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ABSENCE OF EXCESS BODY FATNESS

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2.2.9 Cancer of the breast in women

In women, cancer of the breast constitutes about 25% of all incident cancers and about 15% of all cancer deaths worldwide. There are several established risk factors for breast cancer, including age at menarche, age at menopause, age at first birth, parity, breastfeeding, alcohol consumption, physical activity, and use of exogenous estrogens. Breast cancer diagnosed before menopause differs from breast cancer diagnosed after menopause in both risk factors and clinical characteristics. There are several molecular subtypes of breast cancer; the most important aspect is the presence or absence of estrogen receptors in the tumour, because this substantially affects treatment options and prognosis.

In 2001, the Working Group of the *IARC Handbook* on weight control and physical activity (IARC, 2002) concluded that there was *sufficient evidence* for a cancer-preventive effect of avoidance of weight gain for postmenopausal breast cancer.

(a)   Cohort studies

The evidence published since 2000 includes about 30 publications from cohort studies (excluding analyses that were later updated and analyses based on fewer than 100 incident cases). These findings are displayed for BMI at baseline in Table 2.2.9a for postmenopausal women and Table 2.2.9b (web only; available at: http://publications.iarc.fr/570) for premenopausal women, with comments on findings according to other measures of body fatness, such as weight changes over the life-course.

(i)   BMI

In general, the findings are quite consistent across the studies, showing an inverse association between baseline BMI and premenopausal breast cancer risk and a positive association between baseline BMI and postmenopausal breast cancer risk.

For premenopausal breast cancer, the risk diminishes with increasing BMI on an approximately linear scale, and for postmenopausal breast cancer the risk increases on an approximately linear scale. Two large meta-analyses estimated a 7–8% decrease in premenopausal breast cancer risk and a 12–13% increase in postmenopausal breast cancer risk per 5 kg/m^2 (Renehan et al., 2008; WCRF/AICR, 2010).

Among those studies that have assessed the association between BMI and breast cancer risk by estrogen receptor (ER) status (for postmenopausal and premenopausal breast cancer combined), the association was most robust for women with ER-positive tumours (MacInnis et al., 2004; Suzuki et al., 2006; Vrieling et al., 2010; Canchola et al., 2012; Bandera et al., 2015; Neuhouser et al., 2015).

Among postmenopausal women, the majority of studies that have assessed the interaction between obesity and use of HRT have found the association between BMI and breast cancer risk to be apparent only among non-users of HRT (Feigelson et al., 2004; Lahmann et al., 2004; Eliassen et al., 2006; Mellemkjaer et al., 2006; Ahn et al., 2007; White et al., 2012). Similar conclusions were reported by several meta-analyses and systematic literature reviews (WCRF/AICR, 2010).

(ii)   BMI or weight at earlier time points and weight change

Several investigators have assessed the association of BMI or weight at earlier time points and weight change with subsequent breast cancer risk.

For postmenopausal breast cancer, BMI in middle adulthood (ages 35–50 years) is associated with a risk similar to that with baseline BMI (Ahn et al., 2007), but BMI in early adulthood (generally reported at age 18 years) is either not associated or modestly inversely associated with postmenopausal breast cancer risk (Sweeney

et al., 2004; Ahn et al., 2007; Canchola et al., 2012; Bandera et al., 2015).

Weight gain since age 18 years has been shown to be associated with postmenopausal breast cancer risk (Sweeney et al., 2004; Eliassen et al., 2006). Also, weight gain after age 50 years is positively associated with postmenopausal breast cancer risk (Eng et al., 2005).

Weight loss in adulthood has been examined in six studies (Eliassen et al., 2006; Ahn et al., 2007; Teras et al., 2011; Emaus et al., 2014; Neuhouser et al., 2015; Rosner et al., 2015). Across these studies, there is not consistent evidence that weight loss from about age 50 years to the baseline of entry into the cohort affects postmenopausal breast cancer risk.

(iii) Waist circumference

Seven cohort studies have included measurements of waist circumference (Lahmann et al., 2004; Sweeney et al., 2004; Krebs et al., 2006; Ahn et al., 2007; Canchola et al., 2012; Fourkala et al., 2014; Kabat et al., 2015). Waist circumference (either as measured or as indicated by skirt size) or waist-to-hip ratio was generally positively associated with postmenopausal breast cancer risk, and the strengths of those associations are approximately equivalent to those reported for BMI.

(b) Case–control studies

For the current evaluation, data from more than 400 case–control studies published after 2000 were reviewed. Only studies with more than 100 cases are summarized.

(i) BMI

In postmenopausal women, case–control studies yielded consistent results, with increased risk of breast cancer with higher BMI (Table 2.2.9c).

In premenopausal women, the results are less consistent despite the substantial number of studies; they mostly indicate an inverse

association (Table 2.2.9d; web only; available at: http://publications.iarc.fr/570).

Studies that assessed weight gave similar results to those with BMI for both postmenopausal women (Table 2.2.9e; web only; available at: http://publications.iarc.fr/570) and premenopausal women (Table 2.2.9f; web only; available at: http://publications.iarc.fr/570).

Comparable associations were observed for tumours that are both ER-positive and progesterone receptor (PR)-positive, especially for postmenopausal women; see Table 2.2.9g for postmenopausal women and Table 2.2.9h (web only; available at: http://publications.iarc.fr/570) for premenopausal women.

A meta-analysis based on 35 case–control studies involving 71 216 subjects showed an increased risk of postmenopausal breast cancer (OR, 1.15; 95% CI, 1.07–1.24) but not of premenopausal breast cancer, for which the estimates were suggestive of an inverse association with higher BMI (overweight and obese subjects) (OR, 0.93; 95% CI, 0.86–1.02) (Cheraghi et al., 2012).

(ii) BMI and ethnicity

More than 20 studies were carried out in Caucasian women in North America and western Europe (Wenten et al., 2002; Magnusson et al., 2005; Tsakountakis et al., 2005; Verla-Tebit & Chang-Claude, 2005; Dinger et al., 2006; Rosenberg et al., 2006; Kruk, 2007; Slattery et al., 2007; Justenhoven et al., 2008; Berstad et al., 2010; Healy et al., 2010; Barnes et al., 2011; Cerne et al., 2011; John et al., 2011; Rosato et al., 2011; Attner et al., 2012; Bandera et al., 2013a; Robinson et al., 2014; John et al., 2015a, b; Sanderson et al., 2015), 16 studies in women in East Asia (Hirose et al., 2001, 2003; Shu et al., 2001; Yoo et al., 2001; Adegoke et al., 2004; Chow et al., 2005; Nichols et al., 2005; Tian et al., 2007; Wu et al., 2006; Gao et al., 2009; Shin et al., 2009; Shi et al., 2010; Bao et al., 2011; Kawai et al., 2013; Noh et al., 2013; Sangrajrang et al., 2013; Minatoya et al., 2014), 12 studies in Hispanic or Latina women

(de Vasconcelos et al., 2001; Wenten et al., 2002; Ibarluzea et al., 2004; Ziv et al., 2006; Garmendia et al., 2007; Slattery et al., 2007; Justenhoven et al., 2008; John et al., 2011, 2015a, b; Ronco et al., 2012; Amadou et al., 2014), 8 studies in women in South Asia (Gilani & Kamal, 2004; Mathew et al., 2008; Montazeri et al., 2008; Dey et al., 2009; Dogan et al., 2011; Lodha et al., 2011; Ghiasvand et al., 2012; Singh & Jangra, 2013), and 4 studies in Arab women (Alothaimeen et al., 2004; Dogan et al., 2011; Msolly et al., 2011; Elkum et al., 2014).

Except for Asian populations, there are not clear differences in risk estimates between ethnic groups for either postmenopausal women (Table 2.2.9i; web only; available at: http://publications.iarc.fr/570) or premenopausal women (Table 2.2.9j; web only; available at: http://publications.iarc.fr/570).

The incidence of breast cancer in Hispanic Whites is lower than that in non-Hispanic Whites. In the case–control studies that have evaluated the associations of BMI (or other anthropometric measures) or weight change with breast cancer risk and compared Hispanic Whites with non-Hispanic Whites (Wenten et al., 2002; Slattery et al., 2007; John et al., 2015b), the positive association observed in postmenopausal women was generally stronger in non-Hispanic Whites than in Hispanic Whites.

Most studies in Asian women observed an increased risk of breast cancer with higher BMI, especially for postmenopausal women (Table 2.2.9i; web only; available at: http://publications.iarc.fr/570) and/or tumours that were hormone receptor-positive (ER-positive and/or PR-positive). However, the associations between BMI and breast cancer risk in post-menopausal women are observed at lower BMI levels in Asian populations than in Caucasian populations. Some studies in East Asian women (Bao et al., 2011; Kawai et al., 2013) used BMI < 21 kg/m² or BMI < 18.5 kg/m² as a reference and categories of lower BMI for overweight and obesity, and observed a positive association in

both categories. Such lower BMI categories were not specifically examined in most studies in South Asian women.

(iii) Waist circumference

As for BMI, results from case–control studies using waist circumference as an indicator of body fatness yielded consistent results in postmeno-pausal women, with mostly positive associations (Table 2.2.9k).

In premenopausal women, the results of the 11 available studies were not consistent (Table 2.2.9l; web only; available at: http://publications.iarc.fr/570); two studies (Bandera et al., 2013b; Robinson et al., 2014) showed significant positive associations, whereas two studies showed an inverse association (John et al., 2011 in ER-positive, PR-positive tumours only; Amadou et al., 2014). Interestingly, the significant positive associations were observed in women of African ancestry.

Evidence is scarce about waist circumference and risk of breast cancer by hormone receptor status. The three studies in postmenopausal women (John et al., 2011, 2013; Bandera et al., 2013b; Table 2.2.9k) provided conflicting results.

(iv) Change in BMI or weight

Changes in BMI or weight were mostly studied as an increase from the value at age 18, 21, 25, or 30 years to the value at the reference date or 1 year before the reference date.

In postmenopausal women (Table 2.2.9m), 12 of the 20 studies found a positive association between weight gain and risk of breast cancer (Li et al., 2000; Trentham-Dietz et al., 2000; Shu et al., 2001; Friedenreich et al., 2002; Carpenter et al., 2003, Eng et al., 2005; Han et al., 2006; Wu et al., 2006; Shin et al., 2009), in three studies in non-Hispanic White women only (Wenten et al., 2002; Slattery et al., 2007; John et al., 2013). One of the two studies of BMI gain also found a positive association (Hirose et al., 2001). The remaining studies found no significant association.

In the two studies that assessed weight gain specifically after menopause (weight gain after age 50 years or in the past 10 years) (Shu et al., 2001; Eng et al., 2005), the association was still significant but was slightly weaker than that with weight change since early adulthood.

When premenopausal women were considered (Table 2.2.9n; web only; available at: http://publications.iarc.fr/570), BMI change was consistently not associated with risk of breast cancer in all four available studies (Hirose et al., 2001; Verla-Tebit & Chang-Claude, 2005; Kawai et al., 2014; Robinson et al., 2014). Of 16 studies, 10 confirmed no association between body weight gain and breast cancer risk (Shu et al., 2001; Friedenreich et al., 2002; Wenten et al., 2002; Slattery et al., 2007; Wu et al., 2006; Berstad et al., 2010; Bandera et al., 2013a; Troisi et al., 2013; Robinson et al., 2014; Sanderson et al., 2015). The remaining studies were inconsistent; two found an increased risk with increasing body weight gain (Shin et al., 2009; Cribb et al., 2011), and three found a protective effect of body weight gain in at least one measure of exposure (Verla-Tebit & Chang-Claude, 2005; John et al., 2011; Sangaramoorthy et al., 2011).

(v)   Weight loss

When assessing weight change during adulthood, several studies also assessed the impact of weight loss on breast cancer risk (Trentham-Dietz et al., 2000; de Vasconcelos et al., 2001; Eliassen et al., 2006). The results were inconsistent, probably because of heterogeneity of ethnicity and current BMI between studies.

(c)   Mendelian randomization studies

One Mendelian randomization study has been conducted to assess the association of childhood and adult BMI with all and ER-negative breast cancer risk (Gao et al., 2016; Table 2.2.9o). In this study, each unit increase in adult BMI was associated with a 9% decrease in risk (95% CI, 6–12%; $P = 2.5 \times 10^{-7}$) in all breast cancers, and an 11% decrease in risk (95% CI, 6–16%; $P = 2.0 \times 10^{-5}$) in ER-negative tumours (assuming that a standard deviation [SD] was equivalent to 4.5 kg/m², Locke et al., 2015). Childhood BMI was inversely associated with all (OR per SD increase, 0.71; 95% CI, 0.60–0.80; $P = 6.5 \times 10^{-5}$) and ER-negative breast cancer risk (OR per SD increase, 0.69; 95% CI, 0.53–0.98; $P = 5.8 \times 10^{-3}$), where each SD increase was equivalent to 0.073 kg/m² (Felix et al., 2016). [There was minimal evidence for positive directional pleiotropy in the associations with childhood BMI, suggesting that estimates may be underestimated.]

[Although the inverse association observed between adult BMI and breast cancer risk in this study is inconsistent with the positive associations observed for postmenopausal women in observational studies, Mendelian randomization analyses represent a lifelong predisposition to increased BMI (especially because there is a high correlation between the otherwise independent childhood and adult BMI genetic risk scores). The results may suggest that the positive association between adult BMI and breast cancer risk may be driven by adult weight gain, as a result of environmental factors not captured by genetic risk scores.]

