (or self-reported height, if the measurement was declined). Current body build was assessed using 9 line drawings of bodies ranging from slim to heavy (25, 28). Waist-to-hip ratio (WHR), calculated as measured waist circumference (in centimeters) divided by hip circumference (in centimeters), is a measure of body fat distribution that reflects both adipose tissue and muscle mass; waist-to-height ratio (WHtR), calculated as waist circumference divided by height, measures visceral adiposity independent of height and therefore more directly reflects abdominal adiposity alone (29). Adult weight gain (in kilograms) was calculated as the difference between self-reported weight in a woman's 20s and self-reported weight in the reference year. BMI in all analyses was classified using World Health Organization–defined cutpoints (underweight to normal weight: <25.0; overweight: 25.0–29.9; obese: ≥30.0) (30). For analyses involving all cases, we categorized the body size variables according to the quartile distribution among controls. For race/ethnicity-specific analyses involving ER+/PR+ and ER−/PR− cases only, we categorized the body size variables according to the tertile distribution among controls.

Statistical analysis

Unconditional logistic regression was used to calculate odds ratios and 95% confidence intervals comparing cases with controls, both overall and separately for each racial/ethnic group. Polytomous logistic regression was used to compare ER+/PR+ ($n = 319$) and ER−/PR− ($n = 171$) case groups with controls. Other case groups (ER+/PR− and ER−/PR+) were too small for separate analyses ($n = 65$ and $n = 32$, respectively).

Odds ratios in all analyses were adjusted for age (continuous) and the following variables, which were significantly associated with breast cancer risk in our study: country of birth (United States or other), education level (some high school or less, high school graduate or vocational/technical school, some college, or college graduate), first-degree family history of breast cancer (yes or no), biopsy-confirmed history of benign breast disease (yes or no), age at menarche (≤11, 12, 13, or ≥14 years), parity (0, 1, 2, 3, or ≥4), duration of breastfeeding (nulliparous or 0, ≤6, 7–12, 13–24, or ≥25 months), alcohol consumption during the reference year (0, 0.1–4.9, 5–9.9, 10–19.9, or ≥20 g/day), average lifetime physical activity (hours per week, quartiles), daily caloric intake (quartiles), and height (quartiles). Analyses of all women combined were also adjusted for race/ethnicity. Linear trends were assessed across ordinal values of categorical variables. Significant differences in odds ratios between case groups were tested using the Wald statistic P value, calculated from the polytomous regression model. Two-sided P values were reported for tests of trend and tests of heterogeneity, with P values <0.05 considered statistically significant.

The final analysis was based on 672 premenopausal cases and 808 premenopausal controls after excluding 16 women (9 cases, 7 controls) with missing information on covariates and 52 women (21 cases, 31 controls) with a daily caloric intake that was considered unreliable (<600 kcal or >5,000 kcal). Statistical analyses were conducted using SAS version 9.1 software (SAS Institute, Inc., Cary, North Carolina).

RESULTS

Characteristics of premenopausal cases and controls are shown in Table 1. For cases with known hormone receptor status, ER+/PR+ tumors were more common in Hispanics (57%) and non-Hispanic whites (57%) than in African Americans (45%), whereas ER−/PR− tumors were more common in African Americans (37%) and Hispanics (27%) than in non-Hispanic whites (27%). In comparison, among breast cancer cases ≤50 years of age diagnosed in the greater San Francisco Bay area from 1995 to 2002 (the ascertainment period of the case-control study), the distribution by ER/PR status was similar (data not shown); 64% of non-Hispanic white women had ER+/PR+ tumors, compared with 56% of Hispanic women and 41% of African-American women, and 23% of non-Hispanic whites had ER−/PR− tumors, compared with 30% of Hispanic women and 43% of African American women.

Compared with controls, cases were more likely to be US-born and nulliparous and to have a higher education level, a family history of breast cancer, a personal history of benign breast disease, earlier menarche, lower parity, a shorter duration of breastfeeding, a lower lifetime physical activity level, and higher alcohol consumption (Table 1).

Body size characteristics among controls differed considerably by race/ethnicity (Table 2). African Americans and non-Hispanic whites were of similar average height, whereas Hispanic women were, on average, considerably shorter. Young-adult BMIs were similar in African Americans and Hispanics but higher than in non-Hispanic whites. Weight gain of >20 kg was almost twice as frequent in African Americans as in non-Hispanic whites, and the frequency of large current body size (high weight, obesity, and heavy body build) was highest in African-American women. Average WHRs and WHtRs were similar in Hispanics and African Americans and somewhat higher than in non-Hispanic whites. The proportions of women with high waist circumference, WHR, and WHtR were highest in African Americans, intermediate in Hispanics, and distinctly lower in non-Hispanic whites.

Associations between body size and premenopausal breast cancer risk for all women combined and separately by race/ethnicity are shown in Table 3. For all women combined, risk increased with increasing height ($P_{\text{trend}} < 0.01$), and strong inverse trends were found for current body size (weight, BMI, and body build), young-adult BMI, and weight gain since young adulthood. Risk reductions were similar across racial/ethnic groups for current weight (highest vs. lowest quartile: odds ratios (ORs) ranging from 0.43 to 0.55), BMI (≥30 vs. <25: ORs ranging from 0.52 to 0.65), and body build (heavy vs. slim: ORs ranging from 0.25 to 0.40). Young-adult BMI was inversely associated with risk in Hispanics (highest vs. lowest tertile: OR= 0.57, 95% confidence interval (CI): 0.39, 0.85; $P_{\text{trend}} = 0.01$). A nonsignificant inverse association was also observed in African-American women (OR = 0.64, 95% CI: 0.34, 1.21; $P_{\text{trend}} = 0.17$) but not in non-Hispanic white women. Weight gain was inversely associated with risk among all women combined ($P_{\text{trend}} < 0.01$); when stratified by race/ethnicity, inverse associations were seen in all 3 racial/ethnic groups, although the trend was significant in Hispanic women only. Weight gain of >20 kg was associated with odds ratios of 0.35 (95% CI: 0.21, 0.59) in Hispanics, 0.52 (95% CI: 0.22, 1.22) in African Americans, and 0.57 (95% CI: 0.22, 1.45) in non-Hispanic whites. We found no

