Fat mass changes during menopause: a metaanalysis

Ananthan Ambikairajah, BSc, MTeach, PhDc; Erin Walsh, PhD; Hossein Tabatabaei-Jafari, MD; Nicolas Cherbuin, PhD

OBJECTIVE: Data: Fat mass has been shown to increase in aging women; however, the extent to which menopausal status mediates these changes remains unclear. The purpose of this review was to determine (1) how fat mass differs in quantity and distribution between premenopausal and postmenopausal women, (2) whether and how age and/or menopausal status moderates any observed differences, and (3) which type of fat mass measure is best suited to the detection of differences in fat mass between groups.

STUDY: This review with metaanalyses is reported according to Metaanalysis of Observational Studies in Epidemiology guidelines.

STUDY APPRAISAL AND SYNTHESIS METHODS: Studies (published up to May 2018) were identified via PubMed to provide fat mass measures in premenopausal and postmenopausal women. We included 201 cross-sectional studies in the metaanalysis, which provided a combined sample size of 1,049,919 individuals and consisted of 478,734 premenopausal women and 571,185 postmenopausal women. Eleven longitudinal studies were included in the metaanalyses, which provided a combined sample size of 2472 women who were premenopausal at baseline and postmenopausal at follow up.

RESULTS: The main findings of this review were that fat mass significantly increased between premenopausal and postmenopausal women across most measures, which included body mass index (1.14 kg/m^2; 95% confidence interval, 0.95–1.32 kg/m^2), bodyweight (1 kg; 95% confidence interval, 0.44–1.57 kg), body fat percentage (2.88%; 95% confidence interval, 2.13–3.63%), waist circumference (4.63 cm; 95% confidence interval, 3.90–5.35 cm), hip circumference (2.01 cm; 95% confidence interval, 1.36–2.65 cm), waist-hip ratio (0.04; 95% confidence interval, 0.03–0.05), visceral fat (26.90 cm^2; 95% confidence interval, 13.12–40.68), and trunk fat percentage (5.49%; 95% confidence interval, 3.91–7.06 cm^2). The exception was total leg fat percentage, which significantly decreased (–3.19%; 95% confidence interval, –5.98 to –0.41%). No interactive effects were observed between menopausal status and age across all fat mass measures.

CONCLUSION: The change in fat mass quantity between premenopausal and postmenopausal women was attributable predominantly to increasing age; menopause had no significant additional influence. However, the decrease in total leg fat percentage and increase in measures of central fat are indicative of a possible change in fat mass distribution after menopause. These changes are likely to, at least in part, be due to hormonal shifts that occur during midlife when women have a higher androgen (ie, testosterone) to estradiol ratio after menopause, which has been linked to enhanced central adiposity deposition. Evidently, these findings suggest attention should be paid to the accumulation of central fat after menopause, whereas increases in total fat mass should be monitored consistently across the lifespan.

Key words: adiposity, BMI, body fat percentage, DEXA, fat mass, female, menopause, premenopausal, postmenopausal, waist circumference

Overweight and obesity are major societal problems that are associated with a number of deleterious health and wellbeing outcomes that include type II diabetes mellitus,[1] dementia,[2] and cardiovascular disease (CVD)[3] and result in a significant global economic burden[4] and poorer quality of life.[5] This is of particular importance for women because CVD is the leading cause of death in women worldwide.[6] Many potential factors/mechanisms have been implicated in the accumulation of fat mass at midlife; these include aging,[7] decreased physical activity levels,[8] and sarcopenia (ie, loss of lean muscle mass), which can decrease the resting metabolic rate.[9] However, hormonal changes in middle-aged women may also be relevant particularly in moderating increases in body fat.[10,11] Given that the average age of menopause lies between 46–52 years[12] and that the average life expectancy of women in developed countries lies at approximately 81 years,[13] women will spend, on average, almost 40% of their lives in a postmenopausal state. It is therefore necessary to better understand whether and how menopause might predispose to increasing body fat to better target interventions and health policy responses.

Menopause is defined as the final menstrual period and is characterized by the progressive decline of endogenous estrogen levels.[14] Some studies have proposed that the decrease in endogenous estrogen levels may modulate body fat quantity and distribution and result in greater overall body fat and an increased amount of central fat in postmenopausal women.[10,15–17] However, there is a divide in the literature with some researchers suggesting that any observed differences in fat mass quantity or distribution in women at

From Centre for Research on Ageing, Health and Wellbeing, Research School of Population Health, Australian National University, Canberra, Australia.

The authors report no conflict of interest.

Corresponding author: Ananthan Ambikairajah, BSc, MTeach, PhDc. ananthan.ambikairajah@anu.edu.au

0002-9378/$36.00

https://doi.org/10.1016/j.ajog.2019.04.023

AJOG at a Glance

Why was this study conducted?

The purpose of this study was to determine how fat mass differs in quantity and distribution between premenopausal and postmenopausal women and whether age and/or menopausal status moderates any differences between the groups.

Key Findings

Fat mass increased between premenopausal and postmenopausal women across most measures (eg, waist circumference), except for total leg fat percentage, which decreased. No interactive effects were observed between menopausal status and age.

What does this add to what is known?

The change in fat mass quantity was attributable predominantly to increasing age, with menopause having no significant additional influence. However, the decrease in total leg fat percentage and increase in measures of central fat are indicative of a possible change in fat distribution after menopause. Therefore, attention should be paid to the accumulation of central fat after menopause, whereas increases in total fat mass should be monitored consistently across the lifespan.

midlife are primarily due to aging, with menopausal status having little to no effect.[18–20] The contradictory findings could be due to a number of factors that include (1) the intertwined relationship between menopause and aging, (2) the heterogeneity in criteria that were used between studies when defining premenopausal and postmenopausal women, and (3) the heterogeneity of measures used between studies when they investigated fat mass changes in quantity and distribution.

Because of the inconsistent evidence, it is important to pool data from available studies to determine the differences in fat mass quantity and distribution between premenopausal and postmenopausal women. Moreover, confounding factors that may explain effects that currently are attributed to an altered hormonal profile in women, such as aging, have not been investigated adequately. As far as we are aware, no study to date has comprehensively reviewed the evidence and precisely estimated the results through metaanalysis. Therefore, the current study aimed to determine (1) how fat mass differs in quantity and distribution between premenopausal and postmenopausal women, (2) whether and how age and/or menopausal status moderates any observed differences, and (3) which type of fat mass measure is best suited to the detection of differences in fat mass between groups.

Methods

Reporting guidelines

This review with metaanalysis was reported according to Metaanalysis of Observational Studies in Epidemiology guidelines[21] and was registered prospectively in the PROSPERO database (CRD42018100643), which can be accessed online at the following site: (http://www.crd.york.ac.uk/PROSPERO/display_record.php?ID=CRD42018100643).

Search string

A search was conducted, limited to the PubMed database, to retrieve both cross-sectional and longitudinal studies that reported fat mass differences in quantity or distribution between premenopausal and postmenopausal women. The following search string was used: ("adipose tissue" OR "adiposity" OR "subcutaneous fat" OR "obesity" OR "overweight" OR "bodyweight" OR "body fat distribution" OR "body mass index" OR "BMI" OR "DEXA" OR "DXA" OR "dual energy x-ray absorptiometry" OR "waist to hip ratio" OR "waist-hip ratio" OR "waist circumference" OR "x-ray computed tomography" OR "computed tomography" OR "CT scan" OR "calliper" OR "skinfold" OR "skin fold" OR "abdominal MRI" OR "abdominal magnetic resonance imaging" OR "intra-abdominal fat") AND ("menarche" OR "pre-menopause" OR "premenopause" OR "pre-menopausal" OR "premenopausal" OR "reproductive" OR "menopausal transition") AND ("post-menopause" OR "postmenopause" OR "post-menopausal" OR "postmenopausal" OR "non-reproductive").

PubMed filters were used to exclude nonhuman and non-English studies. No time restrictions were applied to the literature search, which was conducted in May 2018.

Inclusion and exclusion criteria

The eligibility criteria for all included and excluded studies were predefined. Inclusion criteria were specified as (1) peer-reviewed manuscripts written in English or translated from their original language of publication to English, (2) studies that assessed human participants, and (3) studies that used continuous unadjusted measures that provide an estimate of fat mass for both healthy premenopausal and healthy postmenopausal women.

Exclusion criteria were (1) studies that exclusively investigated clinical/pathophysiological populations, (2) studies that selectively recruited women based on specific fat mass ranges or reported differences in fat mass within a narrow predetermined fat mass range (ie, only obese women), (3) studies that matched participants on a measure of fat mass, (4) cross-sectional studies with <40 participants to avoid extreme sampling bias and ensure that small studies, which are more likely to be methodologically less robust, are not included, (5) review articles, systematic reviews, and metaanalyses, (6) conference abstracts, and (7) animal studies.

Screening

Duplicate citations were removed from search results and the remaining entries were title screened by a single author (A.A.). All abstracts were then subdivided and independently double-screened by all the authors with the us of the predetermined inclusion/

exclusion criteria; any discrepancies were resolved through consensus. Finally, full-text and supplementary materials of the remaining articles were double-screened against inclusion/exclusion criteria by 3 authors (A.A., H.T.-J., and E.W.), with data extracted from relevant articles. Where data were missing, authors were contacted via email to obtain relevant information that was required for inclusion in the review. A bibliographic search of available articles and reviews was also used to identify further studies that fit the inclusion criteria.

Data extraction

All data from included articles were double extracted by 2 authors (A.A. and E.W.) to avoid transcription errors; any disagreement was resolved by consensus. Data that were extracted from each study included (1) sample size; (2) age; (3) relevant measures that provide an estimate of fat mass (Supplementary Table 1) and included body mass index (BMI), waist circumference (WC), hip circumference (HC), bodyweight (BW), total body fat percentage (BF%), trunk fat percentage (TF%), waist-to-hip ratio (WTHR), total leg fat percentage (LF%), abdominal (ASF) and suprailiac skinfold thickness (SISF), abdominal subcutaneous fat (AF), and visceral fat (VF); (4) whether information such as menopausal status, WC, and/or BMI was measured or self-reported; (5) definitions used for WC, HC, premenopausal women, and postmenopausal women; (6) whether follicle-stimulating hormone (FSH) criteria were used; (7) whether women were age matched, and (8) whether sample selection that included smoking, surgical menopause, hormone replacement therapy (HRT), CVD, and history of drug and alcohol abuse criteria were used.

Definition of premenopause and postmenopause

The precise definition for "premenopause" and "postmenopause" are known to vary substantially within the literature, which has motivated a series of attempts by international experts collaboratively to develop a comprehensive standardized set of criteria to describe the terminology that is associated with menopause.[14,22–25] The current gold standard for defining menopause nomenclature is the Stages of Reproductive Aging+10 criteria, which was established in 2012.[14] The requirement for papers to adhere to the Stages of Reproductive Aging+10 criteria would have limited the scope of the current review and prevented the inclusion of relevant studies, particular those published before 2012. Therefore, all studies that included premenopausal and postmenopausal women (as defined by the authors of those studies) were considered. Furthermore, women who were classified as perimenopausal were not included in the current metaanalysis so that a clear comparison could be made between groups, with premenopausal women acting as controls for any effect observed after menopause.

Quality assessment

The quality of included studies was assessed independently by 2 authors (A.A. and E.W.), who used an adapted version of the Newcastle-Ottawa Scale.[26] In short, the Newcastle-Ottawa Scale for cohort studies used 3 categories to evaluate individual study quality that included (1) the selection of participants, (2) the comparability of groups, and (3) the assessment/ascertainment of the outcome of interest. Notably, an item was removed from the selection and outcome sections of the Newcastle-Ottawa Scale that did not address the particular quality requirements of the present review (Appendix). Furthermore, given that all studies that included premenopausal and postmenopausal women were considered, 2 additional items were added to the comparability section to ensure that studies with better-suited designs for comparing these groups were scored accordingly. Any discrepancy in quality assessment was resolved by consensus. If consensus decisions were not possible, a third rater was used.

Multiple reports

In the cases in which multiple studies had used the same cohort and reported on the same fat mass measures, only 1 publication was used in any single analysis. Which study to include was based on the following criteria, in order of importance: (1) availability of effect sizes in study (or effect sizes provided by authors after contact), (2) sample size, (3) methods quality rating, and (4) publication date of the study (with more recent studies being prioritized). When multiple studies used the same cohort but reported on different fat mass measures, estimates from the same cohort, but with different studies, were used in separate analyses.

Statistical analysis

All statistical analyses were conducted with the open source software R (version 3.3.3)[27] running in RStudio (version 1.0.143)[28] with the use of the metafor package (version 2.0.0)[29] for the metaanalysis.

Summary measures

For both cross-sectional and longitudinal analyses, effect sizes were calculated with the use of the raw (unstandardized) mean difference (D) for fat mass between postmenopausal and premenopausal women:

$$D = \overline{X}_1 - \overline{X}_2$$

The use of raw mean differences was most appropriate, given that the outcome measure of interest (fat mass) was reported on meaningful scales that were used consistently across studies.[30] For cross-sectional studies, the variance of the effect sizes was calculated with the following formula:

$$V_{D_{\text{cross-sectional}}} = \frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}$$

where S_1 and S_2 is the standard deviation for independent groups (ie, premenopausal and postmenopausal women) and n represents the number of women in each group.

For longitudinal studies, the variance of the effect sizes was calculated with the use of the following formulas:

$$V_{D_{longitudinal}} = \frac{S_{diff}^2}{n}$$

$$S_{diff} = \sqrt{S_1^2 + S_2^2 - 2 \times r \times S_2 \times S_2}$$

where *r* is the correlation between premenopausal and postmenopausal fat mass means.

When standard errors of the mean or 95% confidence intervals (CIs) were reported, authors were first contacted and requested to provide the unstandardized means and standard deviations. If the requested information was not provided, the standard errors of the mean and CIs were converted to standard deviations according to the method outlined in Higgins and Green.[31] Furthermore, volume measurements (cubic centimeters) for computed tomography scans were converted to surface area (square centimeters) in the following manner: thickness of slices × number of slices.

Metaanalysis

Heterogeneity was assumed because sampling and methods varied across studies and resulted in a distribution of effect sizes.[32] Therefore, a random effects model with the use of the restricted maximum likelihood estimator was used in all analyses to estimate the mean of the distribution of these effect sizes.

Heterogeneity across studies was assessed with Cochran's Q statistic (with $P<.01$ indicative of significant heterogeneity) and the I^2 statistic (values 25%, 50%, and 75% suggestive of low, moderate, and high heterogeneity, respectively).[33] To identify studies that excessively contributed to heterogeneity, sensitivity analyses were conducted according to the leave-1-out-method. Metaregression analyses that used a mixed effect model were conducted to determine the influence of moderators, such as aging. For cross-sectional studies, comparisons of fat mass differences between premenopausal and postmenopausal women were made with a test of interaction.

Reporting bias

The possible impact of publication bias was assessed by visual inspection of the funnel plots and with the Egger regression test.[34] The trim-and-fill method was also used to estimate the number of studies that may be missing from the metaanalysis and to estimate adjusted effect sizes.[35,36]

Results

The search strategy identified 2994 unique citations; bibliography searches identified an additional 11 records. After initial screening that was based on titles and abstracts, 586 publications remained for full-text assessment. After the application of inclusion and exclusion criteria, a further 300 publications were excluded (Figure 1). Of the remaining 286 studies, 210 were eligible for inclusion in the quantitative analysis, with 201 studies reporting cross-sectional data[15,18-20,35,37-232] and 11 studies reporting longitudinal data.[10,38,152,233-240]

Some studies included multiple subcohorts of premenopausal and postmenopausal women based on factors such as age,[233] ethnicity,[45,107] physical activity level,[111,213] and geographic location.[96,155,167] In these cases, the subcohorts were extracted separately and treated as discrete samples. Therefore, 217 cross-sectional (Supplementary Table 2) and 13 longitudinal samples (Supplementary Table 3) were included in the analyses.

Study quality rating

For cross-sectional studies, 101 studies were of high quality, as demonstrated by their scores that ranged from 7–9 stars on the adapted version of the Newcastle Ottawa Scale (maximum, 9 stars); 78 studies were of moderate quality (4–6 stars), and 22 studies were of poor quality (0–3 stars; Supplementary Table 4). Almost all longitudinal studies were of high quality, with the exception of 1 study,[235] which was of moderate quality with a score of 4 (Supplementary Table 5).

Summary estimates

The unstandardized mean differences (ie, estimate) of each fat mass measure for both cross-sectional and longitudinal studies are presented in Tables 1 and 2, respectively. Standardized estimates for cross-sectional and longitudinal studies are presented in Supplementary Tables 6 and 7, respectively. Cross-sectional studies compared separate premenopausal and postmenopausal groups; for longitudinal studies, all women were premenopausal at baseline and postmenopausal at follow up.

Cross-sectional metaanalysis

Cross-sectional BMI. One hundred seventy-one cross-sectional studies investigated the relationship between BMI and menopausal status. The analyses revealed that the mean BMI difference was 1.14 kg/m^2 (standard error [SE], 0.09 kg/m^2), with a yearly mean age difference of 0.07 kg/m^2 per year (Table 1).

Cross-sectional BW. One hundred nine cross-sectional studies investigated the relationship between BW and menopausal status. The analyses revealed that the mean BW difference was 1.00 kg (SE, 0.29 kg), with a yearly mean age difference of 0.07 kg per year (Table 1).

Cross-sectional WC. Seventy cross-sectional studies investigated the relationship between WC and menopausal status. The analyses revealed that the mean WC difference was 4.63 cm (SE, 0.37 cm), with a yearly mean age difference of 0.30 cm per year (Table 1).

Cross-sectional WTHR. Forty-eight cross-sectional studies investigated the relationship between WTHR and menopausal status. The analyses revealed that the mean WTHR difference was 0.0421 (SE, 0.0045), with a yearly mean age difference of 0.0026 per year (Table 1).

Cross-sectional BF%. Forty-six cross-sectional studies investigated the relationship between BF% and menopausal status. The analyses revealed that the mean BF% difference was 2.88% (SE, 0.38%), with a yearly mean age difference of 0.21% per year (Table 1).

Cross-sectional HC. Twenty-five cross-sectional studies investigated the relationship between HC and menopausal status. The analyses revealed that the mean HC difference was 2.01 cm (SE, 0.33 cm), with a yearly mean age difference of 0.13 cm per year (Table 1).

Cross-sectional AF and VF. Ten cross-sectional studies investigated the relationship between AF/VF and menopausal status with the use of computed tomography scans. The analyses revealed that the mean AF difference was 28.73 cm^2 (SE, 10.29 cm^2), with a yearly mean age difference of 1.92 cm^2 per year; the mean VF difference was 26.90 cm^2 (SE, 7.03 cm^2), with a yearly mean age difference of 1.81 cm^2 per year (Table 1).