Table 2.2.9a Cohort studies of body mass index and cancer of the breast in postmenopausal women

Reference Cohort Location Follow-up period	Total number of subjects Incidence/ mortality	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates	Comments
Feigelson et al. (2004) CPS2 cohort USA 1992–2001	62 756 Incidence	BMI < 22 22–24.9 25–26.9 27–29.9 30–34.9 ≥ 35 [P_{trend}] BMI < 22 22–24.9 25–26.9 27–29.9 30–34.9 ≥ 35 [P_{trend}]	187 304 182 233 204 72 223 253 102 101 51 22	Non-HRT users 1.00 1.06 (0.88–1.27) 1.11 (0.91–1.36) 1.41 (1.16–1.71) 1.74 (1.42–2.13) 1.61 (1.22–2.12) [< 0.0001] Current HRT users 1.0 0.89 (0.74–1.06) 0.74 (0.59–0.94) 0.86 (0.68–1.09) 0.72 (0.53–0.98) 1.09 (0.70–1.69) [0.12]	Age, race, age at menarche, age at menopause, parity, OC use, family history of BC in first-degree relative, benign breast disease, mammography, height, education level, physical activity, alcohol consumption	Positive association also with adult weight gain No association with adult weight gain
Lahmann et al. (2004) EPIC cohort Europe 1992–2002	103 334 Incidence	BMI, quintiles Q1 Q2 Q3 Q4 Q5 [P_{trend}] BMI, quintiles Q1 Q2 Q3 Q4 Q5 [P_{trend}]	98 127 206 241 239 122 116 113 92 51	Non-HRT users 1.00 1.02 (0.78–1.33) 1.35 (1.06–1.73) 1.38 (1.08–1.76) 1.36 (1.06–1.75) [0.002] HRT users 1.0 0.90 (0.69–1.17) 0.91 (0.70–1.19) 0.85 (0.64–1.13) 0.71 (0.50–1.10) [0.07]	Age, centre, education level, smoking, alcohol consumption, parity, age at first pregnancy, age at menarche	WC and WHR both showed no association
MacInnis et al. (2004) Population-based cohort Australia 1990–2003	13 598 Incidence	BMI, quartiles Q1 Q2 Q3 Q4 [P_{trend}]	357 total	1.0 1.2 (0.9–1.5) 1.4 (1.0–1.9) – [0.02]	Age, education level, country of birth, HRT use	Association limited to ER+ cases

Table 2.2.9a (continued)

Reference Cohort Location Follow-up period	Total number of subjects Incidence/ mortality	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates	Comments
Sweeney et al. (2004) Iowa women's cohort USA 1986–2001	36 658 Incidence	BMI < 23.5 23.5–26 26–29.5 ≥ 29.5 [P_{trend}]	101 78 119 130	55–64 yr 1.00 0.86 (0.64–1.16) 1.26 (0.96–1.64) 1.34 (1.03–1.75) [0.004]	Age, education level, age at first birth, age at menarche, family history of BC, height	Associations with WHR and weight change since age 18 yr similar to those for BMI
		BMI < 23.5 23.5–26 26–29.5 ≥ 29.5 [P_{trend}]	274 306 335 382	65–74 yr 1.00 1.21 (1.03–1.42) 1.26 (1.08–1.49) 1.48 (1.26–1.73) [< 0.0001]		
		BMI < 23.5 23.5–26 26–29.5 ≥ 29.5 [P_{trend}]	112 129 167 153	75–84 yr 1.00 1.19 (0.92–1.53) 1.45 (1.14–1.85) 1.44 (1.12–1.84) [0.001]		
Kuriyama et al. (2005) Population-based cohort Japan 1984–1992	15 054 Incidence	BMI < 18.5–24.9 25–27.4 27.5–29.9 ≥ 30 [P_{trend}]	73 23 12 7	1.00 1.20 (0.75–1.93) 1.55 (0.84–2.87) 1.90 (0.87–4.15) [0.04]	Age, smoking, alcohol consumption, diet, age at menopause, age at menarche, age at first pregnancy	
Rapp et al. (2005) Population-based cohort Austria 1985–2002	78 484 Incidence	BMI 18.5–24.9 30–34.9 ≥ 35 [P_{trend}]	NR	1.00 1.48 (1.12–1.95) 1.29 (0.79–2.11) [0.02]	Age, smoking, occupation	
Chang et al. (2006) USA PLCO cohort 1993–2003	38 660 Incidence	BMI < 22.4 22.5–24.9 25–27.4 27.5–29.9 ≥ 30 [P_{trend}]	139 177 168 114 166	1.00 1.20 (0.96–1.51) 1.24 (0.99–1.56) 1.42 (1.11–1.83) 1.35 (1.06–1.70) [0.014]	Age, study centre, race, family history of BC in first-degree relative, age at menarche, age at menopause, HRT use, education level	

Table 2.2.9a (continued)

Reference Cohort Location Follow-up period	Total number of subjects Incidence/ mortality	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates	Comments
Eliassen et al. (2006) NHS1 and NHS2 USA	87 143 Incidence	Weight change (kg), age 18 yr to baseline loss ≥ 10 loss 5–9.9 loss 2–4.9 stable gain 2–4.9 gain 5–9.9 gain 10–19.9 gain 20–24.9 gain ≥ 25 [P_{trend}]	22 35 33 85 108 204 435 159 313	1.05 (0.64–1.70) 1.14 (0.76–1.70) 0.77 (0.51–1.15) 1.00 1.02 (0.77–1.36) 1.08 (0.83–1.39) 1.34 (1.06–1.69) 1.55 (1.18–2.02) 1.98 (1.55–2.53) [< 0.001]	Age, age at menarche, parity, age at first birth, height, weight at age 18 yr, first-degree family history of BC, benign breast disease, alcohol consumption, use of HRT, age at menopause	Weight change since menopause associated more weakly. Association was much weaker among users of HRT
Krebs et al. (2006) Cohort of older women for osteoporosis USA 1986 Average follow-up, 11.3 yr	7523 Incidence	BMI, quartiles Q1 Q2 Q3 Q4 [P_{trend}]	350 total	1.00 0.82 (0.58–1.15) 1.01 (0.72–1.41) 1.29 (0.92–1.81) [0.06]	Age, HRT use, bone density, family history of BC, exercise, education level, parity, age at menarche, age at menopause, smoking	WC and WHR both showed no association
Lukanova et al. (2006) Population-based cohort Sweden 1994–2004	35 362 Incidence	BMI 18.5–24.9 25–29.9 ≥ 30 [P_{trend}]	213 140 69	1.00 0.92 (0.74–1.14) 1.09 (0.83–1.43) [0.70]	Age, tobacco use	
Mellemkjaer et al. (2006) Population-based cohort Denmark 1993–2002	11 992 Incidence	BMI < 18.5 18.5–24.9 25–29.9 ≥ 30 [P_{trend}]	7 237 130 42	1.23 (0.58–2.63) 1.00 0.88 (0.71–1.09) 0.94 (0.67–1.31) [0.74]	Parity, age at first birth, education level, benign breast disease, alcohol consumption	WC and WHR both showed no association
	11 796 Incidence	BMI < 18.5 18.5–24.9 25–29.9 ≥ 30 [P_{trend}]	1 96 85 35	– 1.00 1.34 (1.00–1.80) 1.17 (0.79–1.73) [0.28]	Parity, age at first birth, education level, benign breast disease, alcohol consumption	WC and WHR both showed no association

Table 2.2.9a (continued)

Reference Cohort Location Follow-up period	Total number of subjects Incidence/ mortality	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates	Comments
Silvera et al. (2006) Canadian mammography screening cohort Canada 1980–2000	40 318 Incidence	BMI < 25 25–29.9 ≥ 30 [P_{trend}]	662 total	1.00 1.12 (0.91–1.38) 1.26 (0.95–1.67) [0.08]	Age, alcohol consumption, smoking, HRT use, age at menarche, age at first birth, family history of BC	
Suzuki et al. (2006) Swedish mammography cohort Sweden 1987–2003	51 823 Incidence	BMI < 18.5 18.5–24.9 25–29.9 ≥ 30 [P_{trend}] BMI < 18.5 18.5–24.9 25–29.9 ≥ 30 [P_{trend}]	11 345 249 111 2 83 52 6	ER+PR+: 1.03 (0.55–1.95) 1.00 1.23 (1.05–1.46) 1.67 (1.34–2.07) [< 0.0001] ER–PR–: 0.80 (0.20–3.27) 1.00 0.96 (0.67–1.38) 0.52 (0.26–1.04) [0.017]	Age, family history of BC, age at menarche, parity, age at first birth, education level, OC use, HRT use, diet, alcohol consumption	
Ahn et al. (2007) NIH-AARP USA 1995–2000	99 039 Incidence	BMI 15–18.4 18.5–22.4 22.5–24.9 25.0–27.4 27.5–29.9 30–34.9 35–39.9 ≥ 40 [P_{trend}]	6 134 179 197 136 175 77 44	Non-HRT users: 0.64 (0.28–1.45) 1.00 1.19 (0.95–1.49) 1.35 (1.08–1.68) 1.52 (1.29–1.94) 1.55 (1.22–1.96) 1.89 (1.40–2.55) 2.08 (1.44–2.99) [< 0.001]	Age, age at first pregnancy, age at menopause, age at first birth, parity, smoking, education level, race, family history of BC, alcohol consumption, diet, physical activity, oophorectomy	Associations with BMI at age 50 yr similar to BMI at baseline. Association null at age 35 yr, inverse at age 18 yr. Both WC and WHR positively associated with risk

Table 2.2.9a (continued)

Reference Cohort Location Follow-up period	Total number of subjects Incidence/ mortality	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates	Comments
Ahn et al. (2007) (cont.)	99 039 Incidence	BMI 15–18.4 18.5–22.4 22.5–24.9 25.0–27.4 27.5–29.9 30–34.9 35–39.9 ≥ 40 [P_{trend}]	11 280 313 257 117 129 40 15	HRT users: 0.79 (0.43–1.44) 1.00 1.13 (0.96–1.33) 1.19 (1.00–1.42) 1.04 (0.83–1.30) 1.14 (0.91–1.42) 1.13 (0.80–1.61) 1.10 (0.64–1.88) [0.22]	Age, age at first pregnancy, age at menopause, age at first birth, parity, smoking, education level, race, family history of BC, alcohol consumption, diet, physical activity, oophorectomy	
Ericson et al. (2007) Malmö cohort Sweden 1991–2003	11 699 Incidence	BMI < 25 25–29.9 ≥ 30 [P_{trend}]	183 147 62	1.00 1.20 (0.96–1.49) 1.19 (0.89–1.59) [0.41]	Age	
Lundqvist et al. (2007) Twin cohort studies Sweden and Finland 1961–2004	14 058 older twins (mean age at baseline, 56 yr) Incidence	BMI < 18.5 18.5–24.9 25–29.9 ≥ 30 [P_{trend}]	12 411 274 59	0.9 (0.5–1.5) 1.0 1.2 (1.0–1.4) 1.3 (1.0–1.7) [< 0.007]	Smoking, physical activity, education level, diabetes	
Reeves et al. (2007) Population-based cohort United Kingdom 1996–2001	1.2 million Incidence	BMI < 22.5 22.5–24.9 25.0–27.4 27.5–29.9 ≥ 30 per 10 kg/m²	879 1336 1262 878 1274	0.85 (0.80–0.91) 1.00 1.10 (1.04–1.16) 1.21 (1.13–1.29) 1.29 (1.22–1.36) 1.40 (1.21–1.49)	Age, region, SES, reproductive history, smoking, alcohol consumption, physical activity, HRT use	
Reinier et al. (2007) Mammography screening cohort in Vermont USA 1996–2002	32 607 Incidence	BMI < 22.0 22–24.9 25.0–27.4 27.5–29.9 ≥ 30	572 total	1.0 1.2 (0.9–1.6) 1.4 (1.0–1.8) 1.6 (1.1–2.1) 1.9 (1.4–2.5)	Age, family history of BC, age at first birth, breast density	

Table 2.2.9a   (continued)

Reference Cohort Location Follow-up period	Total number of subjects Incidence/ mortality	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates	Comments
Song et al. (2008) Korean medial insurance cohort Republic of Korea 1994–2003	107 481 Incidence	BMI < 18.5 18.5–20.9 21.0–22.9 23.0–24.9 25.0–26.7 27.0–29.9 ≥ 30 per 1 kg/m²	11 59 132 186 159 130 36	0.54 (0.17–1.73) 0.87 (0.54–1.41) 1.00 1.27 (0.90–1.80) 1.52 (1.07–2.15) 1.97 (1.37–2.83) 1.64 (0.91–2.97) 1.08 (1.04–1.12)	Age, smoking, alcohol consumption, exercise	
Andreotti et al. (2010) Agricultural workers USA 1993–2005	28 319 Incidence	BMI < 18.5 18.5–24.9 25–29.9 30–34.9 ≥ 35 [P_{trend}]	5 186 156 93 24	– 1.00 1.22 (0.93–1.60) 1.62 (1.17–2.24) 1.07 (0.61–1.87) [0.02]	Age, race, smoking, vegetable intake, exercise, family history of cancer	
Parr et al. (2010) 39 cohorts Asia, Australia, and New Zealand 1961–NR	130 946 Mortality	BMI < 12–18.4 18.5–24.9 25–29.9 ≥ 30 [P_{trend}]	324 total	0.71 (0.22–2.24) 1.00 1.13 (0.85–1.50) 1.63 (1.13–2.35) [0.03]	Age, sex, tobacco use	
Canchola et al. (2012) California Teachers Study USA 1995–2008	52 642 Incidence	BMI < 25 25–29.9 ≥ 30 [P_{trend}] BMI < 25 25–29.9 ≥ 30 [P_{trend}]	740 413 218 156 91 33	ER+PR+: 1.00 1.13 (1.00–1.28) 1.20 (1.03–1.40) [0.01] ER–PR–: 1.00 1.13 (0.87–1.47) 0.77 (0.53–1.12) [0.36]	Age, race, parity, age at menarche, age at first birth, family history of BC, alcohol consumption, HRT use	No association with BMI at age 18 yr. WC positively associated with risk No association with BMI at age 18 yr. WC not associated with risk