Table 1. Characteristics of Premenopausal Cases and Controls in the San Francisco Bay Area Breast Cancer Study, 1995–2004

	Cases (*n* = 672)		Controls (*n* = 808)	
	No.	%	No.	%
Age, years				
35–39	139	21	186	23
40–44	216	32	206	32
45–49	221	33	254	31
50–61	96	14	108	13
Race/ethnicity				
Hispanic	375	56	483	60
US-born[a]	175	47	146	30
Foreign-born	200	53	337	70
African American	154	23	160	20
Non-Hispanic white	143	21	165	20
Joint ER/PR status[b]			N/A	N/A
ER+/PR+	305	45		
ER+/PR−	63	9		
ER−/PR+	31	5		
ER−/PR−	163	24		
Missing	110	16		
Education level				
Some high school or less	129	19	260	32
High school graduate or technical school	167	25	199	25
Some college	194	29	166	21
College graduate	182	27	183	23
Family history of breast cancer in first-degree relatives				
No	579	86	740	92
Yes	93	14	68	8
Personal history of benign breast disease				
No	566	84	746	92
Yes	106	16	62	8
Age at menarche, years				
≤11	174	26	182	23
12	186	28	212	26
13	156	23	204	25
≥14	156	23	210	26
Parity				
Nulliparous	137	20	104	13
1	125	19	118	15
2	198	30	223	28
3	130	19	173	21
≥4	82	12	190	24
Lifetime breastfeeding, months				
Nulliparous	137	20	104	13
0	181	27	189	23
≤6	136	20	151	19
7–12	81	12	89	11
13–24	78	12	134	17
≥25	59	9	141	18
Lifetime physical activity, hours/week				
Quartile 1: ≤6.5	176	26	200	25
Quartile 2: 6.6–14.5	213	32	203	25
Quartile 3: 14.6–24.8	147	22	205	25
Quartile 4: >24.8	136	20	200	25
Alcohol consumption, g/day[c]				
0	315	47	455	56
0.1–4.9	176	26	190	24
5.0–9.9	53	8	48	6
10.0–19.9	62	9	70	9
≥20	66	10	45	6
Total caloric intake, kcal/day[c]				
Quartile 1: ≤1,620	162	24	205	25
Quartile 2: 1,621–2,141	153	23	203	25
Quartile 3: 2,142–2,814	156	23	200	25
Quartile 4: >2,814	201	30	200	25

Abbreviations: ER−, estrogen receptor–negative; ER+, estrogen receptor–positive; N/A, not applicable; PR−, progesterone receptor–negative; PR+, progesterone receptor–positive.

[a] Includes 11 cases and 13 controls born in western countries such as Canada, Europe, Australia, and New Zealand.

[b] Percentages may not add to 100 because of rounding.

[c] In reference year.

association between premenopausal breast cancer risk and waist or hip circumference, WHT, or WHtR in all women combined or in any racial/ethnic group. None of the differences in odds ratios by race/ethnicity were statistically significant ($P > 0.05$).

Associations with body size measures for ER+/PR+ and ER−/PR− tumors are shown in Table 4. Associations with height were similar for the 2 case groups. For other body size measures, strong significant inverse trends were found only for cases with ER+/PR+ tumors. Statistically significant heterogeneity by hormone receptor status was found for current weight, current BMI, and weight gain, and heterogeneity of borderline significance was observed for WHtR ($P = 0.06$), current body build ($P = 0.09$), and waist circumference ($P = 0.09$). WHR was not associated with risk in either case group.

For ER+/PR+ tumors, similar inverse trends in Hispanic and African American women were found for current

Table 2. Body Size Measures (%) Among Control Women by Race/Ethnicity in the San Francisco Bay Area Breast Cancer Study, 1995–2004

	Hispanics (*n* = 485)	African Americans (*n* = 160)	Non-Hispanic Whites (*n* = 165)
Quartile of current height, cm*[a,b,c]			
≤154.6	37	8	7
154.7–159.3	31	17	16
159.4–164.6	22	29	31
>164.6	11	47	46
Mean	157.5	164.5	164.5
Quartile of young-adult weight, kg*[d,c]			
≤53.5	29	17	29
53.6–58.3	24	20	27
58.4–63.5	27	26	24
>63.5	21	37	21
Mean	58.5	62.4	58.8
Quartile of young-adult BMI *[b,c,e,f]			
≤20.9	19	27	42
21.0–22.7	23	23	32
22.8–24.9	28	26	16
>24.9	31	24	10
Mean	23.6	23.1	21.7
Weight change, kg*[b,c,d,g]			
Loss >3.0	4	4	6
None/stable	13	11	25
Gain 3.1–10.0	31	30	31
Gain 10.1–20.0	30	21	21
Gain >20.0	23	34	18
Mean	11.7	15.3	9.5
Quartile of current weight, kg*[b,c,d,h]			
≤61.2	26	17	47
61.3–68.0	25	21	16
68.1–81.6	30	23	19
>81.6	19	39	18
Mean	70.4	77.8	68.4
Current BMI*[b,c,e,i]			
<25.0	24	29	59
25.0–29.9	39	31	21
≥30.0	36	40	20
Mean	28.4	28.8	25.3
Current body build*[b,c,d]			
1–3 (slim)	11	8	22
4	20	26	22
5–6	50	35	38
7–9 (heavy)	19	31	18

Table continues

Table 2. Continued

	Hispanics (*n* = 485)	African Americans (*n* = 160)	Non-Hispanic Whites (*n* = 165)
Quartile of waist circumference, cm*[b,c,d]			
≤78.7	20	16	51
78.8–87.0	28	22	18
87.1–98.0	29	21	18
>98.0	23	42	14
Mean	89.3	94.7	81.4
Quartile of hip circumference, cm*[b,c,d]			
≤99.5	25	14	37
99.6–106.6	27	19	24
106.7–116.3	27	27	19
>116.3	22	41	20
Mean	108.4	113.5	106.0
Quartile of waist-to-hip ratio*[b,c]			
≤0.77	19	20	55
0.78–0.81	27	25	24
0.82–0.85	27	21	14
>0.85	28	34	7
Mean	0.82	0.83	0.77
Quartile of waist-to-height ratio*[b,c,d]			
≤0.50	20	22	60
0.51–0.55	26	30	15
0.56–0.61	28	15	14
>0.61	26	33	11
Mean	0.57	0.58	0.50

Abbreviation: BMI, body mass index.