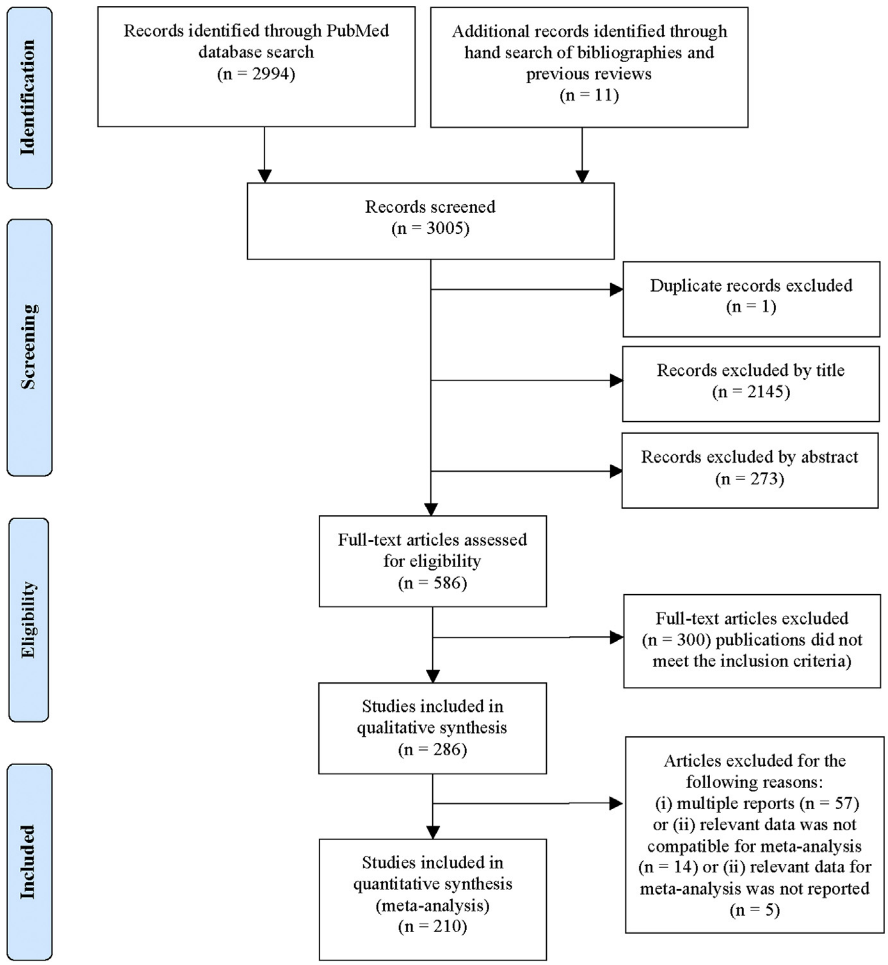
Cross-sectional SISF. Nine cross-sectional studies investigated the relationship between SISF and menopausal status. The analyses revealed that the mean SISF difference was 2.65 mm (SE, 1.12 mm), with a yearly mean age difference of 0.13 mm per year (Table 1).

Cross-sectional TF%. Seven cross-sectional studies investigated the relationship between TF% and menopausal status. The analyses revealed that the mean TF% difference was 5.49% (SE, 0.80%), with a yearly mean age difference of 0.40% per year (Table 1).

Cross-sectional ASF. Four cross-sectional studies investigated the relationship between ASF and menopausal status. The analyses revealed that the mean ASF difference was 6.46 mm (SE, 3.04 mm), with a yearly mean age difference of 0.35 mm per year (Table 1).

Cross-sectional LF%. Three cross-sectional studies investigated the relationship between LF% and menopausal status. The analyses revealed that the mean LF% difference was –3.19% (SE, 1.42%), with a yearly mean age difference of –0.17% per year (Table 1).

FIGURE 1
Flow chart



The flow chart shows the search, screening, and selection process for the studies that were included in the review and metaanalyses.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

Longitudinal metaanalysis

Longitudinal BMI. Eight longitudinal studies investigated the relationship between BMI and menopausal status. The analyses revealed that the mean BMI change was 0.93 kg/m^2 (SE, 0.34 kg/m^2), with an annual change of 0.14 kg/m^2 per year (Table 2).

Longitudinal BW. Seven longitudinal studies investigated the relationship between BW and menopausal status. The analyses revealed that the mean BW change was 2.99 kg (SE, 0.83 kg), with an annual change of 0.37 kg per year (Table 2).

Longitudinal BF%. Four longitudinal studies investigated the relationship between BF% and menopausal status. The analyses revealed that the mean BF % change was 2.18% (SE, 1.01%), with an annual change of 0.41% per year (Table 2).

Longitudinal WC. Three longitudinal studies investigated the relationship between WC and menopausal status. The analyses revealed that the mean WC change was 3.82 cm (SE, 1.51 cm), with an annual change of 0.51 cm per year (Table 2).

Longitudinal AF and VF. Three longitudinal studies investigated the relationship between AF/VF and menopausal status with the use of computed

TABLE 1
Output for cross-sectional studies

Fat mass measure	Studies, n (samples)	Total sample size, n		Mean age, y (standard deviation)[a]			Mean fat mass (standard deviation)[a]		Unstandardized estimate (95% confidence interval)[b]	*P* value
		Premenopausal	Postmenopausal	Premenopausal	Postmenopausal	Age difference	Premenopausal	Postmenopausal		
Body mass index	171 (181)	453,036	523,796	41.96 (3.69)	59.42 (3.06)	14.82 (5.36)	24.75 (1.60)	26.64 (1.25)	1.14 (0.95—1.32)	<.0001
Bodyweight	109 (122)	113,603	204,845	43.36 (4.71)	59.55 (3.27)	15.00 (5.37)	64.82 (7.91)	66.12 (9.17)	1.00 (0.44—1.57)	.0005
Waist circumference	70 (72)	214,712	326,639	42.28 (3.65)	59.07 (1.91)	16.23 (4.24)	78.58 (4.24)	83.61 (3.19)	4.63 (3.90—5.35)	<.0001
Waist-to-hip ratio	47 (50)	199,140	309,797	42.39 (3.44)	59.09 (1.42)	16.17 (3.20)	0.78 (0.03)	0.81 (0.03)	0.04 (0.03—0.05)	<.0001
Body fat percentage	46 (52)	58,605	113,226	43.81 (4.67)	59.55 (3.81)	14.83 (6.56)	32.44 (3.47)	35.69 (3.84)	2.88 (2.13—3.63)	<.0001
Hip circumference	25 (25)	185,885	297,189	42.48 (3.08)	59.15 (0.95)	16.22 (2.61)	100.30 (2.66)	102.73 (2.25)	2.01 (1.36—2.65)	<.0001
Subcutaneous abdominal fat	10 (10)	696	833	41.01 (6.96)	57.48 (5.36)	15.00 (10.70)	194.05 (23.65)	221.21 (32.09)	28.73 (8.56—48.91)	.0053
Visceral fat	10 (10)	696	833	41.01 (6.96)	57.48 (5.36)	15.00 (10.70)	69.22 (15.75)	104.36 (13.92)	26.90 (13.12—40.68)	.0001
Suprailiac skinfold thickness	9 (10)	1,103	745	39.76 (4.41)	61.89 (4.77)	21.46 (6.49)	22.16 (7.04)	24.55 (9.90)	2.65 (0.45—4.85)	.0181
Trunk fat percentage	7 (7)	39,335	95,756	45.28 (6.61)	59.68 (3.41)	14.32 (6.21)	31.27 (4.78)	33.74 (5.36)	5.49 (3.91—7.06)	<.0001
Abdominal skinfold thickness	4 (5)	199	359	40.64 (6.32)	62.99 (5.16)	21.04 (5.00)	26.65 (8.14)	29.43 (9.82)	6.46 (0.51—12.42)	.0335
Total leg fat percentage	3 (3)	991	524	36.96 (1.13)	55.18 (5.17)	19.41 (5.87)	36.33 (5.47)	36.00 (2.62)	—3.19 (—5.98 to —0.41)	.0246

[a] Computed as weighted means and weighted standard deviations, taking into account sample size; [b] Indicates significance at the $P<.05$ level.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

tomography scans. The analyses revealed that there was no significant mean AF difference; however, a significant difference in VF of 12.95 cm^2 (SE, 2.20 cm^2) was detected, with an annual change of 3.43 cm^2 per year (Table 2).

Sensitivity analyses

Significant heterogeneity was found in all metaanalyses performed, and the proportion of real observed variance (not related to random error) between studies (I^2) was high across all analyses (Supplementary Figures 1–17). The influence of single studies was investigated further wherever possible (ie, samples, >3) through leave-1-out analyses. The analyses predominantly demonstrated no particularly influential study and showed relative consistency in reported estimates, with a few notable exceptions. For TF% analyses, the study by Guo et al[106] was found to be influential, which could be due to the large sample size reported (Figure 2) or because bioelectrical impedance analysis was used in comparison with the other 6 studies that used dual-energy x-ray absorptiometry (DEXA) scans. When excluded from the analyses, the mean TF% difference between premenopausal and postmenopausal women increased from 5.49–6.05% (95% CI, 4.94–7.15%), with I^2 decreasing from 89.90–54.44%.

For BF% analyses (cross-sectional), the study by Sherk et al[198] was identified as influential; whereas for BMI and BW analyses (longitudinal), the study by Soreca et al[240] was identified as influential, which could be due to the relatively large mean age difference and follow-up period (41.2 years and 20 years, respectively). When removed from analyses, all estimates decreased (BF%, 2.71 [95% CI, 2.02–3.40]; BMI, 0.63 [95% CI, 0.32–0.94]; BW, 2.3 [95% CI, 1.22–3.55]), with I^2 remaining high. For AF analyses (cross-sectional), Hunter et al[118] was found to be influential. Despite being a relatively older study (published >20 years ago), metaregression analyses revealed that the year of publication had no effect on the overall estimate. When excluded from the analyses, the mean AF difference decreased from 28.73–18.81 cm^2 (95%

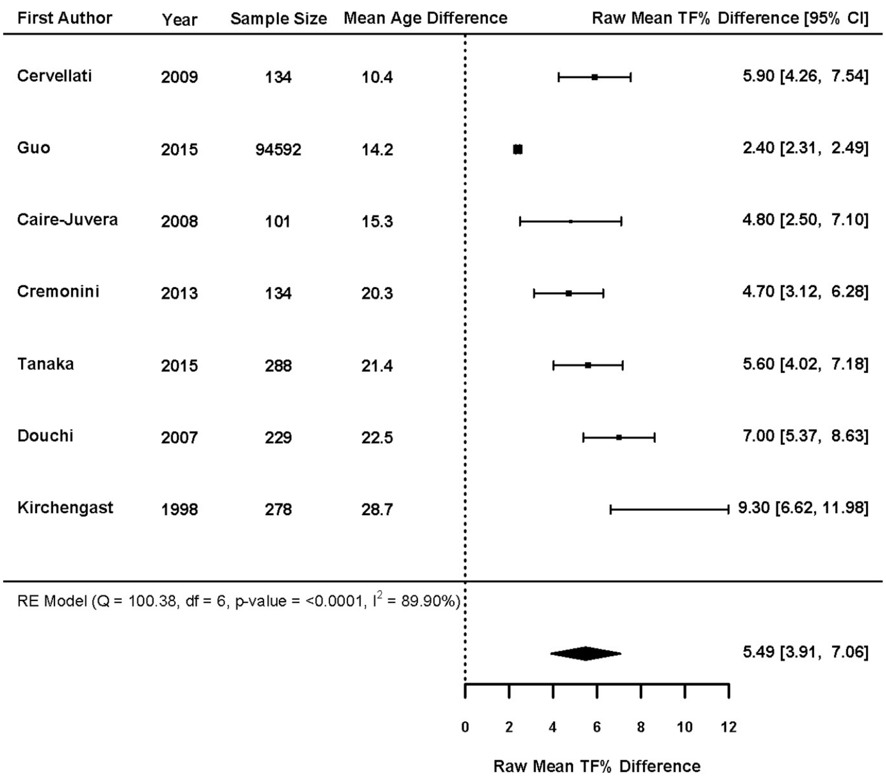
TABLE 2
Output for longitudinal studies

Fat mass measure	Studies, n (samples)	Total sample size, n	Mean age, y (standard deviation)[a]		Mean follow-up period, y (standard deviation)[a]	Mean fat mass (standard deviation)[a]		Unstandardized Estimate (95% confidence interval)	*P* value
			Premenopausal	Postmenopausal		Premenopausal	Postmenopausal		
Body mass index	8 (10)	2355	46.67 (2.53)	52.80 (3.71)	6.68 (2.38)	24.30 (1.97)	25.03 (2.37)	0.93 (0.26–1.59)[b]	.0061
Bodyweight	7 (7)	525	47.64 (3.06)	55.76 (5.08)	7.82 (5.35)	66.11 (3.89)	69.19 (3.71)	2.99 (1.36–4.63)[b]	.0003
Total body fat percentage	4 (4)	176	49.59 (1.24)	55.49 (3.65)	5.82 (3.25)	36.29 (4.88)	37.84 (3.33)	2.18 (0.21–4.16)[b]	.0299
Waist circumference	3 (3)	915	46.99 (2.04)	52.73 (5.17)	7.17 (1.98)	80.79 (3.62)	84.06 (2.61)	3.82 (0.87–6.77)[b]	.0111
Abdominal fat	3 (3)	133	49.65 (1.61)	53.51 (1.64)	3.90 (0.39)	215.14 (66.15)	242.28 (77.34)	18.53 (−3.64–40.69)	.1014
Visceral fat	3 (3)	133	49.65 (1.61)	53.51 (1.64)	3.90 (0.39)	78.63 (14.45)	92.23 (12.77)	12.95 (8.65–17.25)[b]	<.0001

[a] Computed as weighted means and weighted standard deviations, taking into account sample size; [b] Indicates significance at the P<.05 level.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

FIGURE 2
Forest plot



The forest plot shows the cross-sectional raw mean trunk fat percentage difference between pre-menopausal and postmenopausal women. Studies are arranged by mean age difference.

CI, confidence interval; *RE*, random effects; *TF%*, trunk fat percentage.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

CI, 3.38–34.25 cm^2), with I^2 remaining high.

One study, Franklin et al,[235] was found to be influential for BF% analyses (longitudinal), which could be, in part, for the following reasons: (1) the relatively lower quality of the study (4 stars) when compared with other studies that were included in the analyses (8 stars) or (2) the BF% was measured by 2 different methods (ie, hydrostatic weighing [at baseline] and air displacement plethysmograph [at follow up]) compared with other studies that all used DEXA at baseline and follow-up assessment or (3) the very small sample size of the study (8 participants), compared with other studies that have a mean of 56 participants (range, 48–69). When the study by Franklin et al was excluded from the analyses, there was no significant difference in mean BF%.

Publication bias

Funnel plot asymmetry diagnostics and the trim-and-fill test revealed some evidence of publication bias. Eggers regression test was significant for ASF, TF%, and LF% (cross-sectional analyses), BF% (both cross-sectional and longitudinal analyses), and VF (longitudinal analyses), which indicates some degree of asymmetry for these groups. For cross-sectional studies (Supplementary Figures 18–20), the trim-and-fill analyses identified 30 missing studies for BMI and 2 for AF, which produced larger estimates for both. For longitudinal studies (Supplementary Figures 21 and 22), however, 2 missing studies were identified for VF, which produced a smaller estimate.

Subgroup and metaregression analyses

The influence of moderators such as aging (represented as the mean age difference for cross-sectional analyses or length of follow up for longitudinal analyses) and study quality on pooled estimates was investigated by metaregression analyses that used a mixed effects model, for which a sufficient number of studies were available to assess the effect of a single predictor (ie, samples, $\geq$ 10).[31,242] Where metaregression was possible (ie, longitudinal BMI and cross-sectional BMI, BW, WC, WTHR, BF%, HC, AF, VF, and SISF), aging significantly predicted the unexplained variance (9.99–73.90%) in fat mass estimates, except for HC, AF, and SISF (Table 3). No interactive effects were observed between menopausal status and age across all fat mass measures. Furthermore, study quality had no significant effect on the overall estimate.

To examine whether the type of measure could influence the results, we performed subgroup analyses on cross-sectional studies that examined BF% to investigate the impact of DEXA scans vs other methods, such as bioelectrical impedance analysis and hydrodensitometry, on quantifying total and regional body fat percentage. Interestingly, bioelectrical impedance analysis significantly underestimated the quantity of total body fat compared with DEXA (β=–2.64%; 95% CI. –4.23 to –1.04; P=.0012), which supports previous findings.[243] Similarly, when we investigated the effects of measured vs self-reported BMI in cross-sectional studies, self-report significantly underestimated BMI (β=–0.72 kg/m^2; 95% CI, –1.34 to –0.09; P=.0240) compared with direct measurement, which aligns with previous findings.[244] After adjustment for the effect of age, however, self-report had no significant effect on the overall estimate for BMI. All longitudinal studies computed BMI based on objectively measured height and weight. For VF and AF analyses, the use of surface area estimates that were converted from volumes (which was conducted for 1 particular study[20]) had no significant effect on the overall estimate. Notably, almost all subgroup analyses that included women who were using HRT had no significant effect on estimates, except for BF% (significantly increased;

TABLE 3
Metaregression analyses after removal of the effect that is attributable to normal aging

Analyses	Samples, n	Fat mass measure	R^2[a]	Unstandardized β estimate (95% confidence interval)	P value
Longitudinal	10	Body mass index	73.88	0.20 (0.12–0.29)[b]	<.0001
Cross-sectional	176	Body mass index	21.61	0.06 (0.04–0.08)[b]	<.0001
	119	Bodyweight	9.99	0.10 (0.04–0.16)[b]	.0008
	71	Waist circumference	40.13	0.24 (0.16–0.32)[b]	<.0001
	51	Waist-to-hip ratio	24.87	0.0025 (0.0013–0.0037)[b]	<.0001
	50	Total body fat percentage	24.75	0.15 (0.07–0.24)[b]	.0005
	25	Hip circumference	15.74	0.09 (−0.02–0.21)	.1201
	10	Abdominal fat	9.03	1.29 (−0.70–3.28)	.2035
	10	Visceral fat	73.90	1.85 (1.04–2.67)[b]	<.0001
	10	Suprailiac skinfold thickness	0.00	0.21 (−0.19–0.60)	.3033

[a] Proportion of observed variance explained by the model; [b] Indicates significance at the $P<.05$ level; studies that did not report age were omitted from model fitting.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

β=2.46%; 95% CI, 0.16–4.76; P=.0358) and TF% (significantly decreased; β=–3.65%; 95% CI, –5.91 to –1.38; P=.0016).

Comment

This large scale, comprehensive review with metaanalyses investigated the differences in fat mass between healthy premenopausal and postmenopausal women in both cross-sectional and longitudinal studies. The main findings were that (1) there was an increase in fat mass between premenopausal and postmenopausal women across most measures, specifically BMI, BW, WC, WTHR, BF%, HC, ASF, SISF, VF, and TF%, with the exception of LF%, which decreased, and (2) the change in fat mass quantity is largely attributable to increasing age, with menopause having no detectable additional influence. These findings are important because they suggest attention should be paid to the accumulation of central fat after menopause, whereas increases in total fat mass should be monitored consistently across the lifespan.

The relationship between menopause and aging can be difficult to disentangle because both progress concurrently. Previous research indicates that, for women who are 18–45 years old, the typical trend for BMI and BF% is an increase of 0.16 kg/m^2 per year and 0.41% per year, respectively.[245] Interestingly, the longitudinal analyses presented in this paper reflect similar annual estimates for BMI (0.14 kg/m^2 per year) and BF% (0.41% per year), which indicates that the rates of change remain the same throughout early adulthood and middle age, with menopause having no detectable additional influence above and beyond the effect of aging. Furthermore, the metaregression analyses revealed consistent, but comparatively lower, estimates for cross-sectional BMI (0.06 kg/m^2 per year) and BF% (0.15% per year). The reason for the relatively smaller estimates remains to be elucidated; however, it is possible that unmeasured and/or unreported genetic and environmental factors (eg, ethnicity, dietary changes, mood disorders and medications used in their treatment, physical activity levels, metabolic activity, and variation in sleep length and quality[8,246-248]) that varied between groups in cross-sectional studies account for this. Alternatively, this also may be explained by the well-documented differences that emerge from the less robust design of cross-sectional, compared with longitudinal, studies. As a result, the longitudinal study design is better suited to provide yearly rates of change in fat mass, which are more precise than cross-sectional estimates.