Table 2.2.9a (continued)

Reference Cohort Location Follow-up period	Total number of subjects Incidence/ mortality	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates	Comments
White et al. (2012) Population-based Multiethnic Cohort USA 1993–2004	35 495 Incidence	BMI < 20 20–24.9 25–29.9 ≥ 30 [P_{trend}]	63 316 396 329	Never HRT users: 0.90 (0.69–1.18) 1.00 1.35 (1.17–1.57) 1.60 (1.36–1.87) [< 0.0001]	Age, family history of BC, age at first birth, age at menarche, parity, smoking, physical activity, alcohol consumption, height	Analyses available by race/ ethnicity: non-Hispanic White, Latina, Japanese, Native Hawaiian, African American
	28 200 Incidence	BMI < 20 20–24.9 25–29.9 ≥ 30 [P_{trend}]	132 610 376 190	Current HRT users: 1.02 (0.84–1.23) 1.00 1.04 (0.91–1.18) 1.14 (0.97–1.35) [0.18]	Age, family history of BC, age at first birth, age at menarche, parity, smoking, physical activity, alcohol consumption, height	
Fourkala et al. (2014) Ovarian cancer screening cohort United Kingdom 2001–2012	1.2 million Incidence 1.2 million Incidence	BMI per 1 kg/m² Skirt size per 1 unit	1090 1090	1.06 (1.01–1.12) 1.05 (1.01–1.08)	Age, age at menarche, age at menopause	Skirt size remained significant after adjustment for BMI
Gaudet et al. (2014) CPS2 cohort USA 1997–2006	28 965 Incidence	BMI < 25 25–29.9 ≥ 30 per 1 kg/m²	441 401 246	1.00 1.34 (1.17–1.54) 1.60 (1.36–1.89) 1.04 (1.02–1.06)	Age, family history of BC, education level, height, age at menopause, tobacco use, diabetes, race, age at first birth, physical activity, alcohol consumption, OC use, HRT use	Similar association with WC , but in multivariate adjustment, the BMI association persisted but the WC association did not. Cases overlap with Feigelson et al. (2004)
Bandera et al. (2015) Pooled data on African American women in 4 cohorts USA 1995–2013	15 234 Incidence	BMI < 25 25–29.9 30–34.9 ≥ 35 [P_{trend}]	254 469 361 329	ER+: 1.00 1.10 (0.93–1.30) 1.21 (1.01–1.45) 1.32 (1.09–1.60) [0.002]	Age, education level, study, family history of BC, age at menarche, parity, breastfeeding, age at first birth, HRT use, OC use	Inverse association with BMI in young adulthood and risk. WHR positively associated with risk

Table 2.2.9a (continued)

Reference Cohort Location Follow-up period	Total number of subjects Incidence/ mortality	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates	Comments
Bandera et al. (2015) (cont.)		BMI < 25 25–29.9 30–34.9 ≥ 35 [P_{trend}]	130 200 156 126	ER−: 1.00 0.87 (0.69–1.11) 0.90 (0.70–1.17) 0.82 (0.63–1.08) [0.23]	Age, education level, study, family history of BC, age at menarche, parity, breastfeeding, age at first birth, HRT use, OC use	Inverse association with BMI in young adulthood and risk. WHR positively associated with risk
Kabat et al. (2015) Women's Health Initiative cohort USA 1992–2013	143 901 Incidence	BMI, quintiles Q1 Q2 Q3 Q4 Q5 [P_{trend}]	7039 total	1.00 1.09 (1.01–1.18) 1.12 (1.04–1.21) 1.23 (1.14–1.33) 1.41 (1.31–1.53) [< 0.0001]	Age, alcohol consumption, smoking, physical activity, age at menarche, age at first birth, parity, HRT use, family history of BC, ethnicity, education level	WC, WHR not associated any more strongly than BMI
Dartois et al. (2016) E3N cohort France 1990–2008	67 634 Incidence	BMI < 18.5 18.5–24.9 25–29.9 ≥ 30	84 2310 610 134	– 1.00 1.19 (1.10–1.30) 1.25 (1.07–1.46)	Age, family history of BC, education level, height, age at menarche, age at menopause, tobacco use, parity, physical activity, alcohol consumption, OC use, HRT use	Earlier study by Tehard & Clavel-Chapelon (2006) showed similar association between WC and risk, but no associations with WHR

BC, breast cancer; BMI, body mass index (in kg/m²); CI, confidence interval; CPS, Cancer Prevention Study; EPIC, European Prospective Investigation into Cancer and Nutrition; HRT, hormone replacement therapy; NHS, Nurses' Health Study; NIH-AARP, National Institutes of Health–AARP Diet and Health Study; NR, not reported; OC, oral contraceptive; PLCO, Prostate, Lung, Colorectal, and Ovarian Cancer Screening Trial; SES, socioeconomic status; WC, waist circumference; WHR, waist-to-hip ratio; yr, year or years

Table 2.2.9c Case–control studies of body mass index and cancer of the breast in postmenopausal women

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates Comments
Li et al. (2000) USA 1988–1990	479 435 Population; Caucasian women	BMI at age 50–64 yr ≤ 21.5 21.6–24.1 24.2–27.5 ≥ 27.6	 111 126 120 122	 1.00 1.2 (0.9–1.8) 1.1 (0.8–1.6) 1.5 (1.1–2.3)	Age, family history of BC, parity
Trentham-Dietz et al. (2000) USA January 1992–December 1994	Postmenopausal women aged 50–79 yr 5031 5255 Population; matched by age	BMI 11.62–21.94 21.95–24.02 24.03–26.44 26.45–29.44 29.45–54.87 [P_{trend}]	 841 920 971 1013 1286	 1.0 1.0 (0.9–1.2) 1.1 (1.0–1.3) 1.2 (1.1–1.4) 1.6 (1.4–1.9) [< 0.001]	Logistic conditional models on age and state. Parity, age at FFTP, family history of BC, recent alcohol consumption, education level, age at menopause
de Vasconcelos et al. (2001) Brazil May 1995–February 1996	177 377 Hospital/population; visitors at hospital; 27 relatives of BC patients	Current BMI < 24.55 24.55–27.64 27.65–30.79 ≥ 30.80 [P_{trend}]	 38 29 35 29	 1.00 0.61 (0.33–1.14) 0.84 (0.46–1.53) 0.61 (0.33–1.14) [0.24]	Age, parity, family history of BC, education level
Shu et al. (2001) China August 1996–March 1998	1459 aged 25–64 yr enrolled from Shanghai Cancer Registry 1556 Population; randomly selected from female residents of Shanghai (Shanghai Resident Registry), matched to cases by age, 5-yr interval	BMI at diagnosis < 20.70 20.70–22.79 22.80–25.09 25.10–27.90 ≥ 28.0 [P_{trend}]	 63 95 134 125 83	 1.0 1.4 (0.9–2.1) 1.5 (1.0–2.3) 1.7 (1.1–2.6) 2.0 (1.2–3.2) [0.003]	Age, education level, family history of BC, ever had fibroadenoma, age at menarche, age at first live birth, exercise, age at menopause
Yoo et al. (2001) Japan 1988–1992	1154 aged ≥ 25 yr, with no previous history of cancer 21 714 Hospital	BMI per 1 kg/m²		1.07 (1.04–1.10)	Age at interview, occupation, family history of BC, age at menarche, age at menopause, age at FFTP, number of FTPs, months of breastfeeding, alcohol consumption, cigarette smoking, weight, height

Table 2.2.9c (continued)

Reference Study location Period	Study populationª Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates Comments
Friedenreich et al. (2002) Canada, Alberta 1995–1997	1233 1241 Population; frequency-matched to cases by age, 5-yr interval, and place of residence (urban/rural)	BMI < 24.1 ≥ 24.1– < 27.3 ≥ 27.3– < 31.3 ≥ 31.3 [P_{trend}]	206 179 187 199	1.00 0.93 (0.69–1.24) 0.94 (0.70–1.26) 0.99 (0.74–1.32) [0.55]	Current age, total energy intake, total lifetime physical activity, education level, ever use of HRT, ever diagnosed with benign breast disease, first-degree family history of BC, ever alcohol consumption, current smoking
Adebamowo et al. (2003) Nigeria, urban 1998–2000	234 273 Population	BMI ≥ 30 vs < 30	31	1.82 (0.78–4.31)	Age, age at menarche, regularity of periods; only natural menopause
Carpenter et al. (2003) Canada, USA, and western Europe Group I: March 1987– December 1989 Group II: January 1992– December 1992 Group III: September 1995–April 1996	1883 Caucasian (including Hispanic), born in Canada, USA, or western Europe, diagnosed at age ≥ 55 yr 1628 Population; matched to cases by neighbourhood	BMI, 1 yr before diagnosis < 21.7 21.7–23.6 23.7–27.0 ≥ 27.1 [P_{trend}]	366 379 497 641	1.00 1.10 (0.88–1.37) 1.18 (0.95–1.46) 1.34 (1.09–1.66) [0.005]	Age at FFTP, age at menarche, age at menopause, family history of BC, interviewer, average MET hours per week of lifetime exercise activity
Li et al. (2003) USA 1997–1999	975 1007 Population	BMI at age 65–79 yr < 23.32 23.33–26.20 26.21–30.11 ≥ 30.12	209 240 245 245	1.00 1.3 (1.0–1.7) 1.4 (1.1–1.9) 1.4 (1.0–1.8)	Age, income
Pan et al. (2004) Canada 1994–1997	1449 postmenopausal 2492 Population	BMI < 25 25–30 ≥ 30 [P_{trend}]	1449	1.00 1.17 (1.00–1.39) 1.66 (1.33–2.06) [< 0.0001]	
Chow et al. (2005) Hong Kong Special Administrative Region 1995–2000	Chinese women aged 24–85 yr 198 353 Hospital; followed up for benign breast disease; no BC	BMI at diagnosis < 19 19–23 23–27 27–31 > 31 [P_{trend}]	10 38 42 20 10	1.00 1.78 (0.79–4.04) 1.73 (1.04–2.86) 2.06 (1.08–3.93) 3.82 (1.03–14.27) [< 0.001]	

Table 2.2.9c (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates Comments
Zhu et al. (2005) USA 1995–1998	African American, aged 20–64 yr 304, without previous cancer history, interviewed 1–3 yr after diagnosis 305 Population; no history of BC, matched to cases by age (5-yr intervals) and county; women were offered money to participate	BMI at diagnosis < 25 25– < 30 ≥ 30 [P_{trend}]	45 55 61	1.00 1.50 (0.70–3.21) 2.32 (1.04–5.19) [0.039]	Family history of BC, history of benign breast disease, alcohol consumption, smoking, menstrual status, age at menarche, menstrual cycle length, parity, age at first birth, miscarriages, history of radiotherapy, use of estrogen other than for birth control, history of losing weight, history of taking iron pills, age at first sexual intercourse, daily energy intake, physical activity, use of electric bedding devices, history of infertility, demographic variables
Okobia et al. (2006) Nigeria September 2002–April 2004	250 250 Hospital; patients recruited from the same hospitals as cases, treated for non-malignant and non-hormonal surgical disorders	BMI, mean (± SD) Cases, 24.74 (± 6.89) Controls, 25.03 (± 5.33)	108	0.76 (0.44–1.32)	Age
Wu et al. (2006) USA 1995–2001	Asian American (Chinese, Japanese and Filipino) women aged 25–74 yr 1277 1160 Population; neighbourhood controls, frequency-matched by ethnicity and 5-yr age groups	BMI, recent ≤ 20.43 > 20.43–22.32 > 22.32–24.60 > 24.60 [P_{trend}]	139 138 187 241	1.00 0.94 (0.65–1.36) 1.13 (0.79–1.62) 1.35 (0.95–1.93) [0.045]	Age, ethnicity, duration of residence in the USA, education level, age at menarche, number of live births, age at menopause, intake of tea and soy during adolescence and adult life, years of physical activity, height
Garmendia et al. (2007) Chile, Santiago 2005	170 diagnosed within 2 mo before recruitment, aged 33–86 yr 170 Population; mammography service of the same hospitals	BMI ≥ 30	122	0.66 (0.39–1.14)	Crude OR; controls matched to cases by 5-yr age interval and place of residence
Kruk (2007) Poland 2003–2007	858 1085 Hospital; controls frequency-matched by 5-yr age group and place of residence (urban/rural)	Current BMI < 22.5 22.6– < 25.0 25.0– < 30.0 ≥ 30.0 [P_{trend}]	78 127 221 122	1.00 1.85 (0.98–2.84) 2.13 (1.45–3.13) 2.62 (1.66–4.11) [< 0.0001]	Age, recreational activity, breastfeeding, stress, passive smoking $P_{interaction}$ = 0.002