* $P < 0.05$.

[a] Based on measured height (or self-reported adult height when measured height not available).

[b] Chi-square test for the difference between non-Hispanic whites and Hispanics.

[c] Chi-square test for the difference between non-Hispanic whites and African Americans.

[d] Chi-square test for the difference between Hispanics and African Americans.

[e] BMI is determined as weight in kilograms divided by height in meters squared.

[f] Based on average weight in a woman's 20s and measured height at interview (or self-reported adult height when measured height not available).

[g] Self-reported weight (or measured weight if self-reported weight not available) at interview minus self-reported average weight in a woman's 20s.

[h] Based on self-reported weight (or measured weight when self-reported weight not available).

[i] Based on self-reported weight and measured height (if not available, then based on measured weight and/or self-reported height).

Table 3. Body Size and Breast Cancer Risk in Premenopausal Women, by Race/Ethnicity[a], in the San Francisco Bay Area Breast Cancer Study, 1995–2004

	All				Hispanics				African Americans				Non-Hispanic Whites			
	No. of Cases (*n* = 672)	No. of Controls (*n* = 808)	OR[b]	95% CI	No. of Cases (*n* = 375)	No. of Controls (*n* = 483)	OR[c]	95% CI	No. of Cases (*n* = 154)	No. of Controls (*n* = 160)	OR[c]	95% CI	No. of Cases (*n* = 143)	No. of Controls (*n* = 165)	OR[c]	95% CI
Current height, cm[d]																
Quartile 1	109	202	1.0		61	122	1.0		25	42	1.0		30	42	1.0	
Quartile 2	147	202	1.69	0.86, 1.69	87	120	1.38	0.88, 2.15	37	38	1.51	0.71, 3.21	34	43	1.14	0.53, 2.42
Quartile 3	196	202	2.22	1.13, 2.22	84	121	1.23	0.78, 1.94	59	40	2.55	1.24, 5.21	34	39	1.38	0.65, 2.95
Quartile 4	220	202	2.53	1.23, 2.53	143	120	1.84	1.18, 2.85	33	40	1.39	0.65, 2.94	45	41	1.81	0.87, 3.74
P_{trend}				<0.01				0.01				0.20				0.09
Quartile of current weight, kg[e]																
≤61.2	227	229	1.0		134	125	1.0		31	27	1.0		62	77	1.0	
61.3–68.0	148	182	0.76	0.56, 1.04	86	121	0.61	0.40, 0.93	35	34	0.70	0.31, 1.56	27	27	1.25	0.60, 2.60
68.1–81.6	181	214	0.70	0.52, 0.95	102	146	0.48	0.32, 0.73	41	37	0.75	0.35, 1.62	38	31	1.86	0.94, 3.70
>81.6	116	183	0.51	0.36, 0.72	53	91	0.43	0.26, 0.69	47	62	1.62	0.26, 1.14	16	30	0.55	0.23, 1.34
P_{trend}				<0.01				<0.01				0.13				0.96
Current BMI[f,g]																
<25.0	298	262	1.0		146	118	1.0		59	46	1.0		93	98	1.0	
25.0–29.9	195	274	0.65	0.49, 0.85	125	190	0.56	0.38, 0.81	40	50	0.54	0.29, 1.03	30	34	1.02	0.54, 1.93
≥30.0	179	272	0.60	0.45, 0.79	104	175	0.52	0.35, 0.77	55	64	0.65	0.35, 1.23	20	33	0.60	0.28, 1.30
P_{trend}				<0.01				<0.01				0.20				0.28
Current body build																
1–3 (slim)	123	104	1.0		65	55	1.0		21	13	1.0		37	36	1.0	
4	153	173	0.74	0.52, 1.06	75	95	0.76	0.45, 1.28	37	41	0.40	0.14, 0.94	41	37	0.86	0.40, 1.82
5–6	301	357	0.73	0.52, 1.00	185	239	0.68	0.43, 1.06	68	55	0.64	0.26, 1.54	48	63	0.80	0.40, 1.59
7–9 (heavy)	91	170	0.40	0.27, 0.60	46	92	0.40	0.23, 0.71	28	49	0.25	0.10, 0.65	17	29	0.39	0.16, 0.98
P_{trend}				<0.01				<0.01				0.03				0.08
Quartile of young-adult weight, kg[h]																
≤53.5	180	205	1.0		118	132	1.0		24	26	1.0		38	47	1.0	
53.6–58.3	194	185	1.10	0.81, 1.50	113	109	1.03	0.68, 1.55	39	32	1.56	0.66, 3.71	42	44	1.67	0.79, 3.56
58.4–63.5	159	202	0.77	0.56, 1.07	78	122	0.59	0.38, 0.90	47	41	1.16	0.52, 2.59	34	39	1.19	0.55, 2.57
>63.5	131	188	0.65	0.46, 0.92	61	95	0.56	0.35, 0.90	43	59	0.68	0.30, 1.52	27	34	1.12	0.47, 2.68
P_{trend}				<0.01				<0.01				0.12				0.96