Too few longitudinal studies produced precise estimates of fat mass changes across multiple regions; however, the analysis of cross-sectional studies revealed that LF% decreased by 0.17% per year, whereas fat mass increased in abdominal indexes, such as TF% by 0.40% per year and WC (longitudinal) by 0.51 cm per year, which is indicative of a potential change in fat mass distribution after menopause. These changes, at least in part, are likely to be due to hormonal shifts that occur during midlife when women have a higher androgen (ie, testosterone)-to-estradiol ratio after menopause, which has been linked to enhanced central adiposity deposition.[249] Importantly, the increased central deposition of fat has significant clinical implications, given that a 1-cm increase in WC has been associated with a 2% increase in risk of CVD.[250] Furthermore, a higher testosterone/estradiol ratio has also been associated with deleterious health consequences in women, such as CVD.[251] Taken together, these results may help explain the fact that premenopausal women have been found to have lower

CVD incidence and mortality rates compared with men of the same age,[252] whereas postmenopausal women experience higher mortality rates because of CVD compared with men of the same age.[253] The current analyses suggests that measures that are sensitive to detecting the central deposition of adiposity, such as TF% and WC, would be preferable to BW and BMI, which are commonly used indicators of overweight and obesity. This is of particular importance because of the multifactorial changes in body composition that occur in aging women that can influence BW and/or BMI estimates, such as (1) a decrease in bone density,[254,255] (2) sarcopenia,[256] and (3) shrinking,[257] which indicate that measures that are less influenced by these changes, such as TF% and WC, would be preferable. Furthermore, when measures of fat mass were standardized (Supplementary Tables 6 and 7), cross-sectional analyses revealed that BF% had the largest magnitude of effect across estimates. However, WTHR, WC, and TF% produced comparatively more reliable estimates when we compared the precision of CIs. These results should be interpreted with caution, given that variability across measures, which include different samples, sample sizes, and measurement error, could not be accounted for.

Hormone replacement therapy and fat mass

Subgroup analyses revealed that the inclusion of women who used HRT resulted in a significant increase in BF% (β=2.46%; 95% CI, 0.16–4.76; P=.0358) and a significant decrease in TF% (β=–3.65%; 95% CI, –5.91 to –1.38; P=.0016), which is suggestive of a potential protective role of HRT in preventing/reducing trunk fat deposition, although not in preventing overall fat mass gain. These results align with a previous metaanalysis of 8 randomized control trials, which found that postmenopausal women who used HRT had less WC and TF% compared with placebo.[258] Taken together, these findings provide useful estimates for the potential protective effect of HRT on central adiposity, given that, to our knowledge, the most recent systematic review on this topic was published almost 20 years ago[259] and had insufficient studies at the time to evaluate the effect of HRT on fat mass distribution. Moreover, because HRT use has complex interactions with the body and brain, with varying benefits and disadvantages depending on the time of initiation and type and duration of treatment,[260] it is important for this topic to be investigated systematically in future with longitudinal studies.

Strengths and limitations

A key strength of the present study was that a large number of individuals were assessed for cross-sectional analyses across a wide range of measures that estimated fat mass changes in quantity and distribution between premenopausal and postmenopausal women, which resulted in a holistic understanding of body fat changes in women at midlife. Specifically, 201 cross-sectional studies were included in the metaanalysis, which provided a combined sample size of 1,049,919 individuals that consisted of 478,734 premenopausal women and 571,185 postmenopausal women.

Notable limitations included the fact that only 11 longitudinal studies were available for inclusion in the metaanalysis, which provided a combined sample size of 2472 women who were premenopausal at baseline and postmenopausal at follow up. Furthermore, it is possible that relevant studies may have been missed, given that our search was limited to the PubMed database. However, these relative weaknesses were somewhat counterbalanced by the large number of cross-sectional results that facilitated richer and comprehensive analyses that led to very consistent findings. In addition, women who were classified as perimenopausal were not included in the current metaanalysis. This was done to ensure that a clear comparison could be made between groups, with premenopausal women acting as control subjects for any effect that was observed after menopause. Moreover, the criteria that were used to identify premenopausal and postmenopausal women varied substantially among studies and may have reduced the accuracy of the reported effects.

Conclusion

To our knowledge, this is the first comprehensive review with metaanalysis of both longitudinal and cross-sectional studies to investigate changes in fat mass between premenopausal and postmenopausal women. The analyses revealed that fat mass was higher in postmenopausal, compared with premenopausal, women across most measures, with the exception of LF% (which decreased), which was indicative of a potential change in fat mass distribution after menopause. However, the change in fat mass quantity was attributable predominantly to increasing age; menopause had no significant additional influence. Given that central fat accumulation is associated with an increase in CVD risk, these results may help explain the fact that premenopausal women have been found to have lower CVD incidence and mortality rates compared with men of the same age, whereas postmenopausal women experience higher mortality rates because of CVD compared with men of the same age. An important implication of these findings is that attention should be paid to the accumulation of central fat after menopause, whereas increases in total fat mass should be monitored consistently across the lifespan. Further investigation regarding the role of other potential moderators (eg, genetics, ethnicity, dietary changes, physical activity levels, metabolic activity, mood disorders and medications used in their treatment, age of menopause onset, and variation in sleep length and quality) is required to facilitate the development of targeted and effective intervention programs and of heath policies aimed at mitigating the risk posed by increased central adiposity in women at midlife. ■

ACKNOWLEDGMENTS

We thank all corresponding authors for their efforts to provide additional information, which contributed to a richer and more comprehensive analysis for this review.

REFERENCES

1. Guh DP, Zhang W, Bansback N, Amarsi Z, Birmingham CL, Anis AH. The incidence of co-morbidities related to obesity and overweight: a systematic review and metaanalysis. BMC Public Health 2009;9:88.

2. Anstey K, Cherbuin N, Budge M, Young J. Body mass index in midlife and late-life as a risk factor for dementia: a meta-analysis of prospective studies. Obes Rev 2011;12:e426–37.

3. Wilson PF, D'Agostino RB, Sullivan L, Parise H, Kannel WB. Overweight and obesity as determinants of cardiovascular risk: the Framingham experience. Arch Intern Med 2002;162:1867–72.

4. Withrow D, Alter D. The economic burden of obesity worldwide: a systematic review of the direct costs of obesity. Obes Rev 2011;12:131–41.

5. Larsson U, Karlsson J, Sullivan M. Impact of overweight and obesity on health-related quality of life: a Swedish population study. Int J Obes 2002;26:417.

6. World Health Organization. Women's Health, 2013. Available at: https://www.who.int/en/news-room/fact-sheets/detail/women-s-health. Accessed May 31, 2019.

7. Kuk JL, Saunders TJ, Davidson LE, Ross R. Age-related changes in total and regional fat distribution. Ageing Res Rev 2009;8:339–48.

8. Sternfeld B, Wang H, Quesenberry CP Jr, et al. Physical activity and changes in weight and waist circumference in midlife women: findings from the Study of Women's Health Across the Nation. Am J Epidemiol 2004;160:912–22.

9. Karakelides H, Nair KS. Sarcopenia of aging and its metabolic impact. Curr Top in Dev Bio 2005;68:123–48.

10. Razmjou S, Abdulnour J, Bastard J-P, et al. Body composition, cardiometabolic risk factors, physical activity, and inflammatory markers in premenopausal women after a 10-year follow-up: a MONET study. Menopause 2018;25:89–97.

11. Karvonen-Gutierrez C, Kim C. Association of mid-life changes in body size, body composition and obesity status with the menopausal transition healthcare. Healthcare (Basel) 2016 Jul 13;4(3). pii: E42. https://doi.org/10.3390/healthcare4030042.

12. Schoenaker DA, Jackson CA, Rowlands JV, Mishra GD. Socioeconomic position, lifestyle factors and age at natural menopause: a systematic review and metaanalyses of studies across six continents. Int J Epidemiol 2014;43:1542–62.

13. Murray CJ, Barber RM, Foreman KJ, et al. Global, regional, and national disability-adjusted life years (DALYs) for 306 diseases and injuries and healthy life expectancy (HALE) for 188 countries, 1990–2013: quantifying the epidemiological transition. Lancet 2015;386:2145–91.

14. Harlow SD, Gass M, Hall JE, et al. Executive summary of the stages of reproductive aging workshop + 10: addressing the unfinished agenda of staging reproductive aging. J Clin Endocrinol Metab 2012;97:1159–68.

15. Tremollieres FA, Pouilles JM, Ribot CA. Relative influence of age and menopause on total and regional body composition changes in postmenopausal women. Am J Obstet Gynecol 1996;175:1594–600.

16. Park JK, Lim YH, Kim KS, et al. Body fat distribution after menopause and cardiovascular disease risk factors: Korean National Health and Nutrition Examination Survey 2010. J Womens Health 2013;22:587–94.

17. Sowers M, Zheng H, Tomey K, et al. Changes in body composition in women over six years at midlife: ovarian and chronological aging. J Clin Endocrinol Metab 2007;92:895–901.

18. Soriguer F, Morcillo S, Hernando V, et al. Type 2 diabetes mellitus and other cardiovascular risk factors are no more common during menopause: longitudinal study. Menopause 2009;16:817–21.

19. Douchi T, Yonehara Y, Kawamura Y, Kuwahata A, Kuwahata T, Iwamoto I. Difference in segmental lean and fat mass components between pre- and postmenopausal women. Menopause 2007;14:875–8.

20. Trikudanathan S, Pedley A, Massaro JM, et al. Association of female reproductive factors with body composition: the Framingham Heart Study. J Clin Endocrinol Metab 2013;98:236–44.

21. Stroup DF, Berlin JA, Morton SC, et al. Metaanalysis of observational studies in epidemiology: a proposal for reporting. JAMA 2000;283:2008–12.

22. World Health Organization. Research on the menopause in the 1990s: report of a WHO scientific group. 1996. Available at: https://apps.who.int/iris/handle/10665/41841. Accessed May 31, 2019.

23. World Health Organization. Research on the menopause: report of a WHO scientific group [meeting held in Geneva from 8 to 12 December 1980]. 1981. Available at: https://apps.who.int/iris/handle/10665/41526. Accessed May 31, 2019.

24. Soules MR, Sherman S, Parrott E, et al. Executive summary: stages of reproductive aging workshop (STRAW). Climacteric 2001;4:267–72.

25. Utian WH. The International Menopause menopause-related terminology definitions. Climacteric 1999;2:284–6.

26. Wells G, Shea B, O'Connell D, et al. Newcastle-Ottawa quality assessment scale cohort studies, 2014. Available at: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp. Accessed May 31, 2019.

27. R Core Team. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2016-2017.

28. RStudio Team. RStudio: integrated development for R. RStudio, Inc, Boston, MA. Available at: http://wwwrstudiocom 2015;42. Accessed February 14th, 2018.

29. Viechtbauer W. Conducting metaanalyses in R with the metafor. J Stat Software 2010;36:1–48.

30. Borenstein M, Hedges LV, Higgins JP, Rothstein HR. Introduction to metaanalysis. West Sussex, UK: John Wiley & Sons, Ltd; 2009.

31. Higgins J, Green S. Cochrane handbook for systematic reviews of interventions Version 5.1.0. The Cochrane Collaboration. Confidence intervals 2011. Available at: http://handbook-5-1.cochrane.org/. Accessed May 31, 2019.

32. Borenstein M, Hedges LV, Higgins JP, Rothstein HR. A basic introduction to fixed-effect and random-effects models for meta-analysis. Res Synth Methods 2010;1:97–111.

33. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003;327:557.

34. Egger M, Smith GD, Schneider M, Minder C. Bias in metaanalysis detected by a simple, graphical test. BMJ 1997;315:629–34.

35. Bhagat M, Mukherjee S, De P, et al. Clustering of cardiometabolic risk factors in Asian Indian women: Santiniketan women study. Menopause 2010;17:359–64.

36. Duval S, Tweedie R. A nonparametric "trim and fill" method of accounting for publication bias in metaanalysis. J Am Stat Assoc 2000;95:89–98.

37. Abate M, Schiavone C, Di Carlo L, Salini V. Prevalence of and risk factors for asymptomatic rotator cuff tears in postmenopausal women. Menopause 2014;21:275–80.

38. Abdulnour J, Doucet E, Brochu M, et al. The effect of the menopausal transition on body composition and cardiometabolic risk factors: a Montreal-Ottawa New Emerging Team group study. Menopause 2012;19:760–7.

39. Abildgaard J, Pedersen AT, Green CJ, et al. Menopause is associated with decreased whole body fat oxidation during exercise. Am J Physiol Endocrinol Metab 2013;304:E1227–36.

40. Adams-Campbell LL, Kim KS, Dunston G, Laing AE, Bonney G, Demenais F. The relationship of body mass index to reproductive factors in pre- and postmenopausal African-American women with and without breast cancer. Obes Res 1996;4:451–6.

41. Agrinier N, Cournot M, Dallongeville J, et al. Menopause and modifiable coronary heart disease risk factors: a population based study. Maturitas 2010;65:237–43.

42. Aguado F, Revilla M, Hernandez ER, Villa LF, Rico H. Behavior of bone mass measurements. Dual energy x-ray absorptiometry total body bone mineral content, ultrasound bone velocity, and computed metacarpal radiogrammetry, with age, gonadal status, and weight in healthy women. Investig Radiol 1996;31:218–22.

43. Albanese CV, Cepollaro C, de Terlizzi F, Brandi ML, Passariello R. Performance of five phalangeal QUS parameters in the evaluation of gonadal-status, age and vertebral fracture risk compared with DXA. Ultrasound Med Biol 2009;35:537–44.

44. Allali F, El Mansouri L, Abourazzak F, et al. The effect of past use of oral contraceptive on bone mineral density, bone biochemical markers and muscle strength in healthy pre and post menopausal women. BMC Womens Health 2009;9:31.

45. Aloia JF, Vaswani A, Ma R, Flaster E. To what extent is bone mass determined by fat-free or fat mass? Am J Clin Nutr 1995;61:1110–4.

46. Amankwah EK, Friedenreich CM, Magliocco AM, et al. Anthropometric measures and the risk of endometrial cancer, overall and by tumor microsatellite status and histological subtype. Am J Epidemiol 2013;177:1378–87.

47. Amarante F, Vilodre LC, Maturana MA, Spritzer PM. Women with primary ovarian insufficiency have lower bone mineral density. Brazil J Med Biol Res 2011;44:78–83.

48. Amiri P, Deihim T, Nakhoda K, Hasheminia M, Montazeri A, Azizi F. Metabolic syndrome and health-related quality of life in reproductive age and post-menopausal women: Tehran Lipid and Glucose Study. Arch Iranian Med 2014;17:423–8.

49. Angsuwathana S, Leerasiri P, Rattanachaiyanont M, et al. Health check-up program for pre/postmenopausal women at Siriraj Menopause Clinic. J Med AssocThailand 2007;90:1–8.

50. Armellini F, Zamboni M, Perdichizzi G, et al. Computed tomography visceral adipose tissue volume measurements of Italians: predictive equations. Eur J Clin Nutr 1996;50:290–4.

51. Arthur FK, Adu-Frimpong M, Osei-Yeboah J, Mensah FO, Owusu L. The prevalence of metabolic syndrome and its predominant components among pre-and post-menopausal Ghanaian women. BMC Res Notes 2013;6:446.

52. Aydin ZD. Determinants of age at natural menopause in the Isparta Menopause and Health Study: premenopausal body mass index gain rate and episodic weight loss. Menopause 2010;17:494–505.

53. Ayub N, Khan SR, Syed F. Leptin levels in pre and post menopausal Pakistani women. JPMA J Pakistan Med Assoc 2006;56:3–5.

54. Bancroft J, Cawood EH. Androgens and the menopause; a study of 40-60-year-old women. Clin Endocrinol 1996;45:577–87.

55. Bednarek-Tupikowska G, Filus A, Kuliczkowska-Plaksej J, Tupikowski K, Bohdanowicz-Pawlak A, Milewicz A. Serum leptin concentrations in pre- and postmenopausal women on sex hormone therapy. Gynecol Endocrinol 2006;22:207–12.

56. Bell RJ, Davison SL, Papalia MA, McKenzie DP, Davis SR. Endogenous androgen levels and cardiovascular risk profile in women across the adult life span. Menopause 2007;14:630–8.

57. Ben Ali S, Belfki-Benali H, Ahmed DB, et al. Postmenopausal hypertension, abdominal obesity, apolipoprotein and insulin resistance. Clin Exp Hypertens 2016;38:370–4.

58. Ben Ali S, Belfki-Benali H, Aounallah-Skhiri H, et al. Menopause and metabolic syndrome in tunisian women. BioMed Res Inter 2014;2014:457131.

59. Ben Ali S, Jemaa R, Ftouhi B, et al. Relationship of plasma leptin and adiponectin concentrations with menopausal status in Tunisian women. Cytokine 2011;56:338–42.

60. Berg G, Mesch V, Boero L, et al. Lipid and lipoprotein profile in menopausal transition. Effects of hormones, age and fat distribution. Horm Metab Res 2004;36:215–20.

61. Berge LN, Bonaa KH, Nordoy A. Serum ferritin, sex hormones, and cardiovascular risk factors in healthy women. Arterioscler Thromb 1994;14:857–61.

62. Berger GM, Naidoo J, Gounden N, Gouws E. Marked hyperinsulinaemia in postmenopausal, healthy Indian (Asian) women. Diabetic Med 1995;12:788–95.

63. Berstad P, Coates RJ, Bernstein L, et al. A case-control study of body mass index and breast cancer risk in white and African-American women. Cancer Epidemiol Biomarkers Prev 2010;19:1532–44.

64. Bhurosy T, Jeewon R. Food habits, socioeconomic status and body mass index among premenopausal and post-menopausal women in Mauritius. J hum nutr diet 2013;26(suppl1):114–22.

65. Blumenthal JA, Fredrikson M, Matthews KA, et al. Stress reactivity and exercise training in premenopausal and postmenopausal women. Health Psychol 1991;10:384–91.

66. Bonithon-Kopp C, Scarabin PY, Darne B, Malmejac A, Guize L. Menopause-related changes in lipoproteins and some other cardiovascular risk factors. Int J Epidemiol 1990;19:42–8.

67. Caire-Juvera G, Arendell LA, Maskarinec G, Thomson CA, Chen Z. Associations between mammographic density and body composition in Hispanic and non-Hispanic white women by menopause status. Menopause 2008;15:319–25.

68. Campesi I, Occhioni S, Tonolo G, et al. Ageing/menopausal status in healthy women and ageing in healthy men differently affect cardiometabolic parameters. Int J Med Sci 2016;13:124–32.

69. Carr MC, Kim KH, Zambon A, et al. Changes in LDL density across the menopausal transition. J Investig Med 2000;48:245–50.

70. Castracane VD, Kraemer RR, Franken MA, Kraemer GR, Gimpel T. Serum leptin concentration in women: effect of age, obesity, and estrogen administration. Fertil Steril 1998;70:472–7.

71. Catsburg C, Kirsh VA, Soskolne CL, et al. Associations between anthropometric characteristics, physical activity, and breast cancer risk in a Canadian cohort. Breast Cancer Res Treat 2014;145:545–52.

72. Cecchini RS, Costantino JP, Cauley JA, et al. Body mass index and the risk for developing invasive breast cancer among high-risk women in NSABP P-1 and STAR breast cancer prevention trials. Cancer Prev Res 2012;5:583–92.