Absence of excess body fatness

Table 2.2.9c (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates Comments
Tian et al. (2007) Taiwan, China January 2004–December 2005	244 aged 22–87 yr 244 Hospital; recruited from health examination clinics at the same hospital and time, no history of cancer, matched by menopausal status, date of enrolment, and duration of fasting	BMI ≤ 24.45 > 24.45	54 49	1.00 2.94 (1.53–5.68)	Age at enrolment, fasting status, levels of adiponectin
Mathew et al. (2008) India 2002–2005	1866 1873 Accompanying persons to cancer cases; matched by age ± 5 yr and residence type (urban/rural)	BMI < 25 25–29.9 ≥ 30	559 297 76	1.00 1.29 (1.00–1.66) 1.00 (0.64–1.54)	Age, centre, religion, marital status, education level, SES, residence status, parity, age at first birth, duration of breastfeeding, physical activity
Montazeri et al. (2008) Islamic Republic of Iran 1996–2000	116 in situ and invasive cancers 116 Hospital; women presenting for clinical breast examination	BMI 18.5–24.9 25–29.9 ≥ 30	23 51 42	1.00 2.53 (1.20–5.35) 3.21 (1.15–8.47)	Age, age at menopause, family history of BC, parity
Nemesure et al. (2009) Barbados July 2002–March 2006	Women of African descent aged ≥ 21 yr 222 454 Population; Barbados Statistical Services; frequency-matched by 5-yr age group	BMI at age ≥ 50 yr < 25 25–30 ≥ 30	51 42 49	1.00 0.67 (0.36–1.24) 0.70 (0.38–1.28)	Age, HRT use, parity, family history of BC, history of benign breast disease, age at first pregnancy, age at menarche, physical activity, other body size variable
Shin et al. (2009) China 1996–1998 (phase 1), 2002–2005 (phase 2)	3452 aged 20–64 yr (phase 1), 20–70 yr (phase 2) 3474 Population; controls frequency-matched to cases by age	Current BMI ≤ 20.9 21–22.9 23–24.9 ≥ 25 [P_{trend}]	192 285 348 543	1.0 1.3 (1.0–1.7) 1.5 (1.2–1.9) 1.8 (1.4–2.2) [< 0.001]	

Table 2.2.9c   (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates Comments
Berstad et al. (2010) USA 1994–1998	4575 4682 Caucasian: 2953 3021 African American: 1622 1661 Population	BMI, 5 yr before reference date < 25 25–29 30–34 ≥ 35 [P_{trend}]	 918 579 254 149	 1.00 0.98 (0.84–1.14) 1.02 (0.82–1.26) 1.09 (0.83–1.43) [0.67]	Age, race, education level, study site, first-degree family history of BC, parity, age at menopause, HRT use, BMI at age 18 yr
Healy et al. (2010) Ireland NR	200 519 (age-matched) healthy women	BMI, quartiles Q4 vs Q1 > 30 vs 20–25		 2.2 (1.3–3.7) 2.04 (1.3–3.3)	 $P = 0.002$ $P = 0.004$
Ogundiran et al. (2010) Nigeria 1998–2009	1233 1101 Population; community register of Ibadan	BMI < 21 21–23.9 24–27.9 ≥ 28 [P_{trend}]	 100 115 139 151	 1.00 1.04 (0.63–1.71) 0.88 (0.55–1.41) 0.76 (0.48–1.21) [0.15]	Age at diagnosis or interview, ethnicity, education level, age at menarche, number of live births, age at first live birth, duration of breastfeeding, age at menopause, family history of BC, benign breast disease, OC use, alcohol consumption, height $P_{interaction} = 0.85$
Barnes et al. (2011) Germany 2001 (Hamburg); 2002 (Rhein-Neckar-Karlsruhe) to 2005	3074 6386 Population; frequency-matched by year of birth and study region	BMI at age 50–74 yr ≤ 22.4 22.5–24.9 25–29.9 ≥ 30	 1354 993 622 105	 1.00 1.06 (0.95–1.17) 1.04 (0.92–1.18) 0.93 (0.73–1.19)	Family history of BC, benign breast disease, age at menarche, OC use, breastfeeding, parity, cause of menopause, age at menopause, alcohol consumption, HRT use, recent physical activity, occupational status, year of birth, study region, lifetime number of mammograms
Cerne et al. (2011) Slovenia January 2006–December 2008	Caucasian women 784, aged 50–69 yr at diagnosis 709 Hospital; no history of BC	BMI < 25 25–30 ≥ 30	 267 327 190	 1.00 1.34 (1.04–1.73) 1.89 (1.36–2.63)	

Table 2.2.9c (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates Comments
Cribb et al. (2011) Canada, Prince Edward Island 1999–2002	207 621 Population; women presenting for routine mammography screening; matched by age, menopausal status, and family history of BC	BMI > 25 vs ≤ 25	61%	1.71 (1.08–2.70)	
Rosato et al. (2011) Pooled analysis of 2 studies in Italy and Switzerland 1983–1994 (1st study), 1991–2007 (2nd study)	3869, postmenopausal 4082 Hospital; admitted for acute, non-neoplastic diseases, not related to gynaecological or hormonal conditions, matched by age and study centre	BMI < 30 ≥ 30	3292 578	1.00 1.26 (1.11–1.44)	Age, study centre, study period, education level, alcohol consumption, age at menarche, age at first birth, age at menopause, HRT use, family history of BC
Attner et al. (2012) Sweden, County of Scania 2005–2007	2613 19 898 Registry: Population Registry of Scania	Obesity	2.1%	0.79 (0.52–1.19)	90–1461 days (4 yr) before diagnosis Obesity defined as comorbidity diagnosis of obesity (ICD-10: E66)
Ghiasvand et al. (2012) Islamic Republic of Iran September 2005–December 2008 (cases), May–August 2009 (controls)	493 women aged ≥ 50 yr enrolled within 6 mo after diagnosis 493 Hospital; frequency-matched to cases by 5-yr age groups and province of residence; no history of BC	BMI < 18.5 18.5–24.9 25–29.9 ≥ 30 [P_{trend}]	4 129 208 141	0.60 (0.17–2.11) 1.00 1.39 (1.02–1.94) 1.61 (1.18–2.30) [0.01]	Age, parity, age at menarche, education level, occupation, height, family history of BC
Ronco et al. (2012) Uruguay 2004–2009	367 545 Hospital; non-hospitalized women aged 23–69 yr; age-matched, with normal mammography	BMI < 25 25–30 ≥ 30	165	3.60 (0.33–39.8) 5.40 (1.77–16.6) 0.84 (0.33–2.12)	Age, residence, first-degree family history of BC, age at menarche, number of live births, age at first delivery, months of breastfeeding
Bandera et al. (2013a) USA, New York City and New Jersey NR	978 postmenopausal women of African ancestry 958 Population; random-digit dialling	Current BMI < 25 25–29.99 ≥ 30 [P_{trend}]	74 131 304	1.00 0.93 (0.60–1.44) 0.98 (0.66–1.45) [0.94]	Age, ethnicity, country of origin, education level, family history of BC, history of benign breast disease, age at menarche, age at menopause, parity, breastfeeding, age at first birth, HRT use, OC use

Table 2.2.9c   (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates Comments
John et al. (2013) USA Hispanic cases: 1995–2002 African American cases: 1995–1999 Non-Hispanic White cases: 1995–1999	1389 of 2571 1644 of 2706 Hispanic: 1119 1462 African American: 543 598 Non-Hispanic White: 596 646 Population; controls randomly selected and frequency-matched by race/ethnicity and expected 5-yr age distribution of cases	Current BMI < 25.0 25.0–29.9 ≥ 30 [P_{trend}]	208 278 312	1.00 0.95 (0.74–1.21) 0.94 (0.74–1.20) [0.64]	All non-users of HRT
Noh et al. (2013) Republic of Korea 1995–2011	270 540 Population; women attending routine health examination, with no evidence of malignant disease; matched by age, menopausal status, and time of visit to Health Promotion Center	BMI < 25 ≥ 25	106 69 37	1.00 2.24 (1.22–4.10)	Number of live births, family history of BC, age at menarche, smoking, alcohol consumption, physical activity, use of HRT
Sangrajrang et al. (2013) Thailand May 2002–March 2004; August 2005–August 2006	1126 1135 Hospital/population; visitors of hospital patients admitted for conditions other than BC or ovarian cancer	Current BMI < 18.5 18.5–24.9 ≥ 25.0	27 248 203	1.94 (0.98–3.85) 1.00 1.67 (1.24–2.25)	
Singh & Jangra (2013) India August 2009–July 2010	128 aged 20–80 yr 128 Hospital; enrolled from the general surgical ward, without history of any type of cancer, matched to cases within 2-yr age interval	BMI < 18.5 18.5–23.0 23.0–25.0 25.0–30.0 > 30.0 [P_{trend}]	4 34 14 21 6	0.217 1.00 1.647 1.647 2.118 [0.016]	[No CIs provided]

Table 2.2.9c (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates Comments
Troisi et al. (2013) USA 1974–2009	Women aged < 85 yr 22 646 with primary in situ or invasive cancer 224 721 Population; frequency-matched to cases by parity, age, calendar year of delivery, and race/ethnicity	Pre-pregnancy BMI (after 1992) Aged ≥ 50 yr at diagnosis: < 18.5 18.5– < 25 25– < 30 ≥ 30 $[P_{trend}]$	144 3 105 19 17	 0.62 (0.19–2.06) 1.00 0.60 (0.36–1.01) 0.84 (0.48–1.46) [0.33]	Age at delivery, race/ethnicity, parity at index birth, year of index birth
Amadou et al. (2014) Mexico (Mexico City, Monterrey, Veracruz) 2004–2007	1000 1074 Population	BMI < 25 25–29.0 ≥ 30 $[P_{trend}]$	89 239 257	1.00 0.96 (0.64–1.44) 0.75 (0.51–1.12) [0.068]	Age, health-care system, region, SES, breastfeeding, family history of BC, alcohol consumption, physical activity, total energy intake, height, current BMI
Elkum et al. (2014) Saudi Arabia 2007–2012	Arab women 534 638 Population; unmatched, randomly selected from primary health care visitors; free of BC	BMI 18.5–24.9 25–29.9 ≥ 30 BMI 18.5–24.9 ≥ 25	60 70 137	1.00 1.25 (0.73–2.15) 1.66 (1.02–2.70) 1.00 2.22 (1.32–3.72)	None Age, BMI, marital status, HRT use, age at menarche, breastfeeding, education level
Minatoya et al. (2014) Japan September 2012–July 2013	66 66 Hospital; hospitalized for CVD, hypertension, arrhythmia, nephritis, nephrosis; no BC or diabetes; matched by age ± 3 yr and menopausal status	BMI < 19.1 ≥ 19.1– < 22.3 ≥ 22.5 $[P_{trend}]$	4 15 25	0.28 (0.07–1.11) 1.00 1.39 (0.50–3.86) [0.043]	Age at menarche, smoking, alcohol consumption, parity, OC/HRT use P_{trend} based on χ^2 test of log-transformed continuous variables
Trentham-Dietz et al. (2014) USA Pooled analysis of 5 case–control studies 1988–2008	Women aged < 75 yr 23 959 28 304 Population	BMI < 18.5 18.5–24.9 25–29.9 ≥ 30	16 517	0.75 (0.64–0.88) 1.00 1.11 (1.06–1.17) 1.32 (1.24–1.40)	Age, state of residence, study period, family history of BC, alcohol consumption, age at menarche, parity, age at first pregnancy, OC use, smoking status

BC, breast cancer; BMI, body mass index (in kg/m²); CI, confidence interval; CVD, cardiovascular diseases; FFTP, first full-term pregnancy; FTP, full-term pregnancy; HRT, hormone replacement therapy; MET, metabolic equivalent; mo, month or months; NR, not reported; OC, oral contraceptive; OR, odds ratio; SES, socioeconomic status; yr, year or years

[a] In this table, the study population describes the population of the entire study, and the numbers of cases and controls refer to the number of women in the study, not necessarily the number of postmenopausal women.