Quartile of young-adult BMI[i]																
≤20.9	210	195	1.0		95	85	1.0		41	42	1.0		74	68	1.0	
21.0–22.7	200	195	1.07	0.80, 1.44	121	105	1.29	0.84, 1.99	48	37	1.67	0.83, 3.35	31	53	0.52	0.28, 0.96
22.8–24.9	136	195	0.79	0.57, 1.08	81	128	0.74	0.48, 1.17	37	41	0.97	0.49, 1.93	18	26	0.86	0.39, 1.91
>24.9	118	195	0.73	0.52, 1.01	73	140	0.65	0.41, 1.04	27	38	0.87	0.41, 1.86	18	17	1.03	0.43, 2.46
P_{trend}				0.02				0.01				0.42				0.77
Weight change, kg[j]																
Loss >3.0	24	33	0.57		13	17	0.57		7	6	1.17		4	10	0.35	
None/stable	146	115	1.0	0.31, 1.06	82	57	1.0	0.24, 1.36	23	17	1.0	0.28, 4.91	41	41	1.0	0.09, 1.38
Gain 3.1–10.0	217	240	0.73	0.53, 1.02	119	142	0.60	0.38, 0.95	45	48	0.61	0.27, 1.39	53	50	1.35	0.69, 2.65
Gain 10.1–20.0	155	205	0.54	0.38, 0.76	94	138	0.40	0.25, 0.65	34	33	0.68	0.28, 1.62	27	34	0.87	0.40, 1.90
Gain >20.0	122	187	0.44	0.30, 0.63	62	104	0.35	0.21, 0.59	44	54	0.52	0.22, 1.22	16	29	0.57	0.22, 1.45
P_{trend}[k]				<0.01				<0.01				0.32				0.23
Quartile of waist circumference, cm																
≤78.7	192	197	1.0		103	95	1.0		17	23	1.0		72	79	1.0	
78.8–87.0	132	190	0.77	0.56, 1.07	76	131	0.59	0.38, 0.91	31	31	1.60	0.65, 3.93	25	28	0.96	0.46, 1.98
87.1–98.0	155	193	0.87	0.63, 1.21	93	135	0.71	0.46, 1.10	42	30	1.89	0.79, 4.50	20	28	0.75	0.35, 1.65
>98.0	154	191	0.80	0.57, 1.12	91	110	0.74	0.47, 1.17	47	60	1.09	0.47, 2.52	16	21	0.90	0.37, 2.17
P_{trend}				0.30				0.35				0.87				0.59
Quartile of hip circumference, cm																
≤99.5	153	194	1.0		85	116	1.0		16	20	1.0		52	58	1.0	
99.6–106.6	164	191	1.16	0.84, 1.60	106	127	1.20	0.78, 1.83	27	27	1.58	0.60, 4.18	31	37	1.08	0.54, 2.17
106.7–116.3	170	194	1.00	0.72, 1.38	93	126	0.87	0.56, 1.35	51	38	1.51	0.62, 3.70	26	30	1.07	0.51, 2.27
>116.3	146	191	0.91	0.65, 1.28	79	102	1.01	0.63, 1.61	43	58	0.91	0.37, 2.22	24	31	0.97	0.44, 2.15
P_{trend}				0.43				0.64				0.46				0.99
Quartile of waist-to-hip ratio																
≤0.77	223	202	1.0		103	88	1.0		33	29	1.0		87	85	1.0	
0.78–0.81	137	199	0.62	0.45, 0.85	86	125	0.63	0.41, 0.97	28	36	0.61	0.27, 1.37	23	38	0.55	0.28, 1.10
0.82–0.85	117	178	0.64	0.45, 0.89	78	126	0.64	0.41, 1.00	29	30	0.83	0.37, 1.86	10	22	0.40	0.15, 1.02
>0.85	156	190	0.78	0.56, 1.08	96	131	0.71	0.46, 1.11	47	48	0.82	0.39, 1.74	13	11	1.35	0.47, 3.86
P_{trend}				0.15				0.19				0.90			0.38	

Table continues

Table 3. Continued

	All				Hispanics				African Americans				Non-Hispanic Whites			
	No. of Cases (*n* = 672)	No. of Controls (*n* = 808)	OR[b]	95% CI	No. of Cases (*n* = 375)	No. of Controls (*n* = 483)	OR[c]	95% CI	No. of Cases (*n* = 154)	No. of Controls (*n* = 160)	OR[c]	95% CI	No. of Cases (*n* = 143)	No. of Controls (*n* = 165)	OR[c]	95% CI
Quartile of waist-to-height ratio																
≤0.50	234	221	1.0		110	96	1.0		34	32	1.0		90	93	1.0	
0.51–0.55	121	187	0.62	0.45, 0.86	71	120	0.56	0.36, 0.88	33	43	0.78	0.37, 1.64	17	24	0.57	0.26, 1.24
0.56–0.61	137	176	0.88	0.63, 1.23	91	133	0.79	0.50, 1.23	33	21	1.68	0.73, 3.85	13	22	0.70	0.29, 1.67
>0.61	141	187	0.76	0.54, 1.06	91	122	0.74	0.47, 1.17	37	48	0.80	0.37, 1.72	13	17	0.73	0.29, 1.89
P_{trend}				0.31				0.47				0.95				0.27

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a] All *P* values for interaction by race/ethnicity were >0.05.

[b] Adjusted for age (continuous), race/ethnicity (Hispanic, African American, non-Hispanic white), place of birth (US-born, foreign-born), education level (some high school or less, high school graduate or vocational/technical school, some college, college graduate), family history of breast cancer (no, yes), personal history of benign breast disease (no, yes), years of age at menarche (≤11, 12, 13, ≥14), number of full-term pregnancies (0, 1, 2, 3, ≥4), months of breastfeeding (nulliparous, 0, ≤6, 7–12, 13–24, >24), lifetime physical activity (quartiles according to the distribution among premenopausal controls), average daily grams of alcohol consumption (0, 0.1–4.9, 5–9.9, 10–19.9, ≥20), average daily total caloric intake (quartiles according to the distribution among premenopausal controls), and current height (quartiles according to the distribution among premenopausal controls).

[c] Adjusted for above variables except for race/ethnicity.

[d] Based on measured height (or self-reported adult height when measured height not available). Quartile cutpoints for all race/ethnicities combined are ≤154.6, 154.7–159.3, 159.4–164.6, and >164.6. Analyses in each racial/ethnic group are based on race-specific quartiles of height among controls. Quartile cutpoints by race/ethnicity are ≤152.4, 152.5–156.7, 156.8–160.5, and >160.5 for Hispanics, ≤159.9, 160.0–163.9, 164.0–169.3, and >169.3 for African Americans, and ≤159.6, 159.7–164.0, 164.1–168.1, and >168.1 for non-Hispanic whites.

[e] Based on self-reported weight (or measured weight when self-reported weight not available).

[f] Based on self-reported weight and measured height (if not available, then based on measured weight and/or self-reported height).

[g] BMI is determined as weight in kilograms divided by height in meters squared.

[h] Between ages 25–30 for cases diagnosed from April 1995 to April 1998 and matched controls and between ages 20–29 for cases diagnosed from May 1998 to April 2002 and matched controls.