73. Cervellati C, Pansini FS, Bonaccorsi G, et al. Body mass index is a major determinant of abdominal fat accumulation in pre-, peri- and post-menopausal women. Gynecol Endocrinol 2009;25:413–7.

74. Chain A, Crivelli M, Faerstein E, Bezerra FF. Association between fat mass and bone mineral density among Brazilian women differs by menopausal status: the Pro-Saude Study. Nutrition 2017;33:14–9.

75. Chang CJ, Wu CH, Yao WJ, Yang YC, Wu JS, Lu FH. Relationships of age, menopause and central obesity on cardiovascular disease risk factors in Chinese women. Int J Obes Relat Metab Disord 2000;24:1699–704.

76. Cho GJ, Lee JH, Park HT, et al. Postmenopausal status according to years since menopause as an independent risk factor for the metabolic syndrome. Menopause 2008;15:524–9.

77. Cifkova R, Pitha J, Lejskova M, Lanska V, Zecova S. Blood pressure around the menopause: a population study. J Hypertens 2008;26:1976–82.

78. Copeland AL, Martin PD, Geiselman PJ, Rash CJ, Kendzor DE. Predictors of pretreatment attrition from smoking cessation among pre- and postmenopausal, weight-concerned women. Eating Behav 2006;7:243–51.

79. Cremonini E, Bonaccorsi G, Bergamini CM, et al. Metabolic transitions at menopause: in post-menopausal women the increase in serum uric acid correlates with abdominal adiposity as assessed by DXA. Maturitas 2013;75:62–6.

80. Cui LH, Shin MH, Kweon SS, et al. Relative contribution of body composition to bone mineral density at different sites in men and women of South Korea. J Bone Miner Metab 2007;25:165–71.

81. D'Haeseleer E, Depypere H, Claeys S, Van Lierde KM. The relation between body mass index and speaking fundamental frequency in premenopausal and postmenopausal women. Menopause 2011;18:754–8.

82. Da Camara SM, Zunzunegui MV, Pirkle C, Moreira MA, Maciel AC. Menopausal status and physical performance in middle aged women: a cross-sectional community-based study in Northeast Brazil. PLoS One 2015;10:e0119480.

83. Dallongeville J, Marecaux N, Isorez D, Zylbergberg G, Fruchart JC, Amouyel P. Multiple coronary heart disease risk factors are associated with menopause and influenced by substitutive hormonal therapy in a cohort of French women. Atherosclerosis 1995;118:123–33.

84. Dancey DR, Hanly PJ, Soong C, Lee B, Hoffstein V. Impact of menopause on the prevalence and severity of sleep apnea. Chest 2001;120:151–5.

85. Davis CE, Pajak A, Rywik S, et al. Natural menopause and cardiovascular disease risk factors: the Poland and US Collaborative Study on Cardiovascular Disease Epidemiology. Ann Epidemiol 1994;4:445–8.

86. De Kat AC, Dam V, Onland-Moret NC, Eijkemans MJ, Broekmans FJ, van der Schouw YT. Unraveling the associations of age and menopause with cardiovascular risk factors in a large population-based study. BMC Med 2017;15:2.

87. Den Tonkelaar I, Seidell JC, van Noord PA, Baanders-van Halewijn EA, Ouwehand IJ. Fat distribution in relation to age, degree of obesity, smoking habits, parity and estrogen use: a cross-sectional study in 11,825 Dutch women participating in the DOM-project. Int J Obes 1990;14:753–61.

88. Dmitruk A, Czeczelewski J, Czeczelewska E, Golach J, Parnicka U. Body composition and fatty tissue distribution in women with various menstrual status. Rocz Panstw Zakl Hig 2018;69:95–101.

89. Donato GB, Fuchs SC, Oppermann K, Bastos C, Spritzer PM. Association between menopause status and central adiposity measured at different cutoffs of waist circumference and waist-to-hip ratio. Menopause 2006;13:280–5.

90. Douchi T, Oki T, Nakamura S, Ijuin H, Yamamoto S, Nagata Y. The effect of body composition on bone density in pre- and postmenopausal women. Maturitas 1997;27:55–60.

91. Douchi T, Yamamoto S, Yoshimitsu N, Andoh T, Matsuo T, Nagata Y. Relative contribution of aging and menopause to changes in lean and fat mass in segmental regions. Maturitas 2002;42:301–6.

92. Dubois EF, van den Bergh JP, Smals AG, van de Meerendonk CW, Zwinderman AH, Schweitzer DH. Comparison of quantitative ultrasound parameters with dual energy X-ray absorptiometry in pre- and postmenopausal women. Neth J Med 2001;58:62–70.

93. Engmann NJ, Golmakani MK, Miglioretti DL, Sprague BL, Kerlikowske K. Population-Attributable risk proportion of clinical risk factors for breast cancer. JAMA Oncol 2017;3:1228–36.

94. Ertungealp E, Seyisoglu H, Erel CT, Senturk LM, Gezer A. Changes in bone mineral density with age, menopausal status and body mass index in Turkish women. Climacteric 1999;2:45–51.

95. Feng Y, Hong X, Wilker E, et al. Effects of age at menarche, reproductive years, and menopause on metabolic risk factors for cardiovascular diseases. Atherosclerosis 2008;196:590–7.

96. Formica C, Loro ML, Gilsanz V, Seeman E. Inhomogeneity in body fat distribution may result in inaccuracy in the measurement of vertebral bone mass. J Bone Miner Res 1995;10:1504–11.

97. Friedenreich C, Cust A, Lahmann PH, et al. Anthropometric factors and risk of endometrial cancer: the European prospective investigation into cancer and nutrition. Cancer Causes Control 2007;18:399–413.

98. Friedenreich CM, Courneya KS, Bryant HE. Case-control study of anthropometric measures and breast cancer risk. Int J Cancer 2002;99:445–52.

99. Fu X, Ma X, Lu H, He W, Wang Z, Zhu S. Associations of fat mass and fat distribution with bone mineral density in pre- and postmenopausal Chinese women. Osteoporos Int 2011;22:113–9.

100. Fuh JL, Wang SJ, Lee SJ, Lu SR, Juang KD. Quality of life and menopausal transition for middle-aged women on Kinmen island. Qual Life Res 2003;12:53–61.

101. Gambacciani M, Ciaponi M, Cappagli B, Benussi C, De Simone L, Genazzani AR. Climacteric modifications in body weight and fat tissue distribution. Climacteric 1999;2:37–44.

102. Genazzani AR, Gambacciani M. Effect of climacteric transition and hormone replacement therapy on body weight and body fat distribution. Gynecol Endocrinol 2006;22:145–50.

103. Ghosh A. Comparison of risk variables associated with the metabolic syndrome in pre- and postmenopausal Bengalee women. Cardiovasc J S Afr 2008;19:183–7.

104. Ghosh A, Bhagat M. Anthropometric and body composition characteristics in pre- and postmenopausal Asian Indian women: Santiniketan women study. Anthropol Anz 2010;68:1–10.

105. Gram IT, Funkhouser E, Tabar L. Anthropometric indices in relation to mammographic patterns among peri-menopausal women. Int J Cancer 1997;73:323–6.

106. Guo W, Bradbury KE, Reeves GK, Key TJ. Physical activity in relation to body size and composition in women in UK Biobank. Ann Epidemiol 2015;25:406–13.e6.

107. Gurka MJ, Vishnu A, Santen RJ, DeBoer MD. Progression of metabolic syndrome severity during the menopausal transition. J Am Heart Assoc 2016;5.

108. Hadji P, Hars O, Bock K, et al. The influence of menopause and body mass index on serum leptin concentrations. Eur J Endocrinol 2000;143:55–60.

109. Hagner W, Hagner-Derengowska M, Wiacek M, Zubrzycki IZ. Changes in level of VO2max, blood lipids, and waist circumference in the response to moderate endurance training as a function of ovarian aging. Menopause 2009;16:1009–13.

110. Han D, Nie J, Bonner MR, et al. Lifetime adult weight gain, central adiposity, and the risk of pre- and postmenopausal breast cancer in the Western New York exposures and breast cancer study. Int J Cancer 2006;119:2931–7.

111. Harting GH, Moore CE, Mitchell R, Kappus CM. Relationship of menopausal status and exercise level to HDL-cholesterol in women. Exper Aging Res 1984;10:13–8.

112. He L, Tang X, Li N, et al. Menopause with cardiovascular disease and its risk factors among rural Chinese women in Beijing: a population-based study. Maturitas 2012;72:132–8.

113. Hirose K, Tajima K, Hamajima N, et al. Impact of established risk factors for breast cancer in nulligravid Japanese women. Breast Cancer 2003;10:45–53.

114. Hjartaker A, Adami HO, Lund E, Weiderpass E. Body mass index and mortality in a prospectively studied cohort of Scandinavian women: the women's lifestyle and health cohort study. Eur J Epidemiol 2005;20:747–54.

115. Ho S, Wu S, Chan S, Sham A. Menopausal transition and changes of body composition: a prospective study in Chinese perimenopausal women. Int J Obes 2010;34:1265.

116. Hsu YH, Venners SA, Terwedow HA, et al. Relation of body composition, fat mass, and serum lipids to osteoporotic fractures and bone mineral density in Chinese men and women. Am J Clin Nutr 2006;83:146–54.

117. Hu X, Pan X, Ma X, et al. Contribution of a first-degree family history of diabetes to increased serum adipocyte fatty acid binding protein levels independent of body fat content and distribution. Int J Obes 2016;40:1649–54.

118. Hunter G, Kekes-Szabo T, Treuth M, Williams M, Goran M, Pichon C. Intra-abdominal adipose tissue, physical activity and cardiovascular risk in pre- and post-menopausal women. Int J Obes Relat Metab Disord 1996;20:860–5.

119. Iida T, Domoto T, Takigawa A, et al. Relationships among blood leptin and adiponectin levels, fat mass, and bone mineral density in Japanese pre-and postmenopausal women. Hiroshima J Med Sci 2011;60:71–8.

120. Ilich-Ernst J, Brownbill RA, Ludemann MA, Fu R. Critical factors for bone health in women across the age span: how important is muscle mass? Medscape Womens Health 2002;7:2.

121. Ito M, Hayashi K, Uetani M, Yamada M, Ohki M, Nakamura T. Association between anthropometric measures and spinal bone mineral density. Investig Radiol 1994;29:812–6.

122. Jaff NG, Norris SA, Snyman T, Toman M, Crowther NJ. Body composition in the Study of Women Entering and in Endocrine Transition (SWEET): a perspective of African women who have a high prevalence of obesity and HIV infection. Metab Clin Exper 2015;64:1031–41.

123. Jasienska G, Ziomkiewicz A, Gorkiewicz M, Pajak A. Body mass, depressive symptoms and menopausal status: an examination of the "Jolly Fat" hypothesis. Womens Health Issues 2005;15:145–51.

124. Jeenduang N, Trongsakul R, Inhongsa P, Chaidach P. The prevalence of metabolic syndrome in premenopausal and postmenopausal women in Southern Thailand. Gynecol Endocrinol 2014;30:573–6.

125. Jeon YK, Lee JG, Kim SS, et al. Association between bone mineral density and metabolic syndrome in pre- and postmenopausal women. Endocr J 2011;58:87–93.

126. Jurimae J, Jurimae T. Plasma adiponectin concentration in healthy pre- and postmenopausal women: relationship with body composition, bone mineral, and metabolic variables. Am J Physiol Endocrinol Metab 2007;293:E42–7.

127. Kadam N, Chiplonkar S, Khadilkar A, Divate U, Khadilkar V. Low bone mass in urban Indian women above 40 years of age:

prevalence and risk factors. Gynecol Endocrinol 2010;26:909–17.
128. Kang EK, Park HW, Baek S, Lim JY. The association between trunk body composition and spinal bone mineral density in Korean males versus females: a Farmers' Cohort for Agricultural Work-Related Musculoskeletal Disorders (FARM) study. J Korean Med Sci 2016;31: 1595–603.
129. Kaufer-Horwitz M, Pelaez-Robles K, Lazzeri-Arteaga P, Goti-Rodriguez LM, Avila-Rosas H. Hypertension, overweight and abdominal adiposity in women. An analytical perspective. Arch Med Res 2005;36:404–11.
130. Kim HM, Park J, Ryu SY, Kim J. The effect of menopause on the metabolic syndrome among Korean women: the Korean National Health and Nutrition Examination Survey, 2001. Diabetes Care 2007;30:701–6.
131. Kim JH, Choi HJ, Kim MJ, Shin CS, Cho NH. Fat mass is negatively associated with bone mineral content in Koreans. Osteoporos Int 2012;23:2009–16.
132. Kim S, Lee JY, Im JA, et al. Association between serum osteocalcin and insulin resistance in postmenopausal, but not premenopausal, women in Korea. Menopause 2013;20: 1061–6.
133. Kim YM, Kim SH, Kim S, Yoo JS, Choe EY, Won YJ. Variations in fat mass contribution to bone mineral density by gender, age, and body mass index: the Korea National Health and Nutrition Examination Survey (KNHANES) 2008-2011. Osteoporos Int 2016;27:2543–54.
134. Kirchengast S, Gruber D, Sator M, Huber J. Impact of the age at menarche on adult body composition in healthy pre- and postmenopausal women. Am J Phys Anthropol 1998;105:9–20.
135. Kirchengast S, Hartmann B, Huber J. Serum levels of sex hormones, thyroid hormones, growth hormone, IGF I, and cortisol and their relations to body fat distribution in healthy women dependent on their menopausal status. Zeits Morphol Anthropol 1996;81:223–34.
136. Knapp KM, Blake GM, Spector TD, Fogelman I. Multisite quantitative ultrasound: precision, age- and menopause-related changes, fracture discrimination, and T-score equivalence with dual-energy X-ray absorptiometry. Osteoporos Int 2001;12:456–64.
137. Koh SJ, Hyun YJ, Choi SY, et al. Influence of age and visceral fat area on plasma adiponectin concentrations in women with normal glucose tolerance. Clin Chim Acta 2008;389: 45–50.
138. Konrad T, Bär F, Schneider F, et al. Factors influencing endothelial function in healthy pre- and post-menopausal women of the EU-RISC study. Diabet Vasc Dis Res 2011;8:229–36.
139. Kontogianni MD, Dafni UG, Routsias JG, Skopouli FN. Blood leptin and adiponectin as possible mediators of the relation between fat mass and BMD in perimenopausal women. J Bone Miner Res 2004;19:546–51.
140. Konukoglu D, Serin O, Ercan M. Plasma leptin levels in obese and non-obese postmenopausal women before and after hormone replacement therapy. Maturitas 2000;36: 203–7.
141. Koskova I, Petrasek R, Vondra K, et al. Weight, body composition and fat distribution of Czech women in relation with reproductive phase: a cross-sectional study. Prague Med Rep 2007;108:13–26.
142. Kotani K, Chen JT, Taniguchi N. The relationship between adiponectin and blood pressure in premenopausal and postmenopausal women. Clin Investig Med 2011;34:E125–30.
143. Kraemer RR, Synovitz LB, Gimpel T, Kraemer GR, Johnson LG, Castracane VD. Effect of estrogen on serum DHEA in younger and older women and the relationship of DHEA to adiposity and gender. Metabolism 2001;50: 488–93.
144. Kuk JL, Lee S, Heymsfield SB, Ross R. Waist circumference and abdominal adipose tissue distribution: influence of age and sex. Am J Clin Nutr 2005;81:1330–4.
145. Laitinen K, Valimaki M, Keto P. Bone mineral density measured by dual-energy X-ray absorptiometry in healthy Finnish women. Calcif Tissue Int 1991;48:224–31.
146. Lejskova M, Alusik S, Valenta Z, Adamkova S, Pitha J. Natural postmenopause is associated with an increase in combined cardiovascular risk factors. Physiol Res 2012;61: 587–96.
147. Leon Guerrero RT, Novotny R, Wilkens LR, et al. Risk factors for breast cancer in the breast cancer risk model study of Guam and Saipan. Cancer Epidemiol 2017;50:221–33.
148. Ley CJ, Lees B, Stevenson JC. Sex- and menopause-associated changes in body-fat distribution. Am J Clinical Nutr 1992;55:950–4.
149. Lin WY, Yang WS, Lee LT, et al. Insulin resistance, obesity, and metabolic syndrome among non-diabetic pre- and post-menopausal women in North Taiwan. Int J Obes 2006;30: 912–7.
150. Lindquist O, Bengtsson C. Serum lipids, arterial blood pressure and body weight in relation to the menopause: results from a population study of women in Goteborg, Sweden. Scand J Clin Lab Investig 1980;40:629–36.
151. Lindsay R, Cosman F, Herrington BS, Himmelstein S. Bone mass and body composition in normal women. J Bone Miner Res 1992;7:55–63.
152. Lovejoy JC, Champagne CM, de Jonge L, Xie H, Smith SR. Increased visceral fat and decreased energy expenditure during the menopausal transition. Int J Obes 2008;32: 949–58.
153. Lyu LC, Yeh CY, Lichtenstein AH, Li Z, Ordovas JM, Schaefer EJ. Association of sex, adiposity, and diet with HDL subclasses in middle-aged Chinese. Am J Clin Nutr 2001;74: 64–71.
154. Maharlouei N, Bellissimo N, Ahmadi SM, Lankarani KB. Prevalence of metabolic syndrome in pre- and postmenopausal Iranian women. Climacteric 2013;16:561–7.
155. Malacara JM, Canto de Cetina T, Bassol S, et al. Symptoms at pre- and postmenopause in rural and urban women from three States of Mexico. Maturitas 2002;43:11–9.
156. Manabe E, Aoyagi K, Tachibana H, Takemoto T. Relationship of intra-abdominal adiposity and peripheral fat distribution to lipid metabolism in an island population in western Japan: gender differences and effect of menopause. Tohoku J Exp Med 1999;188: 189–202.
157. Manjer J, Kaaks R, Riboli E, Berglund G. Risk of breast cancer in relation to anthropometry, blood pressure, blood lipids and glucose metabolism: a prospective study within the Malmo Preventive Project. Eur J Cancer Prev 2001;10:33–42.
158. Mannisto S, Pietinen P, Pyy M, Palmgren J, Eskelinen M, Uusitupa M. Body-size indicators and risk of breast cancer according to menopause and estrogen-receptor status. Int J Cancer 1996;68:8–13.
159. Martini G, Valenti R, Giovani S, Nuti R. Age-related changes in body composition of healthy and osteoporotic women. Maturitas 1997;27: 25–33.
160. Marwaha RK, Garg MK, Tandon N, Mehan N, Sastry A, Bhadra K. Relationship of body fat and its distribution with bone mineral density in Indian population. J Clin Densitom 2013;16:353–9.
161. Matsushita H, Kurabayashi T, Tomita M, Kato N, Tanaka K. Effects of uncoupling protein 1 and beta3-adrenergic receptor gene polymorphisms on body size and serum lipid concentrations in Japanese women. Maturitas 2003;45:39–45.
162. Matsuzaki M, Kulkarni B, Kuper H, et al. Association of hip bone mineral density and body composition in a rural Indian population: the Andhra Pradesh Children and Parents study (APCAPS). PLoS One 2017;12:e0167114.
163. Matthews KA, Meilahn E, Kuller LH, Kelsey SF, Caggiula AW, Wing RR. Menopause and risk factors for coronary heart disease. N Engl J Med 1989;321:641–6.
164. Mesch VR, Boero LE, Siseles NO, et al. Metabolic syndrome throughout the menopausal transition: influence of age and menopausal status. Climacteric 2006;9:40–8.
165. Meza-Munoz DE, Fajardo ME, Perez-Luque EL, Malacara JM. Factors associated with estrogen receptors-alpha (ER-alpha) and -beta (ER-beta) and progesterone receptor abundance in obese and non obese pre- and post-menopausal women. Steroids 2006;71: 498–503.
166. Minatoya M, Kutomi G, Shima H, et al. Relation of serum adiponectin levels and obesity with breast cancer: a Japanese case-control study. Asian Pac J Cancer Prev 2014;15: 8325–30.
167. Mo D, Hsieh P, Yu H, et al. The relationship between osteoporosis and body composition in pre- and postmenopausal women from different ethnic groups in China. Ethn Health 2017;22: 295–310.