Table 2.2.9g Case–control studies of body mass index and cancer of the breast in postmenopausal women, by hormone receptor status

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Enger et al. (2000) USA 1997–1989	760 1091 Population; matched by age, race (Hispanic/non-Hispanic), parity, and residential neighbourhood	BMI ER+PR+: < 21.7 21.7–23.6 23.7–27.0 ≥ 27.1 $[P_{trend}]$ ER+PR–: < 21.7 21.7–23.6 23.7–27.0 ≥ 27.1 $[P_{trend}]$ ER–PR–: < 21.7 21.7–23.6 23.7–27.0 ≥ 27.1 $[P_{trend}]$	71 101 127 151 34 38 46 41 31 36 25 35	1.00 1.36 (0.96–1.94) 1.78 (1.26–2.51) 2.45 (1.73–3.47) [0.0001] 1.00 1.12 (0.68–1.85) 1.35 (0.83–2.20) 1.29 (0.78–2.15) [0.24] 1.00 1.19 (0.71–1.99) 0.80 (0.45–1.40) 1.20 (0.70–2.05) [0.85]	Age at reference year, SES, number of FTPs, months of breastfeeding, age at menopause, HRT use, family history of BC, alcohol consumption, physical activity Results available for BMI at age 18 yr
Huang et al. (2000) USA 1993–1996	862 790 Population	BMI ER+PR+: < 23 23–31 > 31 ER–PR–: < 23 23–31 > 31	213 111	1.0 1.1 (0.7–1.8) 1.6 (0.9–3.0) 1.0 1.0 (0.6–1.9) 0.8 (0.4–1.7)	Age at selection, race, age at menarche, nulliparity/age at FFTP, breastfeeding, abortion or miscarriage, WHR, OC use, HRT use, first-degree family history of BC, medical radiation to the chest, cigarette smoking, alcohol consumption, education level, and the offset term
Yoo et al. (2001) Japan 1988–1992	Women aged ≥ 25 yr 1154, no previous history of cancer 21 714 Hospital	BMI per 1 kg/m^2 ER+ ER– PR+ PR–		1.09 (1.05–1.13) 1.05 (0.99–1.12) 1.09 (1.04–1.14) 1.07 (1.02–1.11)	

Table 2.2.9g (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Cotterchio et al. (2003) Canada ECSS study: April 1995–March 1996 WHS study: July 1996–September 1998	1867 2452 Population; frequency-matched to cases within 5-yr age groups	BMI ER+PR+: < 20 20–25 25.1–27 > 27 ER–PR–: < 20 20–25 25.1–27 > 27	 45 489 208 631 25 172 72 190	 0.72 (0.43–1.21) 1.00 1.10 (0.84–1.43) 1.61 (1.32–1.98) 1.34 (0.72–2.49) 1.00 1.09 (0.74–1.61) 1.48 (1.09–1.99)	$P_{\text{heterogeneity}}$ = 0.29
Rusiecki et al. (2005) USA January 1994–December 1997	Women aged 40–80 yr 420, no prior BC or benign breast disease 406 Hospital; no BC or benign breast disease or incident fibroadenoma, or atypical hyperplasia, no previous cancer disease except for non-melanoma of the skin, frequency-matched by age within 5-yr intervals	BMI ER+PR+: < 25.0 25.0–29.99 ≥ 30.0 ER+PR–: < 25.0 25.0–29.99 ≥ 30.0 ER–PR+: < 25.0 25.0–29.99 ≥ 30.0 ER–PR–: < 25.0 25.0–29.99 ≥ 30.0 ER+PR+ vs ER–PR–: < 25.0 25.0–29.99 ≥ 30.0	104 65 41 107 104	 1.0 0.7 (0.4–1.2) 1.0 (0.6–1.9) 1.0 0.7 (0.4–1.4) 0.8 (0.4–1.8) 1.0 1.3 (0.6–2.8) 0.9 (0.3–2.3) 1.0 1.3 (0.7–2.1) 1.3 (0.7–2.3) 1.0 0.7 (0.3–1.4) 0.7 (0.3–1.4)	Age, age at menarche, parity (nulliparous treated separately), age at FFTP, lifetime lactation, ever use of estrogen, alcohol consumption, smoking, family history of BC, race P for four categories (ER+PR+, ER+PR–, ER–PR+, ER–PR–), 0.54

Table 2.2.9g (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Tsakountakis et al. (2005) Greece 1996–2002	384 women with primary invasive BC 566 Hospital; women referred for breast screening and who did not develop cancer	BMI > 29 vs ≤ 29: HER2/neu+ HER2/neu− Ratio HER2/neu+ to HER2/neu− ER+ cases: HER2/neu+ HER2/neu− Ratio HER2/neu+ to HER2/neu− ER− cases: HER2/neu+ HER2/neu− Ratio HER2/neu+ to HER2/neu−	180 total 197 total	4.83 (2.75–8.49) 2.67 (1.56–4.55) 2.23 (1.20–4.15) 5.59 (2.58–12.13) 2.48 (1.52–5.32) NS 5.33 (2.59–10.94) 2.41 (1.15–5.04) 2.46 (0.97–6.21)	Age, residence, menopausal age, OC use, HRT use, first-degree family history of BC, age at FFTP, parity, abortion, lactation, medication to suppress lactation, radiation to the chest, BMI, benign breast disease
Li et al. (2006) USA 1997–1999	975 1007 Population	BMI, 65–79 yr ER+PR+: ≤ 24.9 25.0–29.9 ≥ 30.0 ER+PR−: ≤ 24.9 25.0–29.9 ≥ 30.0 ER−PR−: ≤ 24.9 25.0–29.9 ≥ 30.0	615 218 223 174 139 55 48 36 95 38 35 22	1.0 1.3 (1.0–1.6) 1.3 (1.0–1.7) 1.0 1.1 (0.7–1.7) 1.1 (0.7–1.7) 1.0 1.1 (0.7–1.8) 0.9 (0.5–1.6)	Age at diagnosis, reference year, type of menopause
Rosenberg et al. (2006) Sweden October 1993– March 1995	Women aged 50–74 yr 2643 3065 Population: frequency-matched to cases, with no history of invasive cancer other than non-melanoma of the skin	Recent BMI ER+PR+: < 22.2 22.2–24.0 24.1–25.8 25.9–28.2 ≥ 28.3	105 128 135 176 228	1.0 1.3 (1.0–1.7) 1.3 (1.0–1.8) 1.7 (1.3–2.3) 2.2 (1.7–2.8)	P for ER+PR+ vs ER−PR−, 0.48 Exclusion: women who are ever-users of HRT Adjusted for age, age at first birth

Table 2.2.9g (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Rosenberg et al. (2006) (cont.)		ER+PR−:			
		< 22.2	45	1.0	
		22.2–24.0	35	0.8 (0.5–1.3)	
		24.1–25.8	40	0.9 (0.6–1.5)	
		25.9–28.2	37	0.9 (0.5–1.3)	
		≥ 28.3	45	1.0 (0.7–1.6)	
		ER−PR+:			
		< 22.2	7	1.0	
		22.2–24.0	2	0.3 (0.1–1.5)	
		24.1–25.8	11	1.7 (0.7–4.5)	
		25.9–28.2	7	1.1 (0.4–3.1)	
		≥ 28.3	14	2.2 (0.9–5.6)	
		ER−PR−:			
		< 22.2	35	1.0	
		22.2–24.0	41	1.3 (0.8–2.0)	
		24.1–25.8	45	1.4 (0.9–2.2)	
		25.9–28.2	50	1.5 (0.9–2.3)	
		≥ 28.3	55	1.6 (1.0–2.5)	
Phipps et al. (2008) USA Study 1: April 1997–May 1999 Study 2: January 2000–March 2004	1233 (ductal only), aged 65–79 yr at diagnosis (study 1), and 55–74 yr at diagnosis (study 2) (study 1: 975; study 2: 1044) 1447 (study 1: 1007; study 2: 469) Population; from Health Care Financing Administration records, frequency-matched to cases by age	BMI HER2-overexpressing cases:			Age, reference year
		< 25.0	15	1.0	
		25.0–29.0	11	0.8 (0.4–1.8)	
		≥ 30.0	13	1.1 (0.5–2.4)	
		[P_{trend}]		[0.78]	
		Triple-negative cases:			
		< 25.0	24	1.0	
		25.0–29.0	26	1.2 (0.7–2.1)	
		≥ 30.0	27	1.4 (0.8–2.5)	
		[P_{trend}]		[0.26]	
		BMI at age 30 yr HER2-overexpressing cases:			
		< 20.8	11	1.0	
		20.8–22.3	9	0.8 (0.3–2.0)	
		22.4–24.3	6	0.6 (0.2–1.6)	
		> 24.3	13	1.2 (0.5–2.8)	
		[P_{trend}]		[0.74]	

Table 2.2.9g   (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Phipps et al. (2008) (cont.)		Triple-negative cases: < 20.8 20.8–22.3 22.4–24.3 > 24.3 $[P_{trend}]$	21 18 11 27	1.0 0.9 (0.5–1.7) 0.6 (0.3–1.2) 1.4 (0.8–2.5) [0.41]	
Dey et al. (2009) South India 2002–2005	431 387 Population; visitors of non-BC patients, matched to cases by age (5-yr groups) and residence type (urban/rural)	BMI ER+: ≤ 21.4 21.4–25.1 > 25.1 $[P_{trend}]$ ER–: ≤ 21.4 21.4–25.1 > 25.1 $[P_{trend}]$	170 261	1.00 1.72 (1.04–2.84) 1.34 (0.81–2.23) [0.32] 1.00 1.35 (0.88–2.07) 1.51 (0.98–2.30) [0.07]	Age, religion, education level, SES, age at menarche, parity, age at marriage, total duration of breastfeeding, physical activity per day
Bao et al. (2011) China Phase I: 1996–1998, Phase II: 2002–2005	1045 1508 Population; randomly selected, Shanghai Resident Registry; frequency-matched by 5-yr age groups ER+PR+: 522 ER–PR–: 299	BMI ER+PR+: < 21.00 21.00–23.02 23.03–25.15 ≥ 25.16 $[P_{trend}]$ ER–PR–: < 21.00 21.00–23.02 23.03–25.15 ≥ 25.16 $[P_{trend}]$	54 100 152 215 46 67 87 99	1.00 1.59 (1.09–2.33) 1.93 (1.34–2.79) 2.40 (1.65–3.47) [< 0.01] 1.00 1.10 (0.72–1.68) 1.06 (0.70–1.60) 1.00 (0.66–1.53) [0.88]	Age, education, history of breast fibroadenoma, first-degree family history of BC, regular exercise, years of menstruation, history of live birth, parity, study phase (I or II)

Table 2.2.9g (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Barnes et al. (2011) Germany 2001–2005	3074 6386 Population; frequency-matched by year of birth and study region	BMI ER+PR+: ≤ 22.4 22.5–24.9 25–29.9 ≥ 30 ER+PR−: ≤ 22.4 22.5–24.9 25–29.9 ≥ 30 ER−PR−: ≤ 22.4 22.5–24.9 25–29.9 ≥ 30	831 653 402 70 226 152 90 12 252 156 110 22	1.00 1.15 (1.02–1.30) 1.13 (0.97–1.31) 1.06 (0.80–1.42) 1.00 0.96 (0.78–1.20) 0.90 (0.69–1.18) 0.63 (0.34–1.16) 1.00 0.87 (0.70–1.07) 0.92 (0.72–1.18) 0.94 (0.59–1.50)	Family history of BC, benign breast disease, age at menarche, duration of OC use, duration of breastfeeding, parity, cause of menopause, age at menopause, alcohol consumption, HRT use, recent physical activity, occupational status, year of birth, study region, lifetime number of mammograms
Dogan et al. (2011) Turkey NR	250 250 Hospital	BMI, mean ER+ PR+ Luminal		1.144 (1.063–1.746) 1.053 (1.095–1.756) 1.245 (1.023–1.456)	Mostly postmenopausal women, but not clearly stated
Gaudet et al. (2011) USA December 1980– December 1982	890 3432 Population; frequency-matched, aged ≤ 56 yr	BMI treated as ordinal variable Underweight, < 18.5 Normal weight, 18.5– < 25.0 Overweight, 25.0– < 30.0 Obese, ≥ 30.0 Luminal A (n = 455) Luminal B (n = 72) HER2/neu+ (n = 117) Triple-negative (n = 246)	151 18 57 86	1.16 (0.87–1.54) 0.83 (0.36–1.93) 0.93 (0.57–1.52) 1.02 (0.70–1.48)	Age at diagnosis, age at menarche, nulliparity, age at first birth per 5-yr interval, duration of breastfeeding, ever use of OC, benign breast disease, family history of BC P for subtype vs luminal A: 0.58 0.53 0.72
Bandera et al. (2013b) USA NR	Postmenopausal women of African ancestry 978 958 Population; random-digit dialling	Current BMI ER+PR+: < 25 25–29.99 ≥ 30 [P_{trend}]	26 49 131	1.00 1.05 (0.55–1.98) 1.04 (0.50–2.18) [0.95]	Age, ethnicity, country of origin, education level, family history of BC, history of benign breast disease, age at menarche, parity, breastfeeding, age at first birth, HRT use, OC use

Table 2.2.9g (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Bandera et al. (2013b) (cont.)		ER–PR–: < 25 25–29.99 ≥ 30 [P_{trend}]	20 34 47	1.00 0.77 (0.38–1.59) 0.37 (0.15–0.96) [0.03]	
John et al. (2013) USA Hispanic cases: 1995–2002 African American cases: 1995–1999 Non-Hispanic White cases: 1995–1999	1389 of 2571 1644 of 2706 Hispanic: 1119 1462 African American: 543 598 Non-Hispanic White: 596 646 Population; controls randomly selected and frequency-matched by race/ethnicity and expected 5-yr age distribution of cases	Current BMI ER+PR+: < 25.0 25.0–29.9 ≥ 30 [P_{trend}] ER–PR–: < 25.0 25.0–29.9 ≥ 30 [P_{trend}] BMI in young adulthood ER+PR+: T1: ≤ 21.2 T2: 21.3–23.7 T3: > 23.7 [P_{trend}] ER–PR–: T1: ≤ 21.2 T2: 21.3–23.7 T3: > 23.7 [P_{trend}]	98 141 175 34 46 54 147 133 116 46 43 37	1.00 1.09 (0.80–1.49) 1.30 (0.95–1.78) [0.09] 1.00 0.75 (0.46–1.22) 0.72 (0.45–1.16) [0.21] 1.00 0.87 (0.65–1.15) 0.73 (0.54–0.98) [0.04] 1.00 0.82 (0.52–1.29) 0.61 (0.38–0.97) [0.04]	All non-users of HRT Results available for Hispanic, African American, and non-Hispanic White women separately All non-users of HRT Results available for Hispanic, African American, and non-Hispanic White women separately
Kawai et al. (2013) Japan 1997–2009	1017 2902 Hospital; female non-cancer patients = benign tumours, cardiovascular diseases, digestive tract diseases, respiratory tract disease, urological–gynaecological disease	BMI ER+PR+: < 18.5 18.5–22.1 22.1–25.0 25.0–30.0 ≥ 30.0 [P_{trend}]	277 10 54 84 95 34	1.00 0.88 (0.41–1.87) 1.29 (0.61–2.72) 1.72 (0.82–3.60) 6.24 (2.68–14.53) [< 0.0001]	Age, smoking, alcohol consumption, family history of BC, occupation, age at menarche, age at first birth, parity, use of exogenous female hormones or OC, year of recruitment, area, referral base (screening, other), height, time spent exercising

Table 2.2.9g (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Kawai et al. (2013) (cont.)		ER–PR–:	142		$P_{heterogeneity}$ = 0.0002
		< 18.5	5	1.00	
		18.5–22.1	45	1.49 (0.56–3.96)	
		22.1–25.0	47	1.43 (0.53–3.80)	
		25.0–30.0	36	1.19 (0.44–3.21)	
		≥ 30.0	9	2.43 (0.74–7.95)	
		[P_{trend}]		[0.86]	

BC, breast cancer; BMI, body mass index (in kg/m²); CI, confidence interval; ER, estrogen receptor; FFTP, first full-term pregnancy; HER2, human epidermal growth factor receptor 2; HRT, hormone replacement therapy; NR, not reported; NS, not significant; OC, oral contraceptive; PR, progesterone receptor; SES, socioeconomic status; WHR, waist-to-hip ratio; yr, year or years

[a] In this table, the study population describes the population of the entire study, and the numbers of cases and controls refer to the number of women in the study, not necessarily the number of postmenopausal women.