[i] Based on usual weight in a woman's 20s and measured height at interview (or self-reported adult height when measured height not available).

[j] Self-reported weight (or measured weight if self-reported weight not available) at interview minus self-reported usual weight in a woman's 20s.

[k] *P* for trend excludes women with loss of >3.0 kg.

weight, BMI, body build, young-adult BMI, and weight change (Table 5). For non-Hispanic white women, inverse trends of borderline significance were found for current BMI, current body build, and waist circumference. The differences in odds ratios by race/ethnicity were not statistically significant ($P > 0.05$).

DISCUSSION

The present analysis in a multiethnic population found positive associations between height and premenopausal breast cancer risk, as well as substantial inverse associations with obesity and other measures of body fatness and abdominal adiposity (current weight, body build, waist circumference, WHtR, BMI in young adulthood, and weight gain). Importantly, inverse associations were limited to ER+/PR+ tumors. For all tumors combined and for ER+/PR+ tumors, the inverse associations were similar for Hispanic, African-American, and non-Hispanic white women.

Compared with the large number of studies that have examined the relation between body size and premenopausal breast cancer risk in non-Hispanic white women (4), data are relatively sparse and inconsistent for Hispanic (20–22) and African-American (11–15, 17–19) women. We found inverse associations of similar magnitude across racial/ethnic groups but our sample size, particularly in African Americans and non-Hispanic whites, was too small to determine whether the race/ethnicity-specific odds ratios we observed were actually statistically different. Our analysis is the first to examine associations between multiple body size measures and breast cancer risk in a single study of Hispanic, African-American, and non-Hispanic white women. The population-based design and similar response rates among eligible cases and controls from all 3 racial/ethnic groups increased the generalizability of our results. Furthermore, we found the inverse associations to be consistent across multiple measures of body size and in agreement with previous reports for non-Hispanic white women (3, 31).

The present results should be interpreted in the context of some study limitations. Given the inherent need to rely on self-reporting for most variables, we cannot exclude the possibility of inaccurate recall, which could have resulted in misclassification of confounders and exposure variables. For the assessment of body size, we relied on anthropometric measurements in addition to self-reported measures. Because of concern that cases may have experienced treatment-related weight gain or disease-related weight loss (32), we calculated current BMI from self-reported weight in the reference year instead of measured weight at interview, except for the small proportion of cases and controls who declined to self-report but allowed actual weight measurement. Inaccurate recall or misreporting of weight in the reference year could have biased the odds ratios for current BMI and weight towards the null. For young-adult measures (weight and BMI) and weight gain, we relied on 2 measures of weight in a woman's 20s. In the early version of the questionnaire, we assessed weight at the ages of 25–30 years; in a later version, we asked about weight in each decade (e.g., at ages 20–29 years). In a sensitivity analysis, we found that each of the young-adult measures was inversely associated with risk, regardless of the weight measure used, both in all women combined and in women with ER+/PR+ tumors.

Consistent with some (33–35) but not all (22) studies in non-Hispanic white women, we found a positive association between height and breast cancer risk in Hispanic women. Results in other populations have been mixed as well. Positive associations with height have previously been reported for African-American (15, 16) and Nigerian (36, 37) women. Other studies, like ours, did not find significant trends with height in black (13, 38) or non-Hispanic white (2, 39–41) women.

Our finding of a 40% lower risk of premenopausal breast cancer in obese women is consistent with other studies in non-Hispanic whites (3, 31). Importantly, and in agreement with other studies (42), the inverse association with BMI was limited to ER+/PR+ tumors in all 3 racial/ethnic groups. Prior studies of BMI in African-American women, black women in Barbados, and Hispanic women have produced mixed results. Palmer et al. (18) and Nemesure et al. (38) reported inverse associations with obesity, although in the latter study, no significant association remained after adjustment for BMI at age 18 years. In our analysis of current BMI, additional adjustment for young-adult BMI changed the odds ratio estimates only minimally (data not shown). Other studies found no evidence of inverse associations between BMI and breast cancer risk in African-American (11, 12, 14, 15, 17), Nigerian (36, 37), or Hispanic (20–22) women.

Data on other body size measures are sparse for African-American and Hispanic women. We found substantial inverse associations for current weight and body build, with similar findings in the 3 racial/ethnic groups. Another study found no inverse association between current body build and breast cancer risk in African-American women (19). Large young-adult body size has been associated with lower risk of breast cancer in non-Hispanic white women (40, 43–45), although findings are not consistent (41, 46). We found significant inverse trends for young-adult BMI, with similar findings in African Americans and Hispanics, but no clear trend in non-Hispanic whites. Some (12, 18, 19) but not all (17, 21) other studies in these populations have also reported inverse associations with BMI at age 18 years. BMI at age 18 years may be stronger predictor of premenopausal breast cancer risk than current BMI (18, 19, 43), but the present results were similar for the 2 BMI measures.

We found a strong inverse trend with weight gain since young adulthood, with similar findings in Hispanic and African-American women, and with associations limited to ER+/PR+ tumors. Results from other studies are inconsistent. Studies in non-Hispanic white women suggest that an inverse association with weight gain may be limited to women who experienced their lowest adult weight after age 21 years (40), women with a BMI <20 at age 18 years (19), or women diagnosed with early-stage and lower-grade breast cancer (46). Several studies found no association with weight gain in non-Hispanic white (19, 22, 41, 47, 48), African-American (17, 18), or Hispanic (21, 22) women.