168. Muchanga Sifa MJ, Lepira FB, Longo AL, et al. Prevalence and predictors of metabolic syndrome among Congolese pre- and post-menopausal women. Climacteric 2014;17:442–8.
169. Muti P, Stanulla M, Micheli A, et al. Markers of insulin resistance and sex steroid hormone activity in relation to breast cancer risk: a prospective analysis of abdominal adiposity, sebum production, and hirsutism (Italy). Cancer Causes Control 2000;11:721–30.
170. Nitta J, Nojima M, Ohnishi H, et al. Weight gain and alcohol drinking associations with breast cancer risk in Japanese postmenopausal women - results from the Japan Collaborative Cohort (JACC) study. Asian Pac J Cancer Prev 2016;17:1437–43.
171. Noh HM, Song YM, Park JH, Kim BK, Choi YH. Metabolic factors and breast cancer risk in Korean women. Cancer Causes Control 2013;24:1061–8.
172. Nordin BE, Need AG, Bridges A, Horowitz M. Relative contributions of years since menopause, age, and weight to vertebral density in postmenopausal women. J Clin Endocrinol Metab 1992;74:20–3.
173. Ohta H, Kuroda T, Onoe Y, et al. Familial correlation of bone mineral density, birth data and lifestyle factors among adolescent daughters, mothers and grandmothers. J Bone Miner Metab 2010;28:690–5.
174. Oldroyd B, Stewart SP, Truscott JG, Westmacott CF, Smith MA. Age related changes in body composition. Applied Rad Isot 1998;49:589–90.
175. Pacholczak R, Klimek-Piotrowska W, Kuszmiersz P. Associations of anthropometric measures on breast cancer risk in pre- and postmenopausal women–a case-control study. J Physiol Anthropol 2016;35:7.
176. Park JH, Song YM, Sung J, et al. The association between fat and lean mass and bone mineral density: the Healthy Twin Study. Bone 2012;50:1006–11.
177. Park YM, White AJ, Nichols HB, O'Brien KM, Weinberg CR, Sandler DP. The association between metabolic health, obesity phenotype and the risk of breast cancer. Int J Cancer 2017;140:2657–66.
178. Pavicic Zezelj S, Cvijanovic O, Micovic V, Bobinac D, Crncevic-Orlic Z, Malatestinic G. Effect of menopause, anthropometry, nutrition and lifestyle on bone status of women in the northern Mediterranean. West Indian Med J 2010;59:494–502.
179. Pavlica T, Mikalacki M, Matic R, et al. Relationship between BMI and skinfold thicknesses to risk factors in premenopausal and postmenopausal women. Coll Antropol 2013;37(suppl2):119–24.
180. Phillips GB, Jing T, Heymsfield SB. Does insulin resistance, visceral adiposity, or a sex hormone alteration underlie the metabolic syndrome? Studies in women. Metabolism 2008;57:838–44.
181. Polesel DN, Hirotsu C, Nozoe KT, et al. Waist circumference and postmenopause stages as the main associated factors for sleep apnea in women: a cross-sectional population-based study. Menopause 2015;22:835–44.
182. Pollan M, Lope V, Miranda-Garcia J, et al. Adult weight gain, fat distribution and mammographic density in Spanish pre- and post-menopausal women (DDM-Spain). Breast Cancer Res Treat 2012;134:823–38.
183. Portaluppi F, Pansini F, Manfredini R, Mollica G. Relative influence of menopausal status, age, and body mass index on blood pressure. Hypertension 1997;29:976–9.
184. Priya T, Chowdhury MG, Vasanth K, et al. Assessment of serum leptin and resistin levels in association with the metabolic risk factors of pre- and post-menopausal rural women in South India. Diabet Metab Syndr 2013;7:233–7.
185. Rantalainen T, Nikander R, Heinonen A, et al. Neuromuscular performance and body mass as indices of bone loading in premenopausal and postmenopausal women. Bone 2010;46:964–9.
186. Reina P, Cointry GR, Nocciolino L, et al. Analysis of the independent power of age-related, anthropometric and mechanical factors as determinants of the structure of radius and tibia in normal adults: a pQCT study. J Musculoskel Neuron Interact 2015;15:10–22.
187. Revilla M, Villa LF, Hernandez ER, Sanchez-Atrio A, Cortes J, Rico H. Influence of weight and gonadal status on total and regional bone mineral content and on weight-bearing and non-weight-bearing bones, measured by dual-energy X-ray absosorptiometry. Maturitas 1997;28:69–74.
188. Revilla M, Villa LF, Sanchez-Atrio A, Hernandez ER, Rico H. Influence of body mass index on the age-related slope of total and regional bone mineral content. Calcif Tissue Int 1997;61:134–8.
189. Rice MS, Bertrand KA, Lajous M, et al. Reproductive and lifestyle risk factors and mammographic density in Mexican women. Ann Epidemiol 2015;25:868–73.
190. Rico H, Aguado F, Arribas I, et al. Behavior of phalangeal bone ultrasound in normal women with relation to gonadal status and body mass index. Osteoporos Int 2001;12:450–5.
191. Rico H, Arribas I, Casanova FJ, Duce AM, Hernandez ER, Cortes-Prieto J. Bone mass, bone metabolism, gonadal status and body mass index. Osteoporos Int 2002;13:379–87.
192. Roelfsema F, Veldhuis JD. Growth hormone dynamics in healthy adults are related to age and sex and strongly dependent on body mass index. Neuroendocrinology 2016;103:335–44.
193. Rosenbaum M, Nicolson M, Hirsch J, et al. Effects of gender, body composition, and menopause on plasma concentrations of leptin. J Clin Endocrinol Metab 1996;81:3424–7.
194. Salomaa V, Rasi V, Pekkanen J, et al. Association of hormone replacement therapy with hemostatic and other cardiovascular risk factors: the FINRISK Hemostasis Study. Arterioscler Thromb Vasc Biol 1995;15:1549–55.
195. Sarrafzadegan N, Khosravi-Boroujeni H, Esmaillzadeh A, Sadeghi M, Rafieian-Kopaei M, Asgary S. The association between hypertriglyceridemic waist phenotype, menopause, and cardiovascular risk factors. Arch Iran Med 2013;16:161–6.
196. Schaberg-Lorei G, Ballard JE, McKeown BC, Zinkgraf SA. Body composition alterations consequent to an exercise program for pre and postmenopausal women. J Sports Med Phys Fitness 1990;30:426–33.
197. Schwarz S, Volzke H, Alte D, et al. Menopause and determinants of quality of life in women at midlife and beyond: the study of health in pomerania (SHIP). Menopause 2007;14:123–34.
198. Sherk VD, Malone SP, Bemben MG, Knehans AW, Palmer IJ, Bemben DA. Leptin, fat mass, and bone mineral density in healthy pre- and postmenopausal women. J Clin Densitom 2011;14:321–5.
199. Shibata H, Matsuzaki T, Hatano S. Relationship of relevant factors of atherosclerosis to menopause in Japanese women. Am J Epidemiol 1979;109:420–4.
200. Sieminska L, Wojciechowska C, Foltyn W, et al. The relation of serum adiponectin and leptin levels to metabolic syndrome in women before and after the menopause. Endokrynol Polska 2006;57:15–22.
201. Skrzypczak M, Szwed A. Assessment of the body mass index and selected physiological parameters in pre- and post-menopausal women. Homo 2005;56:141–52.
202. Skrzypczak M, Szwed A, Pawlińska-Chmara R, Skrzypulec V. Assessment of the BMI, WHR and W/Ht in pre-and post-menopausal women. Anthropol Rev 2007;70:3–13.
203. Soderberg S, Ahren B, Eliasson M, Dinesen B, Olsson T. The association between leptin and proinsulin is lost with central obesity. J Intern Med 2002;252:140–8.
204. Son MK, Lim NK, Lim JY, et al. Difference in blood pressure between early and late menopausal transition was significant in healthy Korean women. BMC Womens Health 2015;15:64.
205. Staessen J, Bulpitt CJ, Fagard R, Lijnen P, Amery A. The influence of menopause on blood pressure. J Hum Hypertens 1989;3:427–33.
206. Suarez-Ortegon MF, Arbelaez A, Mosquera M, Mendez F, Aguilar-de Plata C. C-reactive protein, waist circumference, and family history of heart attack are independent predictors of body iron stores in apparently healthy premenopausal women. Biol Trace Elem Res 2012;148:135–8.
207. Suliga E, Koziel D, Ciesla E, Rebak D, Gluszek S. Factors associated with adiposity, lipid profile disorders and the metabolic syndrome occurrence in premenopausal and postmenopausal women. PLoS One 2016;11:e0154511.
208. Sumner AE, Falkner B, Kushner H, Considine RV. Relationship of leptin

concentration to gender, menopause, age, diabetes, and fat mass in African Americans. Obes Res 1998;6:128–33.

209. Tanaka NI, Hanawa S, Murakami H, et al. Accuracy of segmental bioelectrical impedance analysis for predicting body composition in pre- and postmenopausal women. J Clin Densitom 2015;18:252–9.

210. Thomas T, Burguera B, Melton LJ 3rd, et al. Relationship of serum leptin levels with body composition and sex steroid and insulin levels in men and women. Metabolism 2000;49:1278–84.

211. Torng PL, Su TC, Sung FC, et al. Effects of menopause and obesity on lipid profiles in middle-aged Taiwanese women: the Chin-Shan Community Cardiovascular Cohort Study. Atherosclerosis 2000;153:413–21.

212. Toth MJ, Tchernof A, Sites CK, Poehlman ET. Effect of menopausal status on body composition and abdominal fat distribution. Int J Obes Relat Metab Dis 2000;24:226–31.

213. Van Pelt RE, Davy KP, Stevenson ET, et al. Smaller differences in total and regional adiposity with age in women who regularly perform endurance exercise. Am J Physiol 1998;275:E626–34.

214. Veldhuis JD, Dyer RB, Trushin SA, Bondar OP, Singh RJ, Klee GG. Interleukins 6 and 8 and abdominal fat depots are distinct correlates of lipid moieties in healthy pre- and postmenopausal women. Endocrine 2016;54:671–80.

215. Wang F, Ma X, Hao Y, et al. Serum glycated albumin is inversely influenced by fat mass and visceral adipose tissue in Chinese with normal glucose tolerance. PLoS One 2012;7:e51098.

216. Wang W, Zhao LJ, Liu YZ, Recker RR, Deng HW. Genetic and environmental correlations between obesity phenotypes and age at menarche. Int J Obes 2006;30:1595–600.

217. Wang WS, Wahlqvist ML, Hsu CC, Chang HY, Chang WC, Chen CC. Age- and gender-specific population attributable risks of metabolic disorders on all-cause and cardiovascular mortality in Taiwan. BMC Public Health 2012;12:111.

218. Wee J, Sng BY, Shen L, Lim CT, Singh G, Das De S. The relationship between body mass index and physical activity levels in relation to bone mineral density in premenopausal and postmenopausal women. Arch Osteoporos 2013;8:162.

219. Williams PT, Krauss RM. Associations of age, adiposity, menopause, and alcohol intake with low-density lipoprotein subclasses. Arterioscler Thromb Vasc Biol 1997;17:1082–90.

220. Wing RR, Matthews KA, Kuller LH, Meilahn EN, Plantinga PL. Weight gain at the time of menopause. Arch Intern Med 1991;151:97–102.

221. Xu L, Nicholson P, Wang QJ, Wang Q, Alen M, Cheng S. Fat mass accumulation compromises bone adaptation to load in Finnish women: a cross-sectional study spanning three generations. J Bone Miner Res 2010;25:2341–9.

222. Yamatani H, Takahashi K, Yoshida T, Takata K, Kurachi H. Association of estrogen with glucocorticoid levels in visceral fat in postmenopausal women. Menopause 2013;20:437–42.

223. Yannakoulia M, Melistas L, Solomou E, Yiannakouris N. Association of eating frequency with body fatness in pre- and postmenopausal women. Obesity 2007;15:100–6.

224. Yoldemir T, Erenus M. The prevalence of metabolic syndrome in pre- and postmenopausal women attending a tertiary clinic in Turkey. Eur J Obstet Gynecol Reprod Biol 2012;164:172–5.

225. Yoo HJ, Park MS, Yang SJ, et al. The differential relationship between fat mass and bone mineral density by gender and menopausal status. J Bone Miner Metab 2012;30:47–53.

226. Yoo KY, Kim H, Shin HR, et al. Female sex hormones and body mass in adolescent and postmenopausal Korean women. J Korean Med Sci 1998;13:241–6.

227. Yoshimoto N, Nishiyama T, Toyama T, et al. Genetic and environmental predictors, endogenous hormones and growth factors, and risk of estrogen receptor-positive breast cancer in Japanese women. Cancer Sci 2011;102:2065–72.

228. Zhong N, Wu XP, Xu ZR, et al. Relationship of serum leptin with age, body weight, body mass index, and bone mineral density in healthy mainland Chinese women. Clin Chim Acta 2005;351:161–8.

229. Zhou JL, Lin SQ, Shen Y, Chen Y, Zhang Y, Chen FL. Serum lipid profile changes during the menopausal transition in Chinese women: a community-based cohort study. Menopause 2010;17:997–1003.

230. Zhou Y, Zhou X, Guo X, et al. Prevalence and risk factors of hypertension among pre- and post-menopausal women: a cross-sectional study in a rural area of northeast China. Maturitas 2015;80:282–7.

231. Zivkovic TB, Vuksanovic M, Jelic MA, et al. Obesity and metabolic syndrome during the menopause transition in Serbian women. Climacteric 2011;14:643–8.

232. Shakir YA, Samsioe G, Nyberg P, Lidfeldt J, Nerbrand C. Cardiovascular risk factors in middle-aged women and the association with use of hormone therapy: results from a population-based study of Swedish women: he Women's Health in the Lund Area (WHILA) Study. Climacteric 2004;7:274–83.

233. Akahoshi M, Soda M, Nakashima E, et al. Effects of age at menopause on serum cholesterol, body mass index, and blood pressure. Atherosclerosis 2001;156:157–63.

234. Ford K, Sowers M, Crutchfield M, Wilson A, Jannausch M. A longitudinal study of the predictors of prevalence and severity of symptoms commonly associated with menopause. Menopause 2005;12:308–17.

235. Franklin RM, Ploutz-Snyder L, Kanaley JA. Longitudinal changes in abdominal fat distribution with menopause. Metabolism 2009;58:311–5.

236. Janssen I, Powell LH, Crawford S, Lasley B, Sutton-Tyrrell K. Menopause and the metabolic syndrome: the Study of Women's Health Across the Nation. Arch Intern Med 2008;168:1568–75.

237. Lee CG, Carr MC, Murdoch SJ, et al. Adipokines, inflammation, and visceral adiposity across the menopausal transition: a prospective study. J Clin Endocrinol Metab 2009;94:1104–10.

238. Liu-Ambrose T, Kravetsky L, Bailey D, et al. Change in lean body mass is a major determinant of change in areal bone mineral density of the proximal femur: a 12-year observational study. Calcif Tissue Int 2006;79:145–51.

239. Macdonald HM, New SA, Campbell MK, Reid DM. Influence of weight and weight change on bone loss in perimenopausal and early postmenopausal Scottish women. Osteoporos Int 2005;16:163–71.

240. Soreca I, Rosano C, Jennings JR, et al. Gain in adiposity across 15 years is associated with reduced gray matter volume in healthy women. Psychosom Med 2009;71:485–90.

241. Williams MJ, Hunter GR, Kekes-Szabo T, et al. Intra-abdominal adipose tissue cut-points related to elevated cardiovascular risk in women. Int J Obes Related Metab Disord 1996;20:613–7.

242. Field A, Miles J, Field Z. Discovering statistics using R. London, UK: Sage publications; 2012.

243. Bolanowski M, Nilsson BE. Assessment of human body composition using dual-energy x-ray absorptiometry and bioelectrical impedance analysis. Med Sc Monit 2001;7:1029–33.

244. Ng SP, Korda R, Clements M, et al. Validity of self-reported height and weight and derived body mass index in middle-aged and elderly individuals in Australia. Aust N Z J Public Health 2011;35:557–63.

245. Siervogel RM, Wisemandle W, Maynard LM, et al. Serial changes in body composition throughout adulthood and their relationships to changes in lipid and lipoprotein levels: The Fels Longitudinal Study. Arterioscler Thromb Vasc Biol 1998;18:1759–64.

246. Patel SR, Malhotra A, White DP, Gottlieb DJ, Hu FB. Association between reduced sleep and weight gain in women. Am J Epidemiol 2006;164:947–54.

247. Davis SR, Castelo-Branco C, Chedraui P, et al. Understanding weight gain at menopause. Climacteric 2012;15:419–29.

248. Demerath EW, Rogers NL, Reed D, et al. Significant associations of age, menopausal status and lifestyle factors with visceral adiposity in African-American and European-American women. Ann Hum Biol 2011;38:247–56.

249. Janssen I, Powell LH, Jasielec MS, Kazlauskaite R. Covariation of change in bioavailable testosterone and adiposity in midlife women. Obesity 2015;23:488–94.

250. De Koning L, Merchant AT, Pogue J, Anand SS. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. Eur Heart J 2007;28:850–6.

251. Zhao D, Guallar E, Ouyang P, et al. Endogenous sex hormones and incident cardiovascular disease in post-menopausal women. J Am Coll Cardiol 2018;71:2555–66.

252. Mikkola TS, Gissler M, Merikukka M, Tuomikoski P, Ylikorkala O. Sex differences in age-related cardiovascular mortality. PloS One 2013;8:e63347.

253. McAloon CJ, Boylan LM, Hamborg T, et al. The changing face of cardiovascular disease 2000–2012: an analysis of the world health organisation global health estimates data. Int J Cardiol 2016;224:256–64.

254. Steiger P, Cummings SR, Black DM, Spencer NE, Genant HK. Age-related decrements in bone mineral density in women over 65. J Bone Miner Res 1992;7:625–32.

255. Douchi T, Kosha S, Uto H, et al. Precedence of bone loss over changes in body composition and body fat distribution within a few years after menopause. Maturitas 2003;46:133–8.

256. Shafiee G, Keshtkar A, Soltani A, Ahadi Z, Larijani B, Heshmat R. Prevalence of sarcopenia in the world: a systematic review and meta-analysis of general population studies. J Diabet Metab Disord 2017;16:21.

257. Perissinotto E, Pisent C, Sergi G, Grigoletto F, Enzi G, Group IW. Anthropometric measurements in the elderly: age and gender differences. Br J Nutr 2002;87:177–86.

258. Salpeter S, Walsh J, Ormiston T, et al. Meta-analysis: effect of hormone-replacement therapy on components of the metabolic syndrome in postmenopausal women. Diabetes Obes Metab 2006;8:538–54.

259. Kongnyuy EJ, Norman RJ, Flight IH, Rees MC. Oestrogen and progestogen hormone replacement therapy for peri-menopausal and post-menopausal women: weight and body fat distribution. Cochrane Database Syst Rev 2000;(2):CD001018.