Table 2.2.9i Case–control studies of body mass index and cancer of the breast in postmenopausal women, by ethnicity

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Wenten et al. (2002) USA January 1992–December 1994	Women aged 30–70 yr 712 diagnosed with invasive or in situ breast cancer 1039 Hispanic: 332 511 Non-Hispanic White: 380 528 Population	Usual BMI Hispanic: < 22 22– < 25 25– < 30 ≥ 30 [P_{trend}] Non-Hispanic White: < 22 22– < 25 25– < 30 ≥ 30 [P_{trend}]	NR	1.00 1.53 (0.67–3.50) 1.60 (0.67–3.82) 1.32 (0.47–3.72) [0.58] 1.00 0.90 (0.51–1.61) 1.15 (0.53–2.47) 2.77 (0.86–8.89) [0.16]	Age, first-degree family history of BC, total METs, parity, OC use, months of breastfeeding, age at first full-term birth, HRT use, weight at age 18 yr Results also reported for BMI at age 18 yr
Ziv et al. (2006) USA 1995–2002	Hispanic/Latina women 357 diagnosed 1997–1999 479 Completed interview: 324 421 Provided blood sample: 241 333 Population; matched to cases by ethnicity and 5-yr age groups	BMI All Latinas: < 25 25–29.9 ≥ 30 Latinas born in USA: < 25 25–29.9 ≥ 30 Foreign-born Latinas: < 25 25–29.9 ≥ 30	48 71 115 106 total 128 total	1.00 1.93 (1.38–2.69) 1.51 (1.12–2.04) 1.00 1.25 (0.79–1.96) 1.26 (0.83–1.92) 1.00 3.44 (1.97–5.99) 1.95 (1.24–3.06)	Age, case–control status, grandparents' place of birth, age at migration, education level, place of birth (born in USA vs foreign-born) Age, case–control status, grandparents' place of birth, education level Age, case–control status, grandparents' place of birth, age at migration, education level

Table 2.2.9i (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Slattery et al. (2007) USA 1999–2004	Hispanic women living in non-reservations and non-Hispanic White women 2325 2525 Non-Hispanic White: 1527 1601 Hispanic: 798 924 Population; matched by ethnicity, age in 5-yr classes, random selection	BMI in reference year, no recent hormone exposure Non-Hispanic White: < 25 25–29.9 ≥ 30 [P_{trend}] Hispanic: < 25 25–29.9 ≥ 30 [P_{trend}] BMI in reference year, recent hormone exposure Non-Hispanic White: < 25 25–29.9 ≥ 30 [P_{trend}] Hispanic: < 25 25–29.9 ≥ 30 [P_{trend}]	146 122 112 43 91 104 306 194 202 92 120 114	1.00 1.60 (1.06–2.40) 1.61 (1.05–2.45) [0.03] 1.00 0.68 (0.38–1.24) 0.80 (0.44–1.45) [0.61] 1.00 1.02 (0.79–1.32) 0.72 (0.54–0.96) [0.04] 1.00 0.91 (0.60–1.38) 0.74 (0.47–1.15) [0.17]	Age, height, physical activity, energy intake, parity, alcohol consumption, age at first pregnancy, age at menopause, centre Analyses of BMI at age 18 yr also reported
Berstad et al. (2010) USA: Atlanta (Georgia), Seattle (Washington), Detroit (Michigan), Philadelphia (Pennsylvania), Los Angeles (California); July 1994–April 1998	4575 4682 Caucasian: 2953 3021 African American: 1622 1661 Population	BMI at age 18 yr Caucasian: < 20 20–24 ≥ 25 [P_{trend}] African American: < 20 20–24 ≥ 25 [P_{trend}]	1261 682 517 62 639 297 286 56	1.00 0.89 (0.75–1.05) 0.70 (0.49–1.00) [0.03] 1.00 0.91 (0.72–1.14) 0.80 (0.54–1.19) [0.22]	Age, race, education level, study site, first-degree family history of BC, parity, age at menopause, HRT use, BMI at the other time point Results available by hormonal status for BMI by age 18 yr and 5 yr before reference date, for each ethnic group

Table 2.2.9i (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Berstad et al. (2010) (cont.)		BMI 5 yr before reference date Caucasian:			
		< 25	733	1.00	
		25–29	333	0.93 (0.77–1.12)	
		30–34	127	0.94 (0.72–1.24)	
		≥ 35	68	0.75 (0.53–1.06)	
		[P_{trend}]		[0.13]	
		African American:			
		< 25	185	1.00	
		25–29	246	1.05 (0.80–1.37)	
		30–34	127	0.98 (0.71–1.35)	
		≥ 35	81	1.26 (0.85–1.85)	
		[P_{trend}]		[0.44]	
Bandera et al. (2013a) USA New York City: 2002–2008 New Jersey: 2006–2012	Postmenopausal women of African and Caucasian ancestry 1751 1673 African American: 979 958 European American: 772 715 Population	BMI at age 20 yr African American:			Age, ethnicity (Hispanic/non-Hispanic), country of origin, family history of BC, history of benign breast disease, age at menarche, parity, breastfeeding status, age at first birth, HRT use, OC use, height and weight at menarche
		< 25	392	1.00	
		25–29.9	52	1.01 (0.65–1.58)	
		≥ 30	17	0.88 (0.43–1.81)	
		[P_{trend}]		[0.82]	
		European American:			
		< 25	342	1.00	
		25–29.9	17	0.82 (0.38–1.77)	
		≥ 30	4	0.15 (0.04–0.60)	
		[P_{trend}]		[0.01]	

Table 2.2.9i (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
John et al. (2013) USA Hispanic cases: 1995–2002 African American cases: 1995–1999 Non-Hispanic White cases: 1995–1999	1389 of 2571 1644 of 2706 Hispanic: 1119 1462 African American: 543 598 Non-Hispanic White: 596 646 Population; controls randomly selected and frequency-matched by race/ethnicity and expected 5-yr age distribution of cases	**Current BMI** Hispanic: < 25.0 25.0–29.9 ≥ 30 [P_{trend}] African American: < 25.0 25.0–29.9 ≥ 30 [P_{trend}] Non-Hispanic White: < 25.0 25.0–29.9 ≥ 30 [P_{trend}] **BMI in young adulthood** Hispanic: T1: ≤ 21.2 T2: 21.3–23.7 T3: > 23.7 [P_{trend}] African American: T1: ≤ 21.2 T2: 21.3–23.7 T3: > 23.7 [P_{trend}] Non-Hispanic White: T1: ≤ 21.2 T2: 21.3–23.7 T3: > 23.7 [P_{trend}]	81 133 161 51 90 101 76 55 50 109 122 115 93 77 67 84 60 34	1.00 0.78 (0.54–1.14) 0.77 (0.53–1.12) [0.24] 1.00 1.19 (0.74–1.94) 1.07 (0.66–1.73) [0.88] 1.00 0.90 (0.56–1.43) 1.19 (0.72–1.99) [0.58] 1.00 0.85 (0.60–1.20) 0.63 (0.45–0.90) [0.01] 1.00 1.17 (0.76–1.79) 0.93 (0.59–1.45) [0.80] 1.00 0.65 (0.41–1.02) 0.52 (0.30–0.90) [0.01]	Non-users of HRT Results available for ER+PR+ tumours (for both current BMI and BMI in young adulthood, separated by race)

Table 2.2.9i (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Robinson et al. (2014) USA 1993–2001	Women aged 20–74 yr 1783 1536 Black: 788 718 White: 995 818 Population; frequency-matched to cases by 5-yr age group	Measured BMI Black: < 25 25–30 30–35 ≥ 35 [P_{trend}] White: < 25 25–30 30–35 ≥ 35 [P_{trend}]	74 121 118 113 212 165 69 30	1.00 0.61 (0.38–0.98) 0.77 (0.47–1.28) 0.58 (0.35–0.94) [0.11] 1.00 0.91 (0.67–1.25) 0.83 (0.55–1.25) 0.61 (0.35–1.06) [0.08]	Age, age squared, family history of BC, alcohol consumption, menarche, parity, age at FFTP composite, lactation, education level, smoking Data also reported for BMI at age 18 yr, 35 yr, and one yr before interview, by ethnicity; all of these associations were null
John et al. (2015b) USA 2 population-based case–control studies San Francisco Bay Area Study 4-Corners Breast Cancer Study Hispanic: 1995–2002 Non-Hispanic White: 1995–2004	4271 4713 Population	ER+PR+: Current BMI Hispanic: per 5 kg/m² Non-Hispanic White: per 5 kg/m² ER–PR–: Current BMI Hispanic: per 5 kg/m² Non-Hispanic White: per 5 kg/m²	294 292 153	0.81 (0.65–1.01) 0.94 (0.74–1.19) 0.76 (0.57–1.01) 0.63 (0.43–0.92)	Age, study, ethnicity/English language acculturation, education level, first-degree family history of BC, age at menarche, number of FTPs, age at FFTP, lifetime months of breastfeeding, average alcohol consumption Age, study, ethnicity, education level, first-degree family history of BC, age at menarche, number of FTPs, age at FFTP, lifetime months of breastfeeding, average alcohol consumption Age, study, ethnicity/English language acculturation, first-degree family history of BC, age at menarche, HRT use Age, study, ethnicity, first-degree family history of BC, age at menarche, HRT use

Absence of excess body fatness

Table 2.2.9i (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Sanderson et al. (2015) USA 2001–2011	Women aged 25–75 yr 2614 with primary ductal carcinoma in situ or invasive breast cancer 2306 Population; matched by 5-yr age groups, race, and county of residence	BMI Black: < 25.0 25.0–29.9 30.0–34.9 ≥ 35 $[P_{trend}]$ White: < 25.0 25.0–29.9 30.0–34.9 ≥ 35 $[P_{trend}]$	 75 129 123 113 493 433 223 121	 1.0 1.0 (0.6–1.7) 1.2 (0.7–2.0) 1.0 (0.6–1.7) [0.90] 1.0 1.1 (0.9–1.3) 1.1 (0.9–1.4) 0.8 (0.6–1.1) [0.67]	Age, education level, first-degree family history of BC, OC use, age at menarche $P_{interaction} = 0.43$

BC, breast cancer; BMI, body mass index (in kg/m²); CI, confidence interval; ER, estrogen receptor; HRT, hormone replacement therapy; MET, metabolic equivalent; NR, not reported; OC, oral contraceptive; PR, progesterone receptor; yr, year or years

[a] In this table, the study population describes the population of the entire study, and the numbers of cases and controls refer to the number of women in the study, not necessarily the number of postmenopausal women.