Table 4. Body Size and Breast Cancer Risk in Premenopausal Women, by Joint ER/PR Status, in the San Francisco Bay Area Breast Cancer Study, 1995–2004

	Controls (n = 808)		ER+/PR+ Cases (n = 305)				ER−/PR− Cases (n = 163)				*P* for Heterogeneity by ER/PR Status
	No.	%	No.	%	OR[a]	95% CI	No.	%	OR[a]	95% CI	
Quartile of current height, cm[b]											
≤154.6	202	25	45	15	1.0		28	17	1.0		0.45
154.7–159.3	202	25	74	24	1.48	0.95, 2.31	29	18	0.90	0.51, 1.60	
159.4–164.6	202	25	96	32	1.93	1.23, 3.02	50	31	1.50	0.87, 2.60	
>164.6	202	25	90	30	1.72	1.07, 2.77	56	34	1.58	0.89, 2.81	
P_{trend}						0.02				0.04	
Quartile of current weight, kg[c]											
≤61.2	229	28	120	39	1.0		42	26	1.0		0.03
61.3–68.0	182	23	67	22	0.68	0.46, 1.00	31	19	0.88	0.52, 1.48	
68.1–81.6	214	27	75	25	0.56	0.38, 0.82	51	31	1.09	0.67, 1.76	
>81.6	183	23	43	14	0.38	0.24, 0.59	39	24	0.93	0.55, 1.57	
P_{trend}						<0.01				0.99	
Current BMI[d,e]											
<25.0	262	32	158	52	1.0		56	34	1.0		<0.01
25.0–29.9	274	34	80	26	0.50	0.35, 0.71	49	30	0.91	0.58, 1.42	
≥30.0	272	34	67	22	0.42	0.29, 0.61	58	36	1.05	0.67, 1.64	
P_{trend}						<0.01				0.81	
Current body build											
1–3 (slim)	104	13	69	23	1.0		25	15	1.0		0.09
4	173	22	74	24	0.68	0.44, 1.06	28	17	0.66	0.36, 1.21	
5–6	357	44	122	40	0.56	0.37, 0.82	83	51	0.97	0.58, 1.63	
7–9 (heavy)	170	21	39	13	0.33	0.20, 0.54	27	17	0.57	0.31, 1.07	
P_{trend}						<0.01				0.32	
Quartile of young-adult weight, kg[f]											
≤53.5	205	26	93	31	1.0		39	24	1.0		0.52
53.6–58.3	185	24	91	30	0.99	0.67, 1.46	42	26	1.04	0.62, 1.73	
58.4–63.5	202	26	62	21	0.59	0.39, 0.90	39	24	0.87	0.52, 1.46	
>63.5	188	24	53	18	0.56	0.36, 0.87	41	26	0.86	0.50, 1.47	
P_{trend}						<0.01				0.45	
Quartile of young-adult BMI[g]											
≤20.9	195	25	106	36	1.0		47	29	1.0		0.81
21.0–22.7	195	25	90	30	0.93	0.64, 1.35	48	30	1.10	0.69, 1.76	
22.8–24.9	195	25	54	18	0.62	0.41, 0.94	30	19	0.74	0.44, 1.24	
>24.9	195	25	49	16	0.61	0.39, 0.94	36	22	0.92	0.55, 1.55	
P_{trend}						0.01				0.45	
Weight change, kg[h]											
Loss >3.0	33	4	16	5	0.80	0.39, 1.65	5	3	0.51	0.18, 1.47	0.03
None/stable	115	15	73	24	1.0		31	19	1.0		
Gain 3.1–10.0	240	31	103	35	0.75	0.50, 1.13	41	26	0.63	0.37, 1.07	
Gain 10.1–20.0	205	26	63	21	0.45	0.29, 0.70	47	29	0.76	0.45, 1.30	
Gain >20.0	187	24	44	15	0.32	0.20, 0.52	37	23	0.62	0.35, 1.10	
P_{trend}[i]					<0.01				0.32		

Table continues

Table 4. Continued

	Controls (n = 808)		ER+/PR+ Cases (n = 305)				ER−/PR− Cases (n = 163)				P for Heterogeneity by ER/PR Status
	No.	%	No.	%	OR[a]	95% CI	No.	%	OR[a]	95% CI	
Quartile of waist circumference, cm											
≤78.7	197	26	104	36	1.0		34	22	1.0		0.09
78.8–87.0	190	25	63	22	0.70	0.47, 1.05	32	21	1.00	0.58, 1.73	
87.1–98.0	193	25	56	19	0.63	0.41, 0.96	39	26	1.19	0.69, 2.05	
>98.0	191	25	65	23	0.65	0.43, 0.99	47	31	1.33	0.78, 2.30	
P_{trend}						0.04				0.24	
Quartile of hip circumference, cm											
≤99.5	194	25	84	29	1.0		32	21	1.0		0.10
99.6–106.6	191	25	79	27	1.02	0.68, 1.51	30	20	0.94	0.54, 1.65	
106.7–116.3	194	25	64	22	0.71	0.47, 1.08	49	32	1.29	0.77, 2.17	
>116.3	191	25	61	21	0.72	0.47, 1.11	41	27	1.11	0.65, 1.92	
P_{trend}						0.06				0.48	
Quartile of waist-to-hip ratio											
≤0.77	202	26	109	36	1.0		50	33	1.0		0.50
0.78–0.81	199	26	66	24	0.63	0.42, 0.93	33	22	0.65	0.39, 1.08	
0.82–0.85	178	23	48	17	0.60	0.39, 0.93	24	16	0.54	0.31, 0.96	
>0.85	190	25	65	23	0.72	0.47, 1.09	45	30	0.95	0.57, 1.58	
P_{trend}						0.11				0.78	
Quartile of waist-to-height ratio											
≤0.50	221	29	128	44	1.0		46	30	1.0		0.06
0.51–0.55	187	24	48	17	0.49	0.32, 0.74	26	17	0.69	0.39, 1.20	
0.56–0.61	176	23	52	18	0.62	0.40, 0.94	37	24	1.23	0.73, 2.08	
>0.61	187	24	60	21	0.61	0.40, 0.93	43	28	1.19	0.70, 2.00	
P_{trend}						0.03				0.24	

Abbreviations: BMI, body mass index; CI, confidence interval; ER, estrogen receptor; OR, odds ratio; PR, progesterone receptor.

[a] Adjusted for age (continuous), race/ethnicity (Hispanic, African American, non-Hispanic white), place of birth (US-born, foreign-born), education level (some high school or less, high school graduate or vocational/technical school, some college, college graduate), family history of breast cancer (no, yes), personal history of benign breast disease (no, yes), years of age at menarche (≤11, 12, 13, ≥14), number of full-term pregnancies (0, 1, 2, 3, ≥4), months of breastfeeding (nulliparous, 0, ≤6, 7–12, 13–24, >24), lifetime physical activity (quartiles according to the distribution among premenopausal controls), average daily grams of alcohol consumption (0, 0.1–4.9, 5–9.9, 10–19.9, ≥20), average daily total caloric intake (quartiles according to the distribution among premenopausal controls), and current height (quartiles according to the distribution among premenopausal controls).