260. Nelson HD, Humphrey LL, Nygren P, Teutsch SM, Allan JD. Postmenopausal hormone replacement therapy: scientific review. JAMA 2002;288:872–81.

Appendix
Adapted Newcastle-Ottawa Quality Assessment Form for Cohort Studies

Selection of premenopausal and postmenopausal women

1. Representativeness of the postmenopausal cohort
   A. Truly representative of the average postmenopausal woman in the community
   B. Somewhat representative of the average postmenopausal woman in the community
   C. Selected group of users eg nurses, volunteers
   D. No description of the derivation of the cohort
2. Selection of the premenopausal cohort
   A. Drawn from the same or similar community as the postmenopausal cohort
   B. Drawn from a different source
   C. No description of the derivation of the premenopausal cohort
3. Ascertainment of menopausal status
   A. Secure record (eg, surgical records)
   B. Structured interview
   C. Written self report
   D. No description
   E. Other

Comparability of premenopausal and postmenopausal women

4. Comparability of premenopausal and postmenopausal women on the basis of the study design
   A. Lifestyle/demographic characteristics of premenopausal and postmenopausal women recorded and reported, with age as a minimum.
   B. The mean difference in age between premenopausal and postmenopausal women enables a reasonable comparison which is not highly confounded by age (ie, approximately $\leq$10 years for cross-sectional studies). Note: For longitudinal studies, an appropriate follow-up period is required (ie, premenopausal at baseline and postmenopausal at follow up).
5. Was a clear definition used to describe premenopausal women?
   A. Yes
   B. No
6. Was a clear definition used to describe postmenopausal women?
   A. Yes
   B. No

Outcome

7. Assessment of fat mass
   A. Measured
   B. Self report
   C. No description
8. Was the same method of measurement of fat mass conducted for both premenopausal and postmenopausal women?
   A. Yes
   B. No
   C. No description

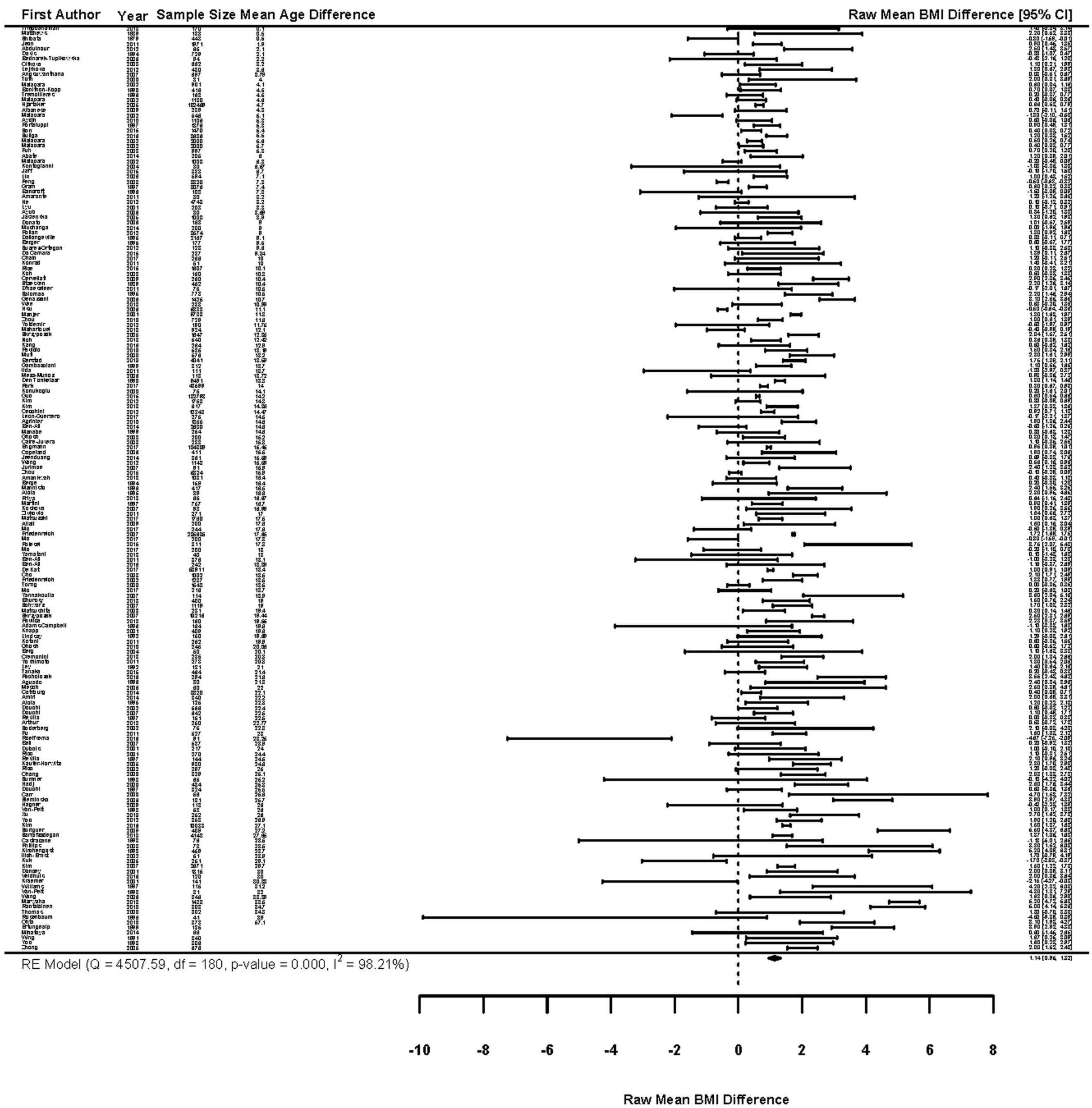
SELECTION	/3
COMPARABILITY	/4
OUTCOME	/2
TOTAL	/9
Rater #1 Initials:	
SELECTION	/3
COMPARABILITY	/4
OUTCOME	/2
TOTAL	/9
Rater #2 Initials:	

Note: A study can be given a maximum of 1 star for each numbered item within the Selection and Outcome categories. The exception to this is for the Comparability section.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 1

Forest plot of the cross-sectional raw mean body mass index difference between premenopausal and postmenopausal women



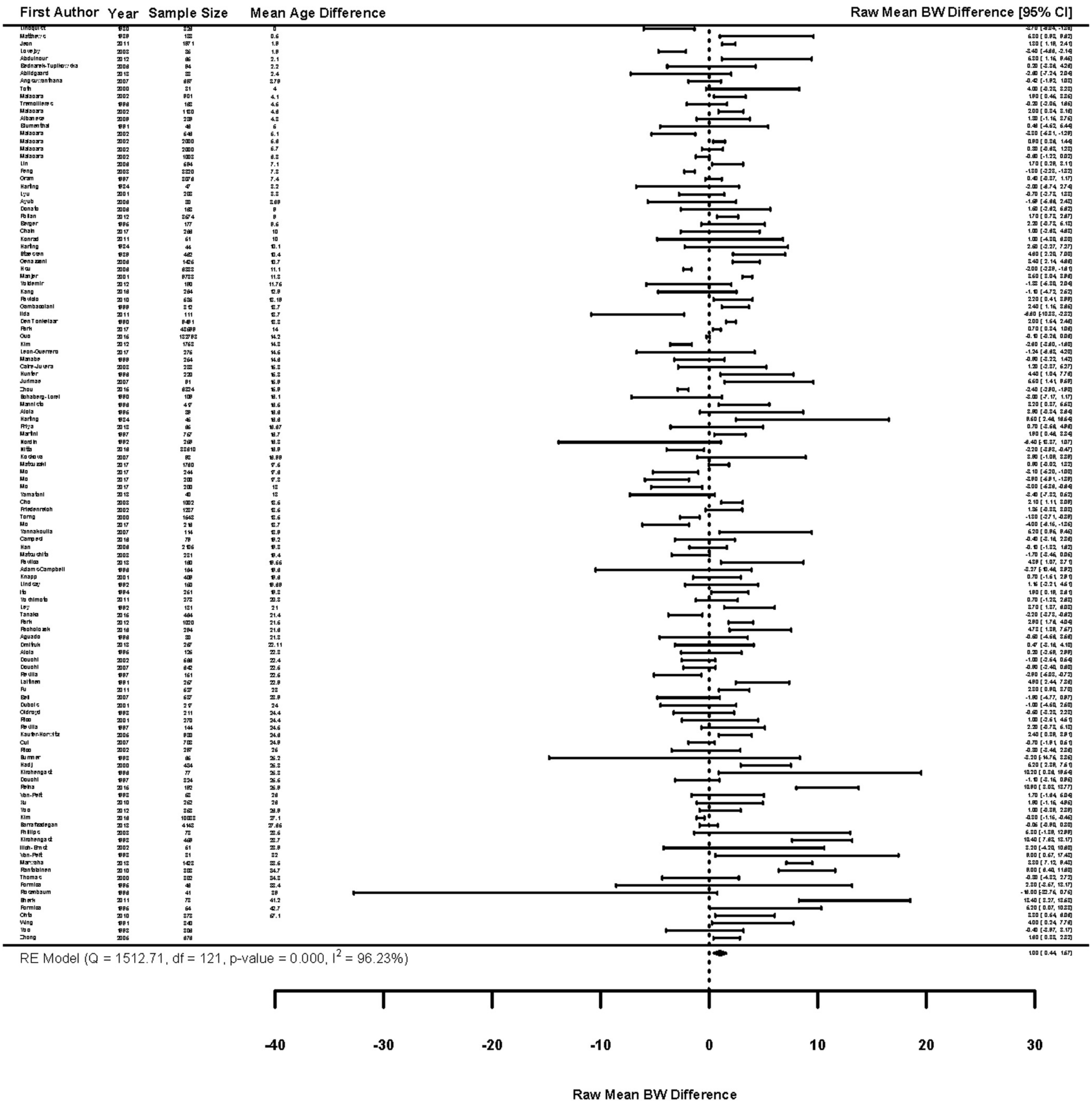
Studies are arranged by mean age difference.

BMI, body mass index; *CI*, confidence interval; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 2

Forest plot of the cross-sectional raw mean bodyweight difference between premenopausal and postmenopausal women



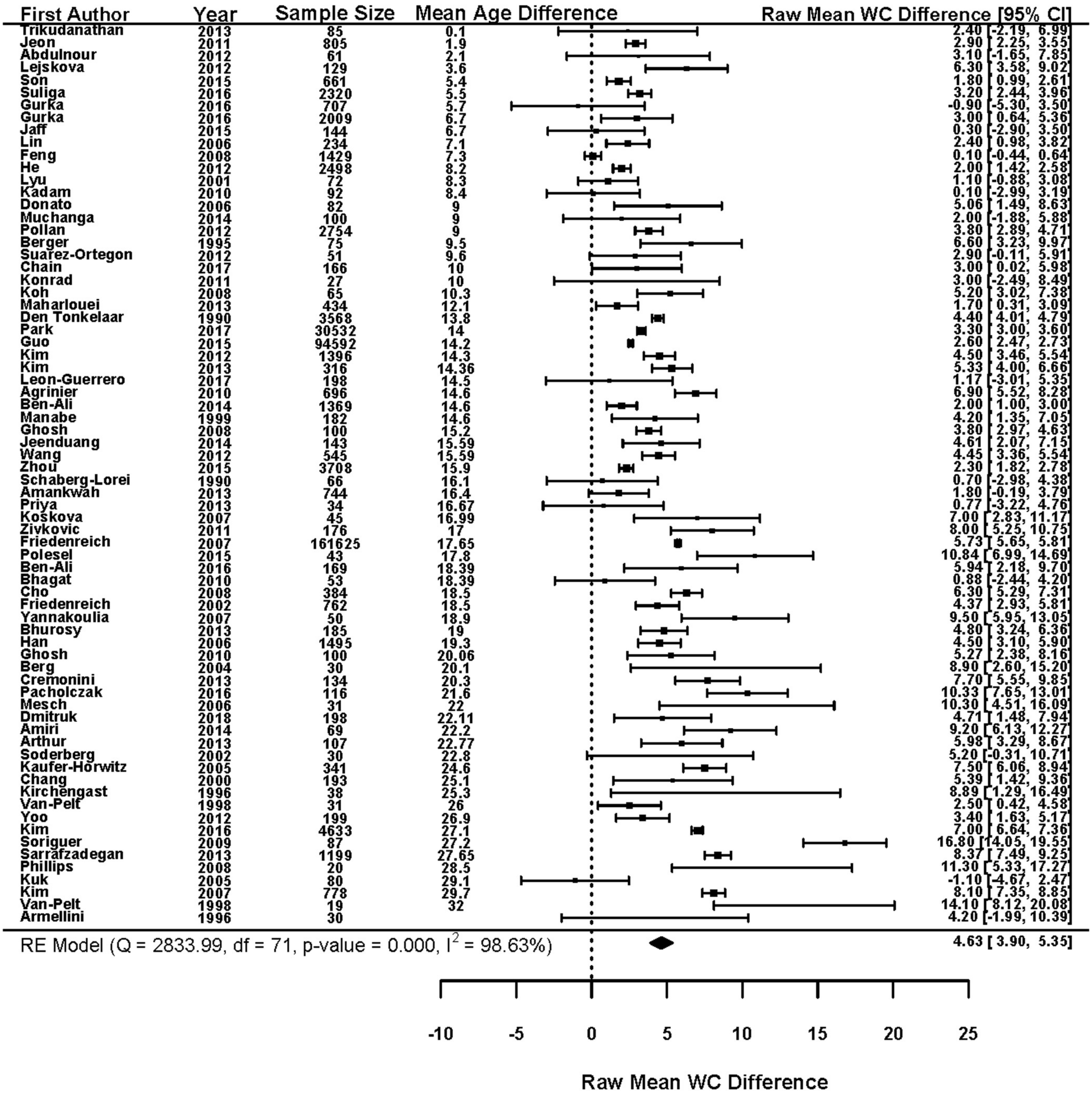
Studies are arranged by mean age difference.

BW, bodyweight; *CI*, confidence interval; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 3

Forest plot of the cross-sectional raw mean waist circumference difference between premenopausal and postmenopausal women



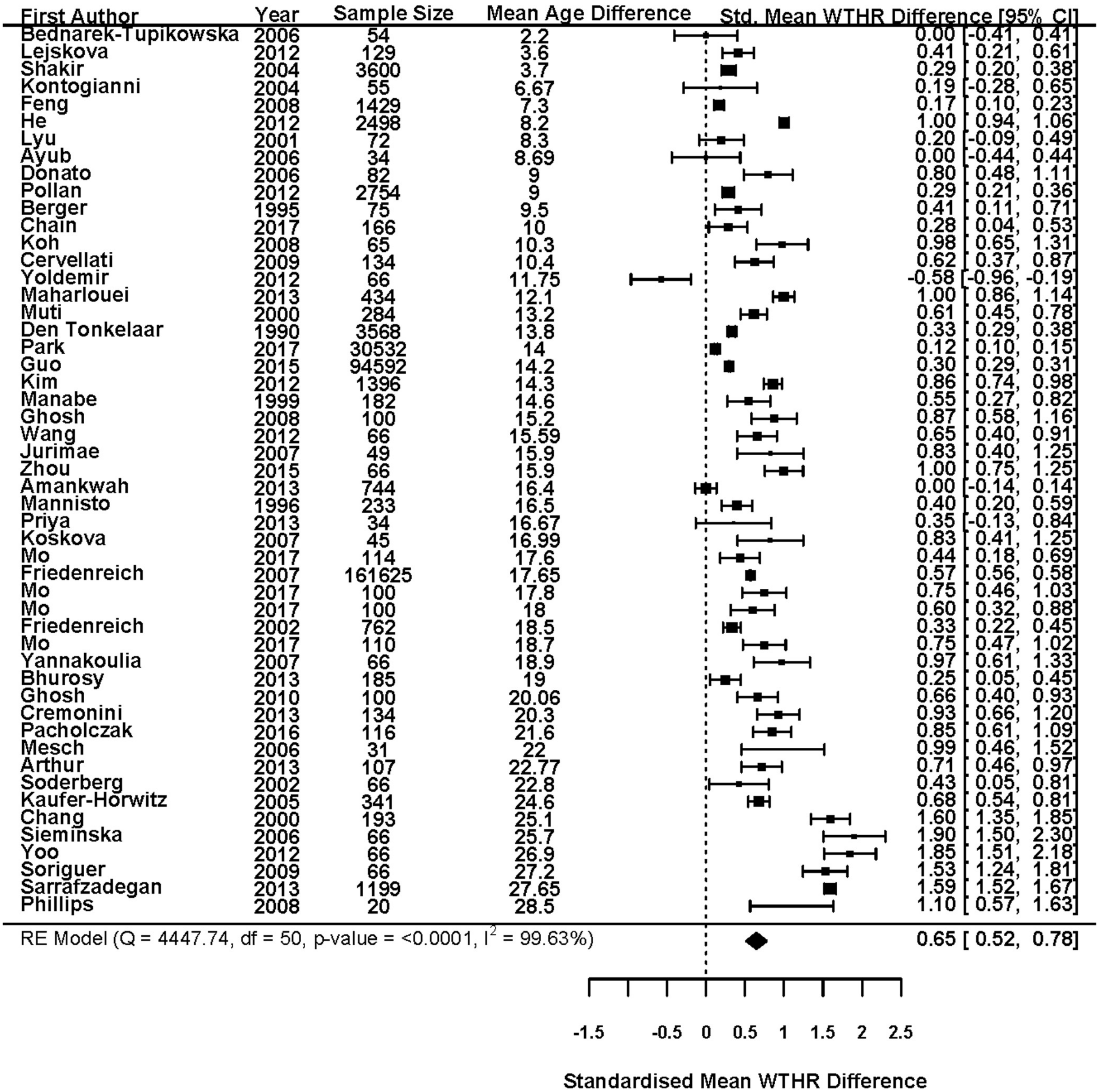
Studies are arranged by mean age difference.