Table 2.2.9k Case–control studies of waist circumference and cancer of the breast in postmenopausal women

Reference, study location and period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories (cm, unless otherwise stated)	Exposed cases	Relative risk (95% CI)	Covariates
Friedenreich et al. (2002) Canada 1995–1997	771 762 Population-based using Waksberg method; frequency-matched to cases by age, 5-yr intervals, and place of residence (urban/rural)	< 75.6 ≥ 75.6– < 82.8 ≥ 82.8– < 91.5 ≥ 91.5 [P_{trend}]	1533 175 159 187 242	1.00 0.89 (0.66–1.20) 1.06 (0.79–1.42) 1.30 (0.97–1.73) [0.07]	Current age, total energy intake, total lifetime physical activity, education level, ever use of HRT, ever diagnosed with benign breast disease, first-degree family history of BC, ever alcohol consumption, current smoking
Slattery et al. (2007) USA 1999–2004	Hispanic women living in non-reservations and non-Hispanic White women Non-Hispanic White: 858 1008 Hispanic: 399 522 Population; matched by ethnicity, age in 5-yr classes, random selection	WC (in), no recent hormone exposure Non-Hispanic White: < 35 35–40 > 40 [P_{trend}] Hispanic: < 35 35–40 > 40 [P_{trend}] WC (in), recent hormone exposure Non-Hispanic White: < 35 35–40 > 40 [P_{trend}] Hispanic: < 35 35–40 > 40 [P_{trend}]	197 95 83 80 83 71 393 180 115 148 108 65	1.00 1.73 (1.16–2.58) 1.29 (0.83–1.99) [0.11] 1.00 0.98 (0.59–1.63) 0.81 (1.47–1.39) [0.45] 1.00 0.99 (0.76–1.28) 0.88 (0.64–1.21) [0.48] 1.00 1.18 (0.80–1.75) 0.86 (0.53–1.38) [0.74]	Age, height, physical activity, energy intake, parity, alcohol consumption, age at first pregnancy, age at menopause, centre

Table 2.2.9k (continued)

Reference, study location and period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories (cm, unless otherwise stated)	Exposed cases	Relative risk (95% CI)	Covariates
Tian et al. (2007) Taiwan 2004–2005	102 aged 22–87 yr 103 Hospital; recruited from health examination clinics at the same hospital and time, free for cancer history, matched by menopausal status, date of enrolment, duration of fasting	≤ 81.00 > 81.00	54 48	1.00 2.02 (1.05–3.91)	Age at enrolment, fasting status, levels of adiponectin
Mathew et al. (2008) India 2002–2005	968 691 Accompanying persons to cancer cases; matched by age ± 5 yr and residence type (urban/rural)	≤ 85 > 85 Unknown	57 380 31	1.00 1.61 (1.22–2.12) 2.88 (0.76–10.90)	Age, centre, religion, marital status, education level, SES, residence status, parity, age at first birth, duration of breastfeeding, physical activity
Nemesure et al. (2009) Barbados 2002–2006	Women of African descent aged ≥ 21 yr 222 454 Population; Barbados Statistical Services; frequency-matched by 5-yr age group	Aged ≥ 50 yr: < 80 80–101 ≥ 101	18 88 38	1.00 1.35 (0.57–3.18) 2.98 (0.91–9.71)	Current age, HRT use, parity, family history of BC, history of benign breast disease, age at first pregnancy, age at menarche, physical activity, other body size variable
Rosato et al. (2011) Italy, Switzerland 1983–1994 (Italy), 1991–2007 (Switzerland)	Postmenopausal women 1747 1935 Hospital; admitted for acute, non-neoplastic diseases, not related to gynaecological or hormonal conditions, matched by age and study centre	< 88 ≥ 88	869 878	1.00 1.17 (1.02–1.35)	Age, study centre, study period, education level, alcohol consumption, age at menarche, age at first birth, age at menopause, HRT use, family history of BC

Table 2.2.9k (continued)

Reference, study location and period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories (cm, unless otherwise stated)	Exposed cases	Relative risk (95% CI)	Covariates
Bandera et al. (2013b) USA NR	Postmenopausal women of African ancestry 978 958 Population; random-digit dialling	≤ 87.88 87.89–97.75 97.76–110.25 > 110.25 $[P_{trend}]$ ER+PR+: ≤ 87.88 87.89–97.75 97.76–110.25 > 110.25 $[P_{trend}]$ ER–PR–: ≤ 87.88 87.89–97.75 97.76–110.25 > 110.25 $[P_{trend}]$	87 119 154 140 36 39 56 74 23 25 25 27	1.00 1.13 (0.73–1.76) 1.51 (0.92–2.48) 1.23 (0.64–2.34) [0.48] 1.00 0.88 (0.48–1.60) 1.30 (0.68–2.48) 1.55 (0.68–3.55) [0.20] 1.00 0.93 (0.45–1.92) 1.11 (0.48–2.57) 1.08 (0.35–3.31) [0.83]	BMI, age, ethnicity, country of origin, education level, family history of BC, history of benign breast disease, age at menarche, age at menopause, parity, breastfeeding, age at first birth, HRT use, OC use
John et al. (2013) USA 1995–2002	1389 postmenopausal women 1644 Population; controls randomly selected and frequency-matched by race/ethnicity and expected 5-yr age distribution of cases	All: ≤ 85.0 85.1–96.4 > 96.4 $[P_{trend}]$ ER+PR+: ≤ 85.0 85.1–96.4 > 96.4 $[P_{trend}]$ ER–PR–: ≤ 85.0 85.1–96.4 > 96.4 $[P_{trend}]$	198 214 293 95 106 162 28 40 48	1.00 0.99 (0.77–1.27) 1.32 (1.03–1.69) [0.02] 1.00 1.11 (0.80–1.54) 1.76 (1.28–2.41) [< 0.01] 1.00 1.13 (0.67–1.89) 1.24 (0.75–2.06) [0.41]	All non-users of HRT

Table 2.2.9k (continued)

Reference, study location and period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories (cm, unless otherwise stated)	Exposed cases	Relative risk (95% CI)	Covariates
Sangrajrang et al. (2013) Thailand May 2002–March 2004; August 2005–August 2006	470 385 Hospital/population; female visitors of hospital patients admitted for conditions other than BC or ovarian cancer	< 80 ≥ 80	199 271	1.00 1.18 (0.89–1.57)	
Amadou et al. (2014) Mexico 2004–2007	585 598 Population	< 93 93–103 ≥ 103 [P_{trend}]	187 218 180	1.00 0.96 (0.70–1.32) 0.62 (0.44–0.85) [0.003]	Age, health care system, region, SES, breastfeeding, family history of BC, alcohol consumption, physical activity, total energy intake, height, current BMI
Robinson et al. (2014) USA 1993–2001	Women aged 20–74 yr 911 825 Black: 434 380 White: 477 445 Population; frequency-matched to cases by 5-yr age group	Black: ≤ 88 > 88 [P_{trend}] White: ≤ 88 > 88 [P_{trend}]	113 321 314 163	1.00 1.39 (0.92–2.10) [0.11] 1.00 1.31 (0.88–1.95) [0.18]	Age, age squared, family history of BC, alcohol consumption, menarche, parity, age at FFTP composite, lactation, education level, smoking, reference BMI

BC, breast cancer; BMI, body mass index (in kg/m²); CI, confidence interval; ER, estrogen receptor; FFTP, first full-term pregnancy; HRT, hormone replacement therapy; NR, not reported; OC, oral contraceptive; PR, progesterone receptor; SES, socioeconomic status; WC, waist circumference (in cm); yr, year or years

[a] In this table, the study population describes the population of the entire study, and the numbers of cases and controls refer to the number of women in the study, not necessarily the number of postmenopausal women.

Table 2.2.9m Case–control studies of change in body mass index or weight and cancer of the breast in postmenopausal women

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
BMI change					
Hirose et al. (2001) Japan 1988–1997	1584 15 331 First visit outpatients (screening) without any previous diagnosis of cancer	BMI change from age 20 yr, without family history of BC			Age, age at menarche, menstrual regularity in the 20s, age at first birth, parity
		< 0	127	0.69 (0.52–0.92)	
		0–1.24	89	1.00	
		1.25–2.99	137	1.02 (0.77–1.40)	
		≥ 3	238	1.34 (1.00–1.70)	
		[P_{trend}]		[< 0.001]	
		BMI change from age 20 yr, with family history of BC			
		< 0	9	1.56 (0.44–5.60)	
		0–1.24	4	1.00	
		1.25–2.99	13	2.74 (0.82–9.10)	
		≥ 3	17	2.19 (0.68–7.00)	
		[P_{trend}]		[0.26]	
Robinson et al. (2014) USA 1993–2001	1783 women aged 20–74 yr 1536 Black: 788 718 White: 995 818 Population; frequency-matched to cases by 5-yr age group	BMI change, ages 18–35 yr Black:			Age, age squared, family history of BC, alcohol consumption, menarche, parity, age at FFTP composite, lactation, education level, smoking, reference BMI
		< 1.77	103	1.0	
		1.77–4.44	151	1.47 (0.98–2.18)	
		≥ 4.44	161	1.14 (0.76–1.70)	
		[P_{trend}]		[0.63]	
		White:			
		< 1.77	194	1.0	
		1.77–4.44	172	1.17 (0.85–1.60)	
		≥ 4.44	98	1.33 (0.88–2.02)	
		[P_{trend}]		[0.16]	
Weight change					
Li et al. (2000) USA January 1988–June 1990	479 435 Population; Caucasian women	Weight change (lb), age 18 yr to reference date, 50–64 yr			Age, height, weight at age 18 yr, family history of BC, parity, HRT use, OC use
		< −10	14	0.9 (0.4–1.9)	
		−10 to 10	113	1.0	
		11–30	153	1.1 (0.7–1.5)	
		31–50	100	1.2 (0.8–1.7)	
		51–70	43	1.3 (0.7–2.1)	
		> 70	55	2.7 (1.5–4.9)	

Table 2.2.9m (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Trentham-Dietz et al. (2000) USA January 1992– December 1994	Postmenopausal women aged 50–79 yr 5031 5255 Population; matched by age and state	Weight loss (kg), overall 0.0 0.1–4.9 5.0–9.9 ≥ 10.0 [P_{trend}]	1690 1637 809 668	1.0 1.1 (1.0–1.2) 1.0 (0.9–1.2) 1.0 (0.9–1.2) [0.1]	Parity, age at FFTP, family history of BC, recent alcohol consumption, education level, age at menopause, height, highest weight and age at highest weight Analyses of weight loss since age 11–45 yr and since age > 45 yr gave similar results to weight loss overall
		Weight gain (kg), overall 0–5.0 5.1–10.0 10.1–15.0 15.1–25.0 > 25.0 [P_{trend}]	730 853 872 1409 1008	1.0 1.1 (0.9–1.3) 1.1 (1.0–1.3) 1.4 (1.2–1.6) 1.7 (1.5–2.0) [< 0.001]	Parity, age at FFTP, family history of BC, recent alcohol consumption, education level, age at menopause, height, lowest weight and time since lowest weight Analyses of weight gain since age 20, since age 21–30 yr and since age > 30 yr gave similar results to weight gain overall
de Vasconcelos et al. (2001) Brazil May 1995–February 1996	177 377 Hospital/population; visitors at hospital; 27 relatives of breast cancer patients	Weight change (kg) since age 18 yr > 22.3 13.11–22.3 0–13.10 Weight loss [P_{trend}]	31 38 28 12	1.00 1.39 (0.75–2.59) 1.24 (0.62–2.50) 2.05 (0.75–5.59) [0.24]	Age, parity, age at menarche, family history of BC, weight and height at 18 yr Analyses of weight change from age 18 yr to age 30 yr and weight change since age 30 yr gave similar results

Table 2.2.9m   (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Shu et al. (2001) China August 1996–March 1998	Women aged 25–64 yr 1459 of 1602 1556 of 1724 Population; randomly selected from female residents of Shanghai (Shanghai Resident Registry), matched to cases by age, 5-yr interval	Weight gain (kg) since age 20 yr < 1.15 1.15–3.41 3.42–5.64 ≥ 5.65 [P_{trend}] Weight gain (kg) during past 10 yr < 1.15 1.15–3.41 3.42–5.64 ≥ 5.65 [P_{trend}]	 20.4% 31.7% 26.6% 21.3% 37.1% 19.8% 14.3% 28.8% 	 1.0 1.4 (1.0–2.1) 1.3 (0.9–1.9) 2.7 (1.7–4.2) [< 0.001] 1.0 1.6 (1.1–2.2) 1.2 (0.8–1.8) 1.5 (1.1–2.1) [0.03]	Age, education level, family history of BC, ever had fibroadenoma, age at menarche, age at first live birth, exercise, age at menopause
Friedenreich et al. (2002) Canada 1995–1997	1233 1241 Population-based using Waksberg method; frequency-matched to cases by age, 5-yr interval, and place of residence (urban/rural)	Weight gain (kg) since age 20 yr < 7.80 ≥ 7.80– < 15.7 ≥ 15.7– < 25.0 ≥ 25.0 [P_{trend}] Difference, maximum – minimum weight (kg) over adult lifetime < 9.07 ≥ 9.07– < 15.4 ≥ 15.4– < 22.7 ≥ 22.7 [P_{trend}]	 181 173 182 231 161 161 184 265 	 1.00 1.02 (0.75–1.37) 1.08 (0.80–1.45) 1.35 (1.01–1.81) [0.05] 1.00 0.94 (0.69–1.28) 1.21 (0.89–1.64) 1.56 (1.16–2.08) [0.0007]	Current age, total energy intake, total lifetime physical activity, education level, ever use of HRT, ever diagnosed with benign breast disease, first-degree family history of BC, ever alcohol consumption, current smoking