[b] Based on measured height (or self-reported adult height when measured height not available).

[c] Based on self-reported weight (or measured weight when self-reported weight not available).

[d] BMI is determined as weight in kilograms divided by height in meters squared.

[e] Based on self-reported weight and measured height (if not available, then based on measured weight and/or self-reported height).

[f] Between ages 25–30 for cases diagnosed from April 1995 to April 1998 and matched controls and between ages 20–29 for cases diagnosed from May 1998 to April 2002 and matched controls.

[g] Based on usual weight in a woman's 20s and measured height at interview (or self-reported adult height when measured height not available).

[h] Self-reported weight (or measured weight if self-reported weight not available) at interview minus self-reported usual weight in 20s.

[i] P for trend does not include loss >3.0 group.

In agreement with other studies (3, 49, 50), we found no association with WHR overall or in any racial/ethnic group. High WHR has been associated with increased risk of premenopausal breast cancer in both African-American and white women from North Carolina (15) and in Nigerian women (37), but most studies, including ours, have found no association (18, 38, 51). Similarly, a study of breast cancer in Hispanic women found no association with WHR (22). However, we found inverse associations with waist circumference and with WHtR for ER+/PR+ tumors.

Overall, our findings are generally consistent across race/ethnicity and are in agreement with previous reports for non-Hispanic white women. Our results also confirm those of some, but not all, previous studies in African-American

Table 5. Body Size and Risk of ER+/PR+ Breast Cancer Among Premenopausal Women, by Race/Ethnicity[a], in the San Francisco Bay Area Breast Cancer Study, 1995–2004

	Hispanics						African Americans						Non-Hispanic Whites					
	Cases (n = 178)		Controls (n = 483)		OR[b]	95% CI	Cases (n = 57)		Controls (n = 160)		OR[b]	95% CI	Cases (n = 70)		Controls (n = 165)		OR[b]	95% CI
	No.	%	No.	%			No.	%	No.	%			No.	%	No.	%		
Current height, cm[c]																		
Tertile1	31	17	161	33	1.0		16	28	53	33	1.0		24	34	55	33	1.0	
Tertile 2	60	34	160	33	1.84	1.08, 3.12	28	49	54	34	1.38	0.59, 3.19	23	33	54	33	1.51	0.64, 3.53
Tertile 3	87	49	162	34	2.20	1.31, 3.72	13	23	53	33	0.66	0.26, 1.70	23	33	56	34	1.35	0.59, 3.11
P_{trend}						<0.01						0.44						0.50
Tertile of current weight, kg[d]																		
≤63.5	85	48	178	37	1.0		22	39	41	26	1.0		39	56	83	50	1.0	
63.6–77.1	55	31	175	36	0.59	0.37, 0.92	19	33	39	24	0.88	0.35, 2.20	21	30	43	26	1.05	0.49, 2.27
>77.1	38	21	130	27	0.57	0.35, 0.96	16	28	80	50	0.23	0.09, 0.59	10	14	39	24	0.53	0.19, 1.52
P_{trend}						0.02						<0.01						0.34
Current BMI[e,f]																		
<25.0	82	46	118	24	1.0		27	47	46	29	1.0		49	70	98	59	1.0	0
25.0–29.9	51	29	190	39	0.45	0.28, 0.72	14	25	50	31	0.36	0.14, 0.91	15	21	34	21	0.90	0.39, 2.09
≥30.0	45	25	175	36	0.42	0.25, 0.69	16	28	64	40	0.32	0.13, 0.81	6	9	33	20	0.29	0.09, 0.93
P_{trend}						<0.01						0.02						0.06
Current body build																		
1–3 (slim)	40	23	55	11	1.0		7	12	13	8	1.0		22	31	36	22	1.0	
4	37	21	95	20	0.59	0.32, 1.10	19	33	41	26	0.60	0.16, 2.22	18	26	37	22	0.41	0.15, 1.10
5–6	76	43	239	50	0.50	0.29, 0.86	23	40	55	35	0.55	0.15, 1.99	23	33	63	38	0.67	0.28, 1.61
7–9 (heavy)	24	14	92	19	0.36	0.18, 0.72	8	14	49	31	0.16	0.04, 0.67	7	10	29	18	0.21	0.06, 0.73
P_{trend}						<0.01						0.01						0.05
Tertiles of young-adult weight, kg[g]																		
≤54.4	75	43	177	39	1.0		18	32	40	25	1.0		31	46	63	38	1.0	
54.5–61.2	58	33	161	35	0.86	0.55, 1.36	20	36	51	32	0.90	0.34, 2.41	26	38	58	35	0.89	0.40, 2.00
>61.2	42	24	120	26	0.76	0.45, 1.28	18	32	67	42	0.51	0.20, 1.32	11	16	43	26	0.45	0.16, 1.27
P_{trend}					0.29						0.16						0.15	
Tertile of young-adult BMI[e,h]																		
≤21.5	72	41	118	26	1.0		25	45	49	31	1.0		48	71	90	55	1.0	
21.6–24.0	54	31	152	33	0.71	0.44, 1.14	20	36	57	36	0.62	0.27, 1.45	10	15	49	30	0.34	0.14, 0.83
>24.0	49	28	188	41	0.60	0.37, 0.98	11	20	52	33	0.34	0.13, 0.92	10	15	25	15	1.03	0.38, 2.79
P_{trend}						0.04						0.03						0.34
Weight change, kg[i]																		
Loss >3.0	11	6	17	4	0.88	0.33, 2.33	4	7	6	4	1.47	0.21, 10.3	1	2	10	6	0.29	0.03, 2.71
None/stable	43	25	57	13	1.0		8	14	17	11	1.0		22	32	41	25	1.0	
Gain 3.1–10.0	56	32	142	31	0.54	0.30, 0.95	21	38	48	30	0.65	0.20, 2.12	26	38	50	31	1.30	0.55, 3.05
Gain, >10.0	65	37	242	53	0.30	0.17, 0.52	23	41	87	55	0.31	0.09, 1.04	19	28	63	38	0.75	0.30, 1.87
P_{trend}[j]						<0.01						0.01						0.51