CI, confidence interval; *RE*, random effects; *WC*, waist circumference.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 4

Forest plot of the cross-sectional standardized mean waist-to-hip ratio difference between premenopausal and postmenopausal women



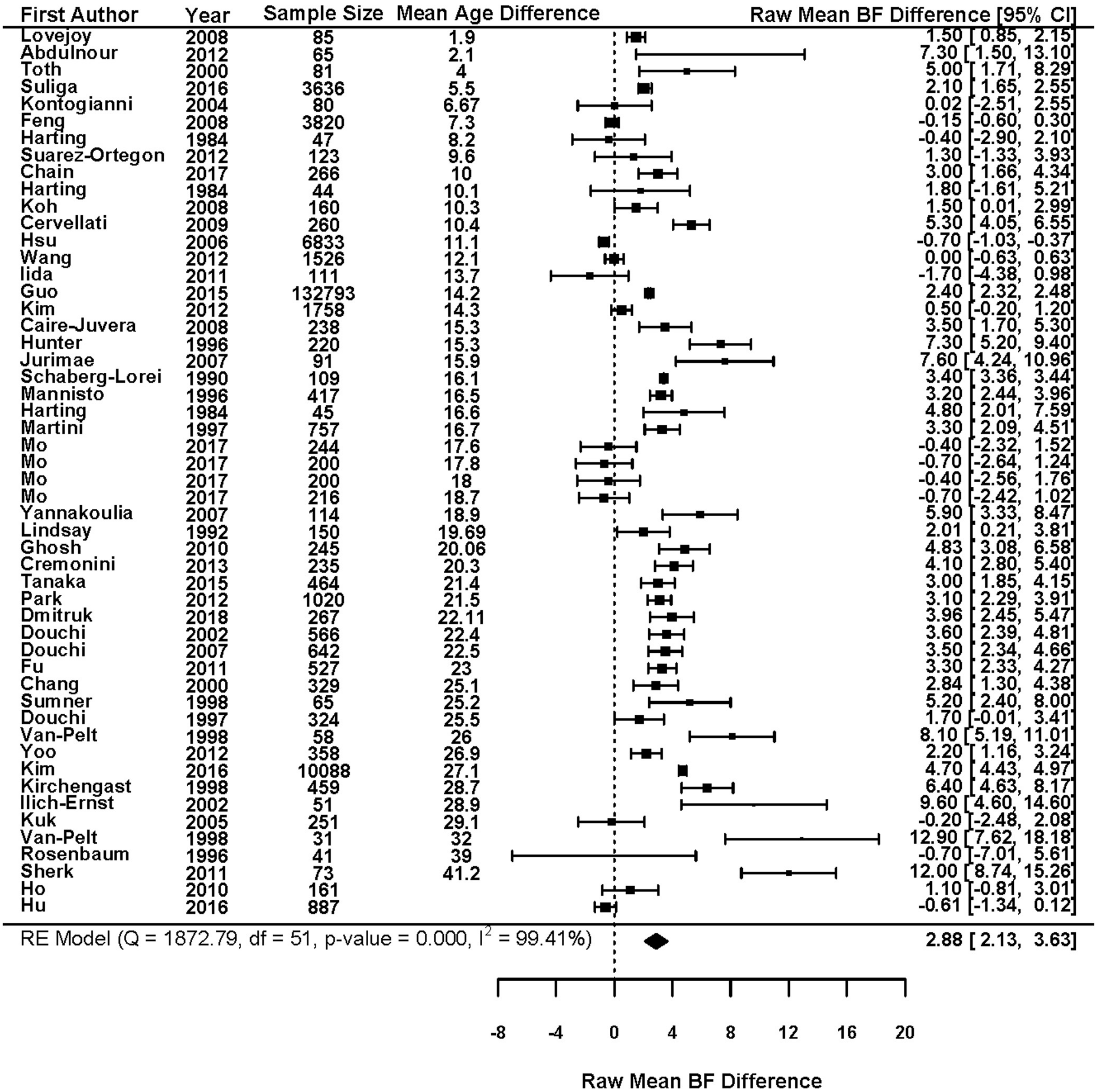
Studies are arranged by mean age difference. Standardized units have been used because of the amount of (residual) heterogeneity with nonpositive sampling variances.

CI, confidence interval; *RE*, random effects; *Std*, standardized; *WTHR*, waist-to-hip ratio.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 5

Forest plot of the cross-sectional raw mean body fat percentage difference between premenopausal and postmenopausal women



Studies are arranged by mean age difference.

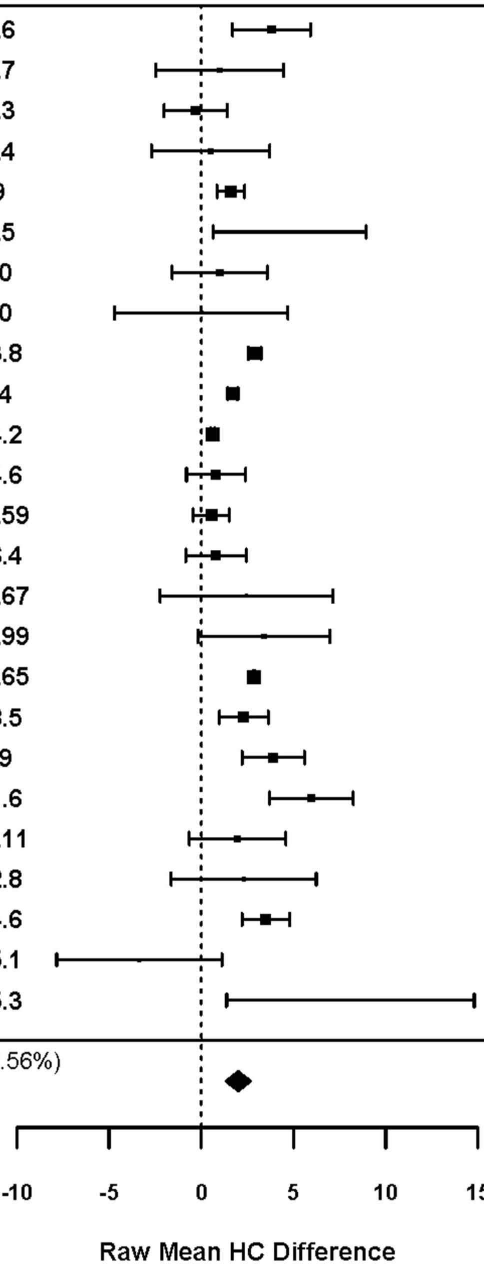
BF, body fat; *CI*, confidence interval; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 6

Forest plot of the cross-sectional raw mean hip circumference difference between premenopausal and postmenopausal women

First Author	Year	Sample Size	Mean Age Difference	Raw Mean HC Difference [95% CI]
Lejskova	2012	129	3.6	3.80 [1.69, 5.91]
Jaff	2015	144	6.7	1.00 [-2.47, 4.47]
Lyu	2001	72	8.3	-0.30 [-2.02, 1.42]
Kadam	2010	92	8.4	0.50 [-2.70, 3.70]
Pollan	2012	2754	9	1.60 [0.85, 2.35]
Berger	1995	75	9.5	4.80 [0.66, 8.94]
Chain	2017	166	10	1.00 [-1.58, 3.58]
Konrad	2011	27	10	0.00 [-4.70, 4.70]
Den Tonkelaar	1990	3568	13.8	2.90 [2.55, 3.25]
Park	2017	30532	14	1.70 [1.43, 1.97]
Guo	2015	94592	14.2	0.60 [0.49, 0.71]
Manabe	1999	182	14.6	0.80 [-0.80, 2.40]
Wang	2012	545	15.59	0.54 [-0.45, 1.53]
Amankwah	2013	744	16.4	0.80 [-0.84, 2.44]
Priya	2013	34	16.67	2.45 [-2.24, 7.14]
Koskova	2007	45	16.99	3.40 [-0.18, 6.98]
Friedenreich	2007	161625	17.65	2.86 [2.79, 2.93]
Friedenreich	2002	762	18.5	2.30 [0.98, 3.62]
Bhurosy	2013	185	19	3.90 [2.20, 5.60]
Pacholczak	2016	116	21.6	5.97 [3.70, 8.24]
Dmitruk	2018	198	22.11	1.96 [-0.66, 4.58]
Soderberg	2002	30	22.8	2.30 [-1.64, 6.24]
Kaufer-Horwitz	2005	341	24.6	3.50 [2.21, 4.79]
Chang	2000	193	25.1	-3.36 [-7.84, 1.12]
Kirchengast	1996	38	25.3	8.09 [1.38, 14.80]
RE Model (Q = 1236.98, df = 24, p-value = 0.000, I^2 = 97.56%)				2.01 [1.36, 2.65]



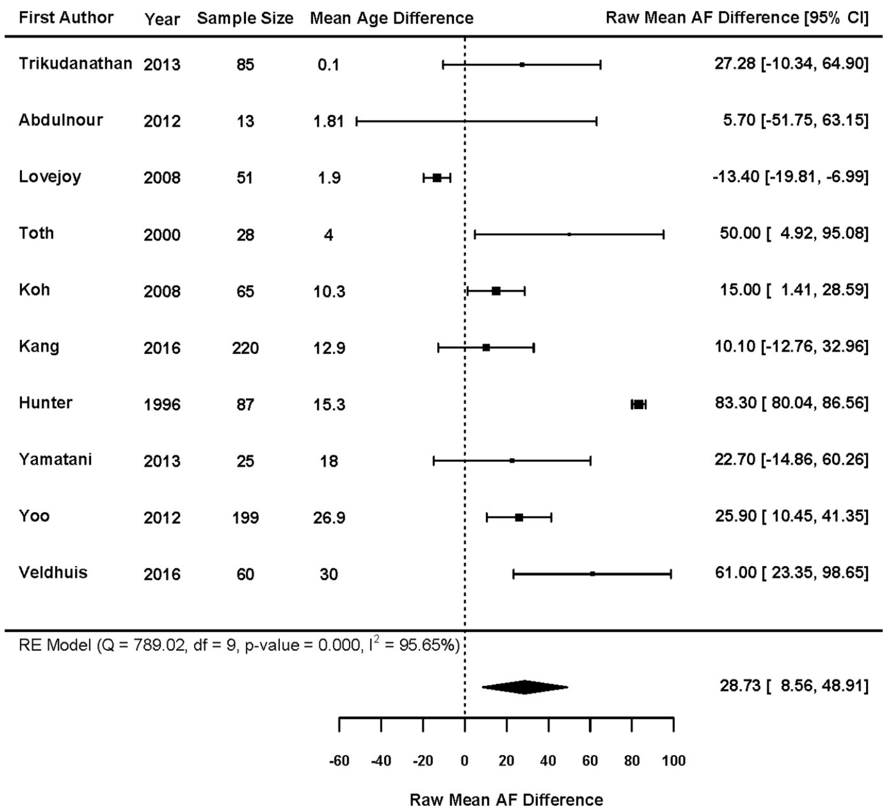
Studies are arranged by mean age difference.

CI, confidence interval; *HC*, hip circumference; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 7

Forest plot of the cross-sectional raw mean abdominal fat difference between premenopausal and postmenopausal women



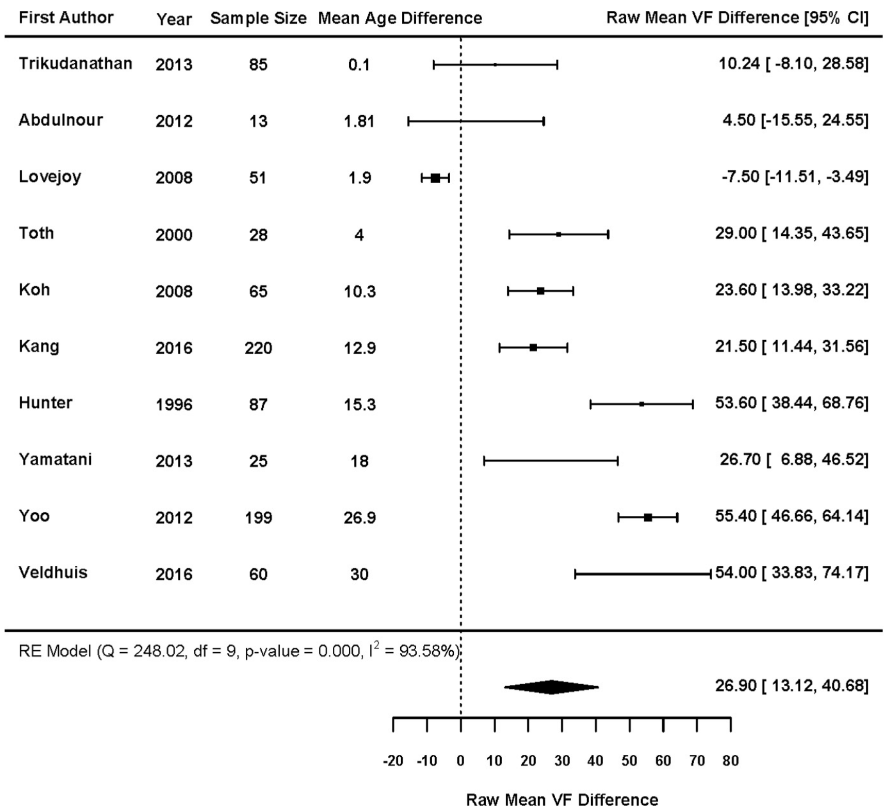
Studies are arranged by mean age difference.

AF, abdominal fat; *CI*, confidence interval; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 8

Forest plot of the cross-sectional raw mean visceral fat difference between premenopausal and postmenopausal women



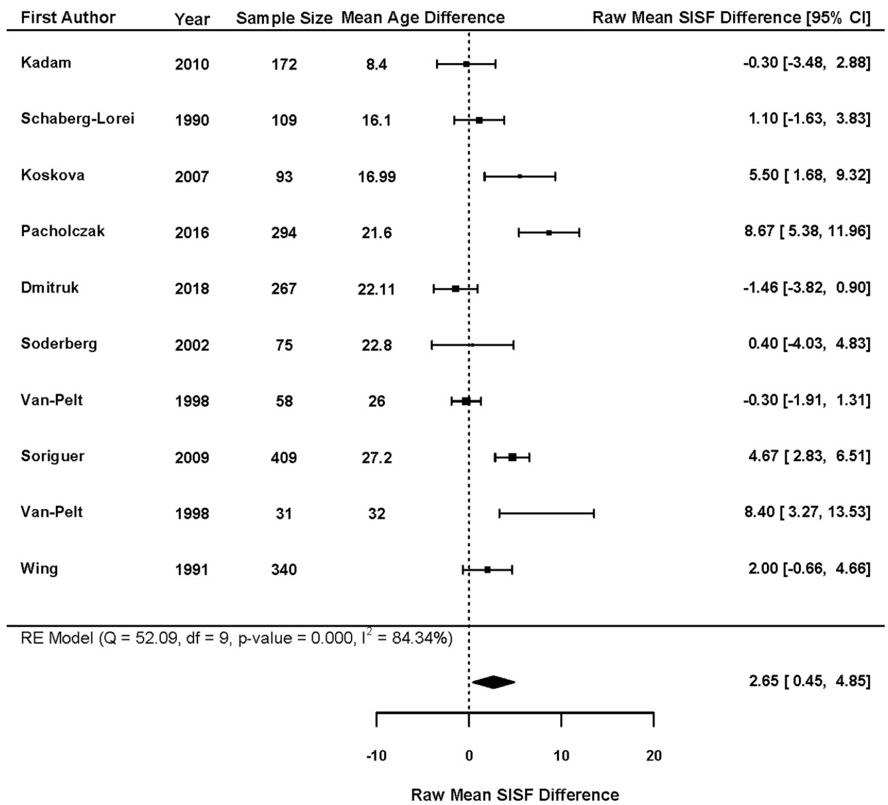
Studies are arranged by mean age difference.

CI, confidence interval; *RE*, random effects; *VF*, visceral fat.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 9

Forest plot of the cross-sectional raw mean suprailiac skinfold thickness difference between premenopausal and postmenopausal women



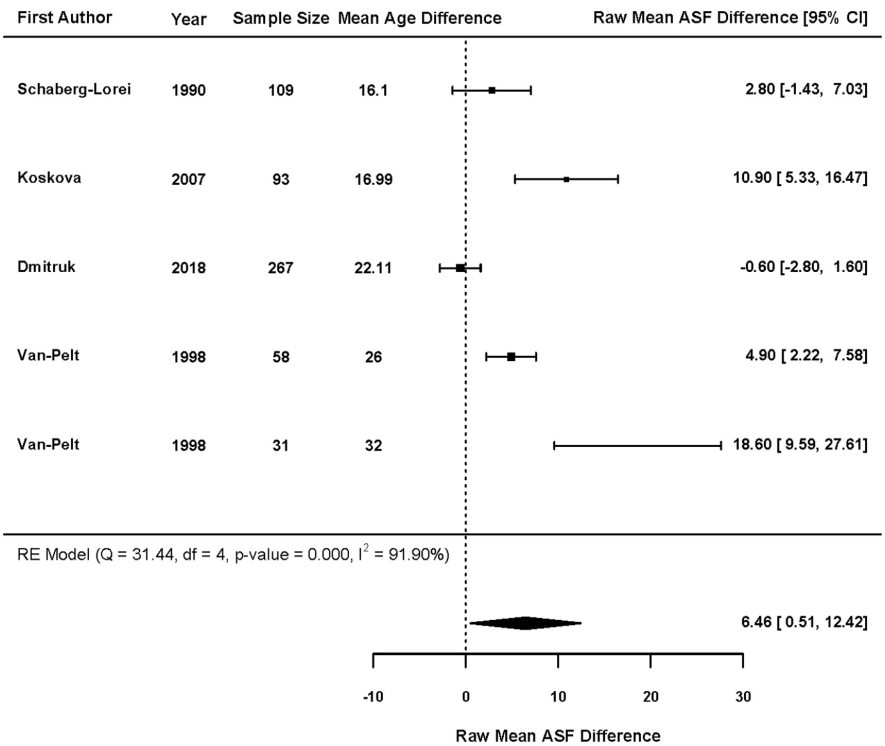
Studies are arranged by mean age difference.

CI, confidence interval; *RE*, random effects; *SISF*, suprailiac skinfold thickness.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 10

Forest plot of the cross-sectional raw mean abdominal skinfold thickness difference between premenopausal and postmenopausal women



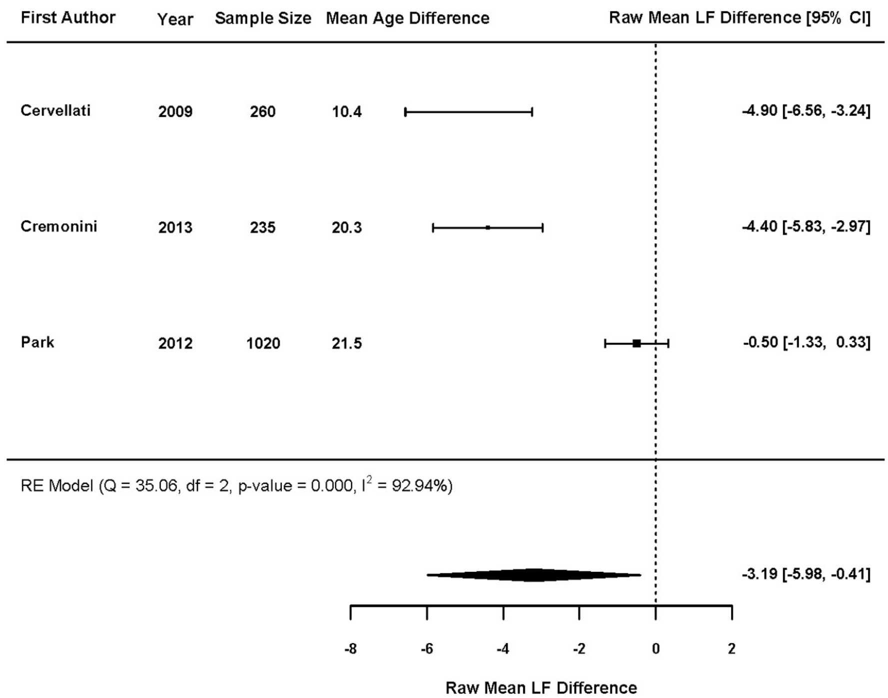
Studies are arranged by mean age difference.