Table 2.2.9m (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Wenten et al. (2002) USA January 1992–December 1994	712 women aged 30–70 yr diagnosed with invasive or in situ breast cancer 1039 Hispanic: 332 511 Non-Hispanic White: 380 528 Population	Weight change (kg), age 18 yr to usual adult weight Hispanic: < 4 4–7 8–14 > 14 [P_{trend}] Non-Hispanic White: < 4 4–7 8–14 > 14 [P_{trend}]		1.00 2.48 (0.89–6.93) 2.04 (0.73–5.68) 2.46 (0.98–6.17) [0.14] 1.00 1.34 (0.66–2.74) 1.33 (0.63–2.77) 2.27 (1.09–4.73) [0.04]	Age, first-degree family history of BC, total METs, parity, OC use, months of breastfeeding, age at first full-term birth, HRT use, weight at age 18 yr
Carpenter et al. (2003) Canada, USA, western Europe Group I: March 1987–December 1989 Group II: January 1992–December 1992 Group III: September 1995–April 1996	Caucasian (including Hispanic), born in Canada, USA, or western Europe 1883 diagnosed at age 55–64 yr (Group I), age 55–69 yr (Group II), or age 55–72 yr (Group III) 1628 Population; matched to cases by neighbourhood	Weight change (%), age 18 yr to reference date (1 yr before diagnosis) Negative change to no change > 0–16.9% 17.0–29.1% ≥ 29.2% [P_{trend}]	229 573 404 677	1.00 1.16 (0.92–1.47) 1.13 (0.88–1.45) 1.36 (1.08–1.73) [0.01]	Age at FFTP, ages at menarche and menopause, family history of BC, interviewer, average MET hours per week of lifetime exercise activity
Eng et al. (2005) USA August 1996–July 1997	1006 990 Population; frequency-matched by 5-yr age group	Weight change (kg), age 20 yr to 1 yr before reference date −44.91 to −3.01 −3.00 to 3.00 3.01–7.71 7.71–8.15 8.16–14.96 14.97–87.09 [P_{trend}]	36 103 141 241 209 256	0.55 (0.32–0.96) 1.00 1.03 (0.70–1.50) 1.18 (0.84–1.74) 1.21 (0.84–1.74) 1.58 (1.11–2.26) [0.0001]	Age at reference date, number of pregnancies, months of HRT use, history of BC in a first-degree relative, history of benign breast disease, BMI at age 20 yr

Table 2.2.9m (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Eng et al. (2005) (cont.)		Weight change (kg), age 50 yr to 1 yr before reference date			Age at reference date, number of pregnancies, months of HRT use, history of BC in a first-degree relative, history of benign breast disease, BMI at age 50 yr
		−68.04 to −0.01	157	1.19 (0.85–1.67)	
		0.00	167	1.00	
		0.01–2.71	133	1.19 (0.84–1.69)	
		2.72–4.98	124	0.96 (0.68–1.37)	
		4.99–11.33	195	1.58 (1.14–2.23)	
		11.34–62.14	171	1.62 (1.14–2.30)	
		$[P_{trend}]$		[0.003]	
Han et al. (2006) USA 1996–2001	1166 2105 Population; frequency-matched by age, race, and county of residence	Weight change (kg), age 20 yr to 1 yr before study enrolment			Age, education level, previous benign disease, age at menarche, age at first birth, family history of BC, age at menopause, HRT use, BMI residuals Weight change (kg) from age at first pregnancy to age at menopause also showed a positive association with breast cancer risk (P_{trend} = 0.01)
		≤ 0	841	0.90 (0.56–1.45)	
		0–9.1	47	1.00	
		9.1–17.7	137	1.45 (1.06–1.96)	
		17.7–27.3	208	1.53 (1.12–2.08)	
		> 27.3	227	1.71 (1.23–2.37)	
		$[P_{trend}]$	222	[0.05]	
Wu et al. (2006) USA 1995–2001	Asian American women 1277 aged 25–74 yr at diagnosis 1160 Chinese: 450 486 Japanese: 352 311 Filipino: 475 363 Population; neighbourhood controls; frequency-matched by ethnicity and 5-yr age group	Weight gain (kg) since age 18 yr (recent weight − weight at age 18 yr)			Age, ethnicity, duration of residence in the USA, education level, age at menarche, number of live births, age at menopause, intake of tea and soy during adolescence and adult life, years of physical activity, height
		≤ 10	319	1.00	
		> 10– ≤ 15	138	1.24 (0.90–1.72)	
		> 15– ≤ 20	95	1.10 (0.75–1.62)	
		> 20	95	1.66 (1.09–2.53)	
		$[P_{trend}]$		[0.036]	
		Weight gain (kg) since age 30 yr (recent weight − weight at age 30 yr)			
		≤ 10	518	1.00	
		> 10– ≤ 15	91	1.51 (1.02–2.22)	
		> 15– ≤ 20	44	1.17 (0.70–1.96)	
		> 20	27	2.23 (1.00–4.94)	
		$[P_{trend}]$		[0.023]	

Table 2.2.9m (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Slattery et al. (2007) USA 1999–2004	Hispanic women living in non-reservations and non-Hispanic White women 2325 2525 Non-Hispanic White: 1527 1601 Hispanic: 798 924 Population; matched by ethnicity, age in 5-yr classes, random selection	Total weight gain (kg) between age 15 yr and reference year No recent hormone exposure Non-Hispanic White: ≤ 5.0 5.1–15.0 15.1–25.0 > 25.0 $[P_{trend}]$ Hispanic: ≤ 5.0 5.1–15.0 15.1–25.0 > 25.0 $[P_{trend}]$ Recent hormone exposure Non-Hispanic White: ≤ 5.0 5.1–15.0 15.1–25.0 > 25.0 $[P_{trend}]$ Hispanic: ≤ 5.0 5.1–15.0 15.1–25.0 > 25.0 $[P_{trend}]$	57 99 94 104 22 37 79 78 115 176 182 200 25 77 98 108	1.00 1.19 (0.67–2.09) 1.40 (0.79–2.48) 1.75 (1.00–3.05) [0.03] 1.00 1.14 (0.49–2.67) 0.70 (0.32–1.52) 0.76 (0.35–1.65) [0.25] 1.00 1.14 (0.80–1.61) 1.08 (0.77–1.53) 0.95 (0.66–1.35) [0.57] 1.00 0.73 (0.37–1.43) 0.79 (0.41–1.51) 0.64 (0.34–1.23) [0.26]	Age, height, physical activity, energy intake, parity, alcohol consumption, age at first pregnancy, age at menopause, centre
Shin et al. (2009) China 1996–1998 (phase 1), April 2002–February 2005 (phase 2)	3452 aged 20–64 yr (phase 1), 20–70 yr (phase 2) 3474 Population; controls frequency-matched to cases by age	Weight change (kg) since age 20 yr ≤ 0 0.1–9.4 9.5–14.9 ≥ 15 $[P_{trend}]$	141 383 307 471	1.0 1.3 (1.0–1.6) 1.5 (1.1–2.0) 1.8 (1.4–2.4) [< 0.001]	

Table 2.2.9m (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Berstad et al. (2010) USA July 1994–April 1998	4575 4682 Caucasian: 2953 3021 African American: 1622 1661 Population	Weight change (kg) since age 18 yr ≤ 5 5.1–15.0 15.1–25.0 ≥ 25.1 [P_{trend}]	1900 363 641 507 389	1.00 1.10 (0.91–1.32) 1.01 (0.83–1.23) 1.03 (0.84–1.27) [0.92]	Also adjusted for BMI at age 18 yr
Cribb et al. (2011) Canada 1999–2002	207 621 Population; women presenting for routine mammography screening; matched by age, menopausal status, and family history of BC	Weight gain (kg) since age 25 yr > 10	61%	1.34 (0.85–2.12)	Parity, OC use, BMI, smoking
Sangaramoorthy et al. (2011) USA 1998–2002	Women aged 35–79 yr 931 of 1031 1050 of 1198 Hispanic: 650 766 African American: 134 137 Non-Hispanic White: 147 147 Population; frequency-matched by race and age in 5-yr groups, without history of BC	Relative weight vs peers at age 10 yr Women not currently using HRT Lighter Same Heavier [P_{trend}]	205 114 61 23	1.00 0.84 (0.55–1.29) 0.68 (0.37–1.25) [0.19]	Analysis of Hispanic women only Age, country of birth, education level, first-degree family history of BC, prior biopsy history of benign breast disease, number of FTPs, age at FFTP, lifetime breastfeeding, OC use, adult height, alcohol consumption, average energy intake, BMI Measures of relative weight vs peers at 15 yr and 20 yr gave similar results

Table 2.2.9m (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Bandera et al. (2013b) USA New York City: 2002–2008 New Jersey: 2006–2012	Postmenopausal women of African and European ancestry 1751 1673 African American: 979 958 European American: 772 715 Population	Weight gain (kg) since age 20 yr, quartiles African American: Q1: ≤ 13.82 Q2: 13.83–23.72 Q3: 23.73–34.56 Q4: > 34.56 [P_{trend}] European American: Q1: ≤ 7.57 Q2: 7.58–14.57 Q3: 14.58–24.52 Q4: > 24.52 [P_{trend}]	75 115 110 139 75 77 91 90	1.00 1.35 (0.87–2.10) 1.29 (0.80–2.09) 1.42 (0.80–2.53) [0.34] 1.00 0.97 (0.56–1.66) 0.90 (0.52–1.57) 0.95 (0.46–1.95) [0.88]	Age, ethnicity (Hispanic/non-Hispanic), country of origin, family history of BC, history of benign breast disease, age at menarche, age at menopause, parity, breastfeeding status, age at first birth, HRT use, OC use, current BMI
John et al. (2013) USA Hispanic cases: 1995–2002 African American cases: 1995–1999 Non-Hispanic White cases: 1995–1999	1389 of 2571 1644 of 2706 Hispanic: 1119 1462 African American: 543 598 Non-Hispanic White: 596 646 Population; controls randomly selected and frequency-matched by race/ethnicity and expected 5-yr age distribution of cases	Weight gain (kg) from 20s, all non-users of HRT Stable 3.0–9.9 10.0–19.9 20.0–29.9 ≥ 30.0 [P_{trend}]	78 180 217 142 111	1.00 1.15 (0.82–1.63) 1.06 (0.76–1.48) 1.03 (0.72–1.48) 1.19 (0.81–1.75) [0.75]	Subanalysis by race/ethnicity showed a positive association in White non-Hispanic women only

Table 2.2.9m (continued)

Reference Study location Period	Study population[a] Total number of cases Total number of controls Source of controls	Exposure categories	Exposed cases	Relative risk (95% CI)	Covariates
Troisi et al. (2013) USA 1974–2009	22 646 women aged < 85 yr, with primary in situ or invasive cancer 224 721 Population; frequency-matched to cases by parity, age, calendar year of delivery, and race/ethnicity	Weight gain (lb), since 1989 Aged ≥ 50 yr at diagnosis: < 25 25– < 31 31– < 40 ≥ 40	299 62 99 72 66	1.00 1.33 (0.95–1.86) 1.23 (0.86–1.76) 1.06 (0.74–1.54)	Age at delivery, race/ethnicity, parity at index birth, year of index birth
Robinson et al. (2014) USA 1993–2001	Women aged 20–74 yr 1783 1536 Black: 788 718 White: 995 818 Population; frequency-matched to cases by 5-yr age group	Adult weight gain (lb) since age 18 yr Black: ≤ 25 26–54 ≥ 55 $[P_{trend}]$ White: ≤ 25 26–54 ≥ 55 $[P_{trend}]$	81 126 222 185 184 101	1.00 0.70 (0.44–1.12) 0.84 (0.50–1.40) [0.64] 1.00 1.17 (0.82–1.65) 1.25 (0.70–2.23) [0.38]	Age, age squared, family history of BC, alcohol consumption, age at menarche, parity, age at FFTP composite, lactation, education level, smoking, reference BMI
Sanderson et al. (2015) USA 2001–2011	2614 aged 25–75 yr, primary ductal carcinoma in situ or invasive breast cancer 2306 Population; matched by 5-yr age groups, race, and county of residence	Weight change (lb) since age 18 yr Black: ≤ 0 1–31 32–60 > 61 $[P_{trend}]$ White: ≤ 0 1–31 32–60 > 61 $[P_{trend}]$	23 79 138 200 71 406 460 329	1.0 0.8 (0.3–2.1) 0.9 (0.4–2.3) 0.9 (0.4–2.2) [0.90] 1.0 1.2 (0.8–1.6) 1.3 (0.9–1.9) 1.1 (0.8–1.6) [0.76]	Age, education level, first-degree family history of BC, OC use, age at menarche, weight at 18 yr $P_{interaction} = 0.62$

BC, breast cancer; BMI, body mass index (in kg/m²); CI, confidence interval; FFTP, first full-term pregnancy; FTP, full-term pregnancy; HRT, hormone replacement therapy; MET, metabolic equivalent of task; OC, oral contraceptive; yr, year(s)

[a] In this table, the study population describes the population of the entire study, and the numbers of cases and controls refer to the number of women in the study, not necessarily the number of postmenopausal women.

Table 2.2.9o Mendelian randomization studies of body mass index and cancer of the breast

Reference Study	Study population	Sample size	Exposure assessment	Outcome	Relative risk (95% CI)
Gao et al. (2016) Genetic Associations and Mechanisms in Oncology (GAME-ON) Consortium	Women from 11 studies of individuals of European ancestry	33 832 (15 748 cases and 18 084 controls)	Adult BMI: Increase of 1 SD (equivalent to 4.5 kg/m²) in genetically predicted adult BMI	Adult BMI: All breast cancer ER– breast cancer	0.91 (0.88–0.94) 0.89 (0.84–0.94)
			Increase of 1 SD (~0.073 kg/m²) in genetically predicted childhood BMI	Childhood BMI: All breast cancer ER– breast cancer	0.71 (0.60–0.80) 0.69 (0.53–0.98)

BMI, body mass index (in kg/m²); CI, confidence interval; ER, estrogen receptor; SD, standard deviation

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