Tertile of waist circumference, cm																		
≤81.2	69	40	133	28	1.0		11	22	33	23	1.0		47	71	90	58	1.0	
81.3–93.5	48	28	179	38	0.58	0.35, 0.95	17	34	42	29	1.10	0.38, 3.22	12	18	34	22	0.60	0.24, 1.52
>93.5	55	32	159	34	0.64	0.39, 1.05	22	44	69	48	0.87	0.32, 2.35	7	11	32	21	0.43	0.14, 1.30
P_{trend}						0.08						0.72						0.10
Tertile of hip circumference, cm																		
≤101.5	67	39	153	33	1.0		9	18	26	18	1.0		32	49	78	50	1.0	
101.6–112.8	56	33	170	36	0.76	0.47, 1.21	20	40	46	32	1.41	0.45, 4.44	20	30	37	24	1.34	0.59, 3.04
>112.8	49	29	148	31	0.66	0.40, 1.09	21	42	71	50	0.80	0.25, 2.32	14	21	41	26	1.03	0.41, 3.00
P_{trend}						0.10						0.39						0.82
Tertile of waist-to-hip ratio																		
≤0.79	69	40	142	30	1.0		17	34	49	34	1.0		56	85	105	67	1.0	
0.80–0.84	54	31	167	36	0.85	0.53, 1.36	11	22	37	26	0.94	0.33, 2.67	4	6	34	22	0.17	0.05, 0.63
>0.84	49	29	161	34	0.77	0.46, 1.27	22	44	57	40	1.21	0.50, 2.96	6	9	17	11	0.67	0.17, 2.70
P_{trend}						0.30						0.66						0.07
Tertile of waist-to-height ratio																		
≤0.51	71	41	113	24	1.0		14	28	43	30	1.0		53	80	100	64	1.0	
0.52–0.59	49	29	198	42	0.52	0.31, 0.85	17	34	43	30	1.31	0.48, 3.59	6	9	34	22	0.33	0.11, 0.96
>0.59	52	30	160	34	0.61	0.37, 1.02	19	38	58	40	0.97	0.37, 2.57	7	11	22	14	0.66	0.21, 2.13
P_{trend}						0.07						0.90						0.15

Abbreviations: BMI, body mass index; CI, confidence interval; OR, odds ratio.

[a] All *P* values for interaction by race/ethnicity were >0.05.

[b] Adjusted for age (continuous), place of birth (US-born, foreign-born), education level (some high school or less, high school graduate or vocational/technical school, some college, college graduate), family history of breast cancer (no, yes), personal history of benign breast disease (no, yes), years of age at menarche (≤11, 12, 13, ≥14), number of full-term pregnancies (0, 1, 2, 3, ≥4), months of breastfeeding (nulliparous, 0, ≤6, 7–12, 13–24, >24), lifetime physical activity (quartiles according to the distribution among premenopausal controls), average daily grams of alcohol consumption (0, 0.1–4.9, 5–9.9, 10–19.9, ≥20), average daily total caloric intake (quartiles according to the distribution among premenopausal controls), and current height (quartiles according to the distribution among premenopausal controls).

[c] Based on measured height (or self-reported adult height when measured height not available). Analyses in each racial/ethnic group are based on race-specific tertiles of height among controls. Tertile cutpoints by race/ethnicity are ≤153.6, 153.7–159.0, and >159.0 for Hispanics, ≤161.2, 161.3–167.4, and >167.4 for African Americans, and ≤161.8, 161.9–166.6, and >166.6 for non-Hispanic whites.

[d] Based on self-reported weight (or measured weight when self-reported weight not available).

[e] BMI is determined as weight in kilograms divided by height in meters squared.

[f] Based on self-reported weight and measured height (if not available, then based on measured weight and/or self-reported height).

[g] Between ages 25–30 for cases diagnosed from April 1995 to April 1998 and matched controls and between ages 20–29 for cases diagnosed from May 1998 to April 2002 and matched controls.

[h] Based on usual weight in a woman's 20s and measured height at interview (or self-reported adult height when measured height not available).

[i] Self-reported weight (or measured weight if self-reported weight not available) at interview minus self-reported usual weight in a woman's 20s.

[j] *P* for trend does not include loss >3.0 group.

and Hispanic women. Variability in observed associations across studies may be explained, in part, by differences in the proportion of cases with ER−/PR− tumors, which are more common in African Americans and Hispanics than in non-Hispanic whites. Our data clearly show inverse associations with measures of body size only for ER+/PR+ tumors; no associations were found for ER−/PR− tumors. Similarly, Berstad et al. (19) reported a significant inverse association with BMI in African American women that was limited to ER+/PR+ tumors. No other study in African Americans and Hispanics presented associations with body size measures for premenopausal breast cancer by hormone receptor status. Failure to take hormone receptor status into account may obscure associations with body size and may have contributed to the inconsistent results in African-American and Hispanic women.

The biologic mechanisms underlying associations between large body size and breast cancer risk remain uncertain. The observation that BMI and other body size measures are inversely associated with ER+/PR+ but not ER−/PR− tumors suggests the importance of sex-steroid hormone pathways. Elevated BMI may contribute to lower serum levels of sex hormone–binding globulin (52, 53) and total estradiol (52, 53) and higher levels of free testosterone (53), as well as a higher frequency of anovulatory and irregular menstrual cycles in premenopausal women, which in turn results in reduced production of estrogen and progesterone (54). In 2 recent studies (18, 43), however, the inverse association with large body size was not explained by menstrual cycle characteristics, self-reported infertility, or probable polycystic ovary syndrome, suggesting the importance of other mechanisms.

In conclusion, our results suggest that the inverse association between premenopausal breast cancer and larger body size is similar in Hispanic, African-American, and non-Hispanic white women but is limited to ER+/PR+ tumors. Thus, hormone receptor status is important to consider when evaluating the association between body size and premenopausal breast cancer risk. Although our results indicated a lower risk of premenopausal breast cancer in obese women, repeated studies have noted that weight gain and obesity are associated with increased breast cancer risk during the postmenopausal years, when breast cancer occurs much more commonly than during the premenopausal years; thus, avoidance of weight gain before menopause remains advisable.

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