ASF, abdominal skinfold thickness; *CI*, confidence interval; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 11

Forest plot of the cross-sectional raw mean leg fat percentage difference between premenopausal and postmenopausal women



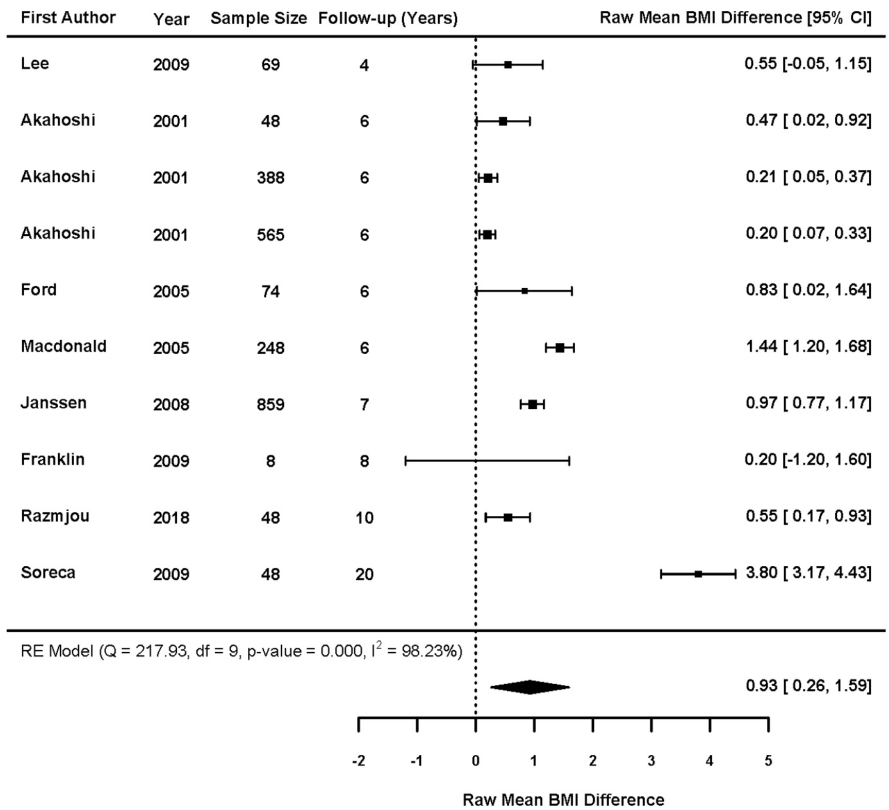
Studies are arranged by mean age difference.

CI, confidence interval; *LF*, leg fat; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 12

Forest plot of the longitudinal body mass index change for postmenopausal women who were premenopausal at baseline



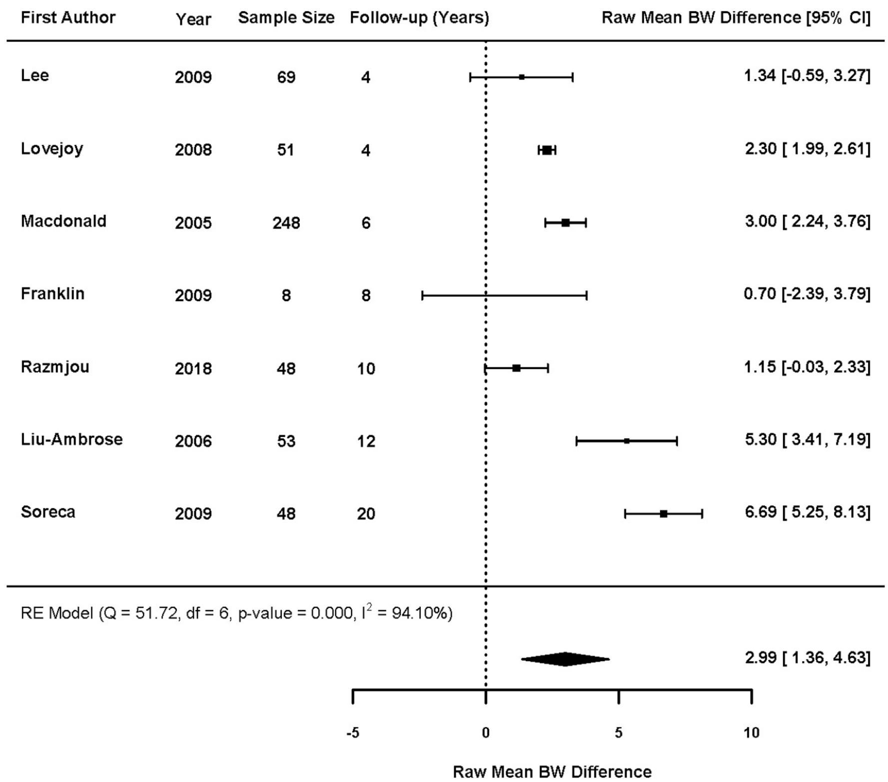
Studies are arranged by follow-up period.

BMI, body mass index; *CI*, confidence interval; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 13

Forest plot of the longitudinal bodyweight change for postmenopausal women who were premenopausal at baseline



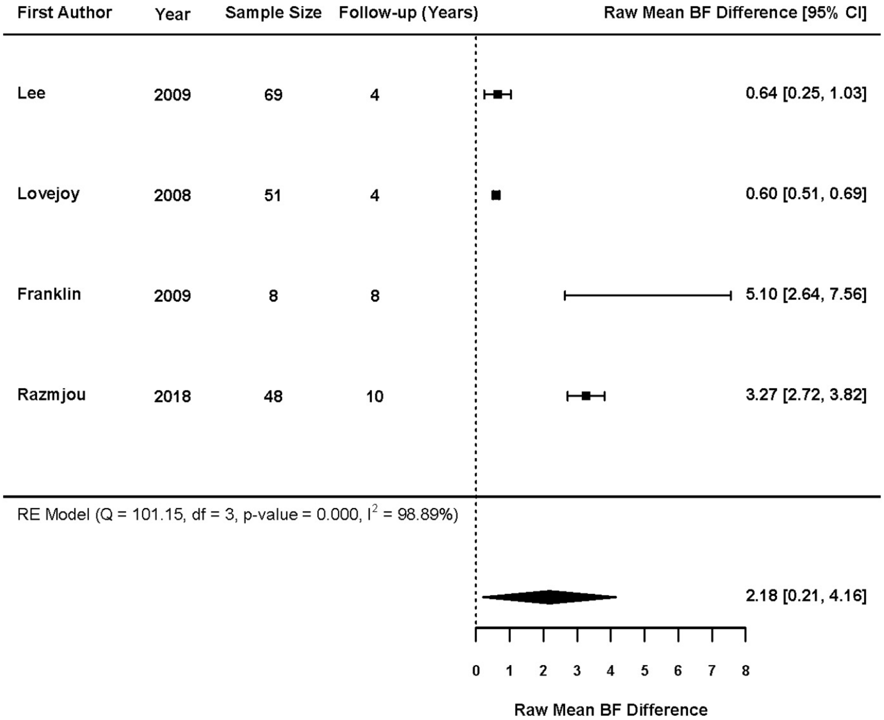
Studies are arranged by follow-up period.

BW, bodyweight; *CI*, confidence interval; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 14

Forest plot of the longitudinal body fat percentage change for postmenopausal women who were premenopausal at baseline



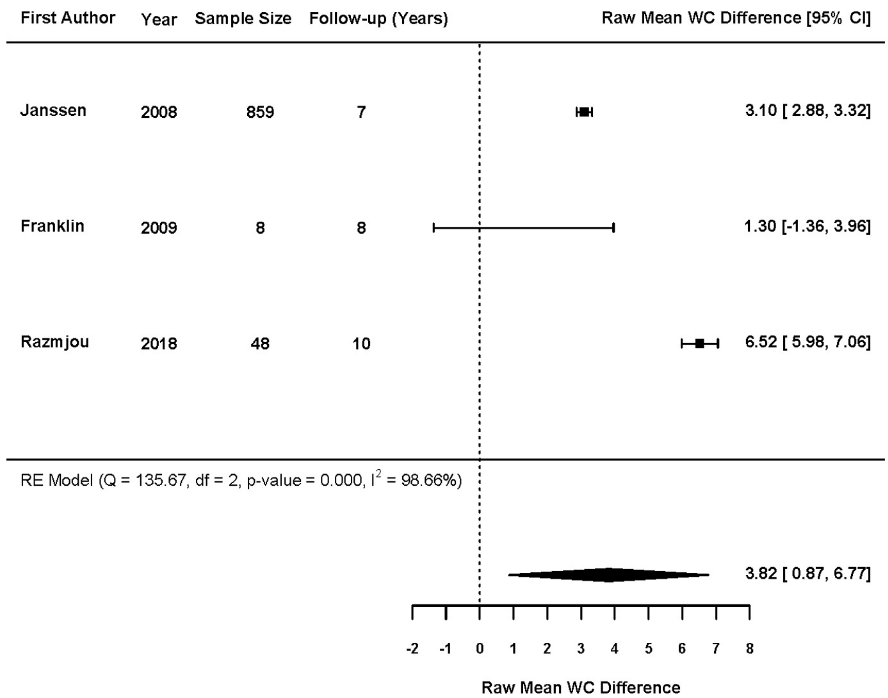
Studies are arranged by follow-up period.

BF, body fat; *CI*, confidence interval; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 15

Forest plot of the longitudinal waist circumference change for postmenopausal women who were premenopausal at baseline



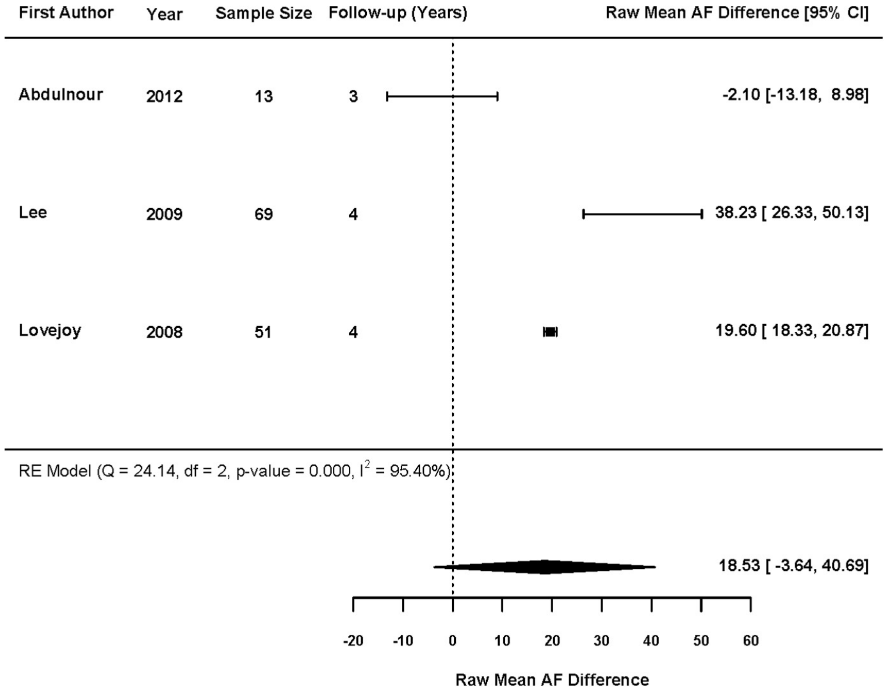
Studies are arranged by follow-up period.

CI, confidence interval; *RE*, random effects; *WC*, waist circumference.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 16

Forest plot of the longitudinal abdominal fat change for postmenopausal women who were premenopausal at baseline



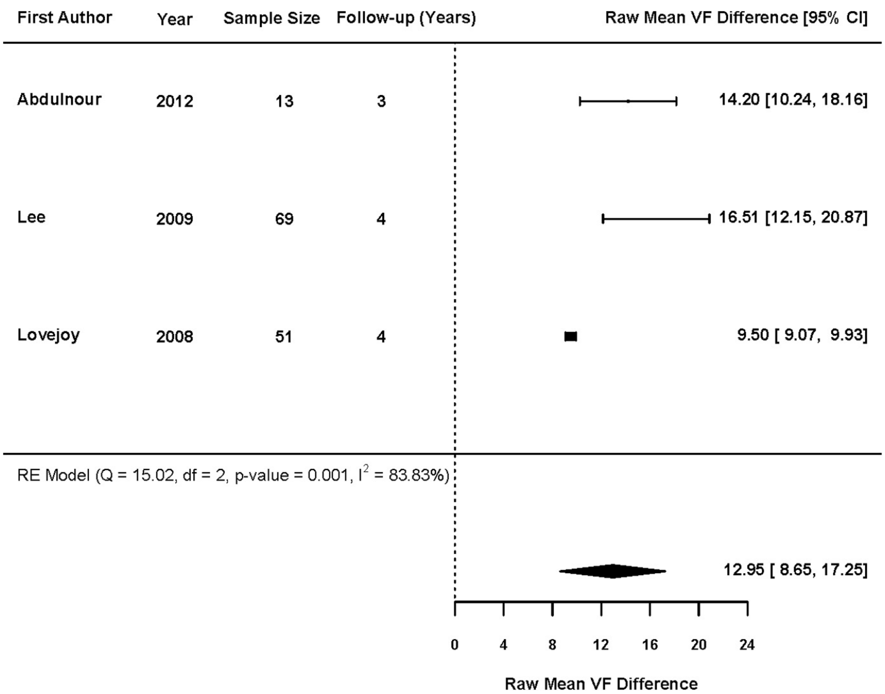
Studies are arranged by follow-up period.

AF, abdominal fat; *CI*, confidence interval; *RE*, random effects.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 17

Forest plot of the longitudinal visceral fat change for postmenopausal women who were premenopausal at baseline

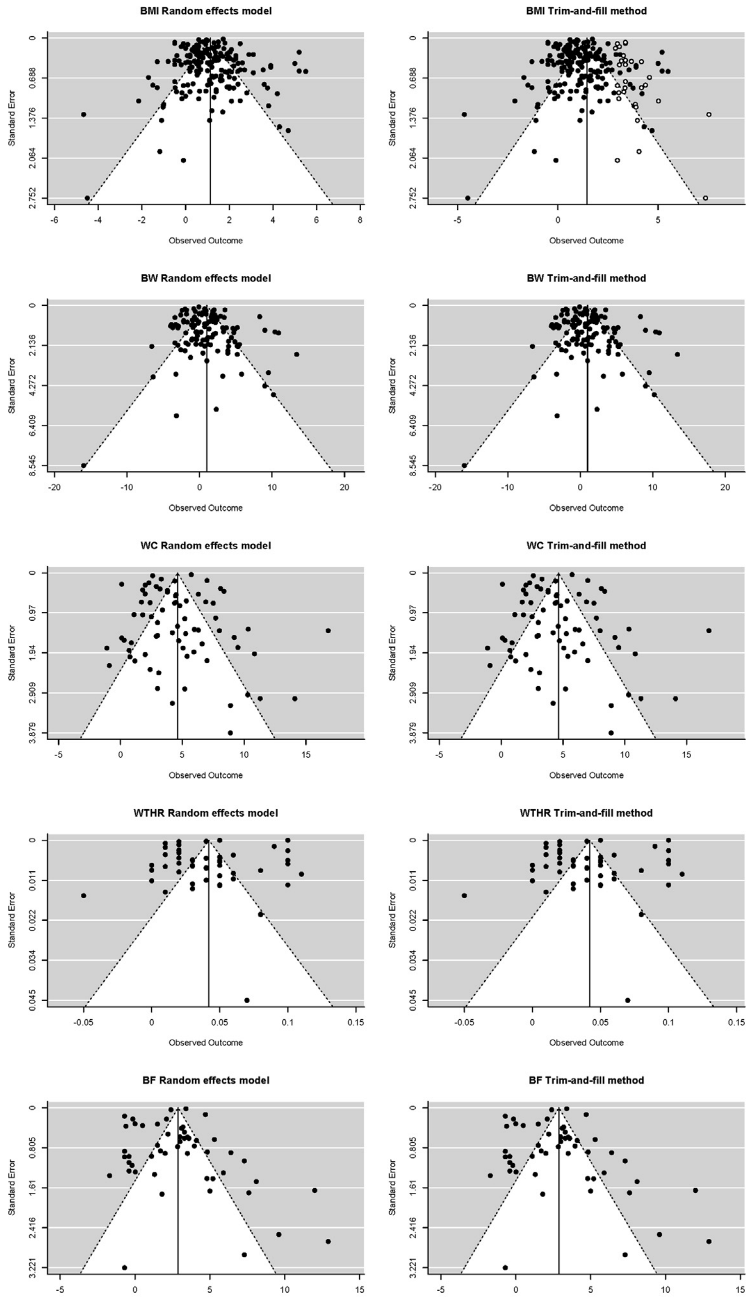


Studies are arranged by follow-up period.

CI, confidence interval; *RE*, random effects; *VF*, visceral fat.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 18
Funnel plots for cross-sectional studies with the use of a random effects model and the trim and fill method



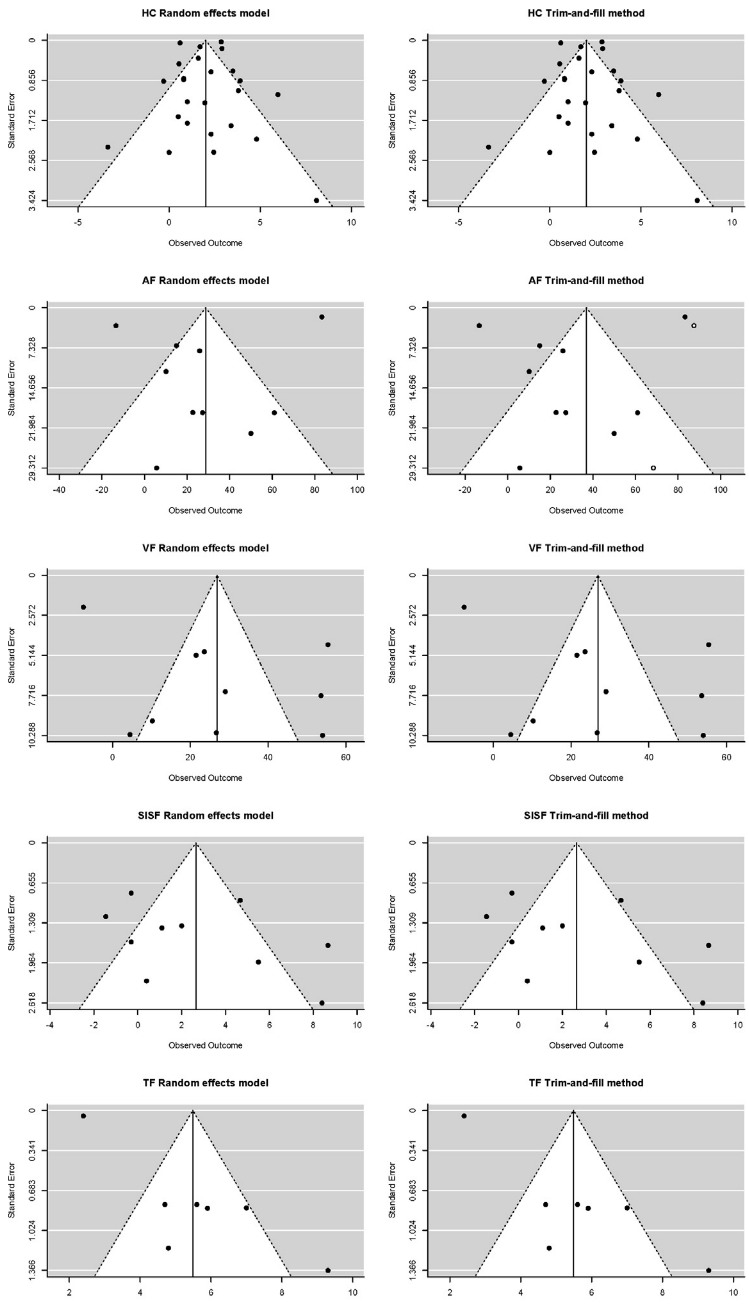
Left column, random effects model; **right column**, trim and fill method. *Filled circles* represent studies that were included in the metaanalyses; *open circles* represent possible missing studies.

BF, body fat; *BMI*, body mass index; *BW*, bodyweight; *WC*, waist circumference; *WTHR*, waist-to-hip ratio.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 19

Funnel plots for cross-sectional studies with the use of a random effects model and the trim and fill method



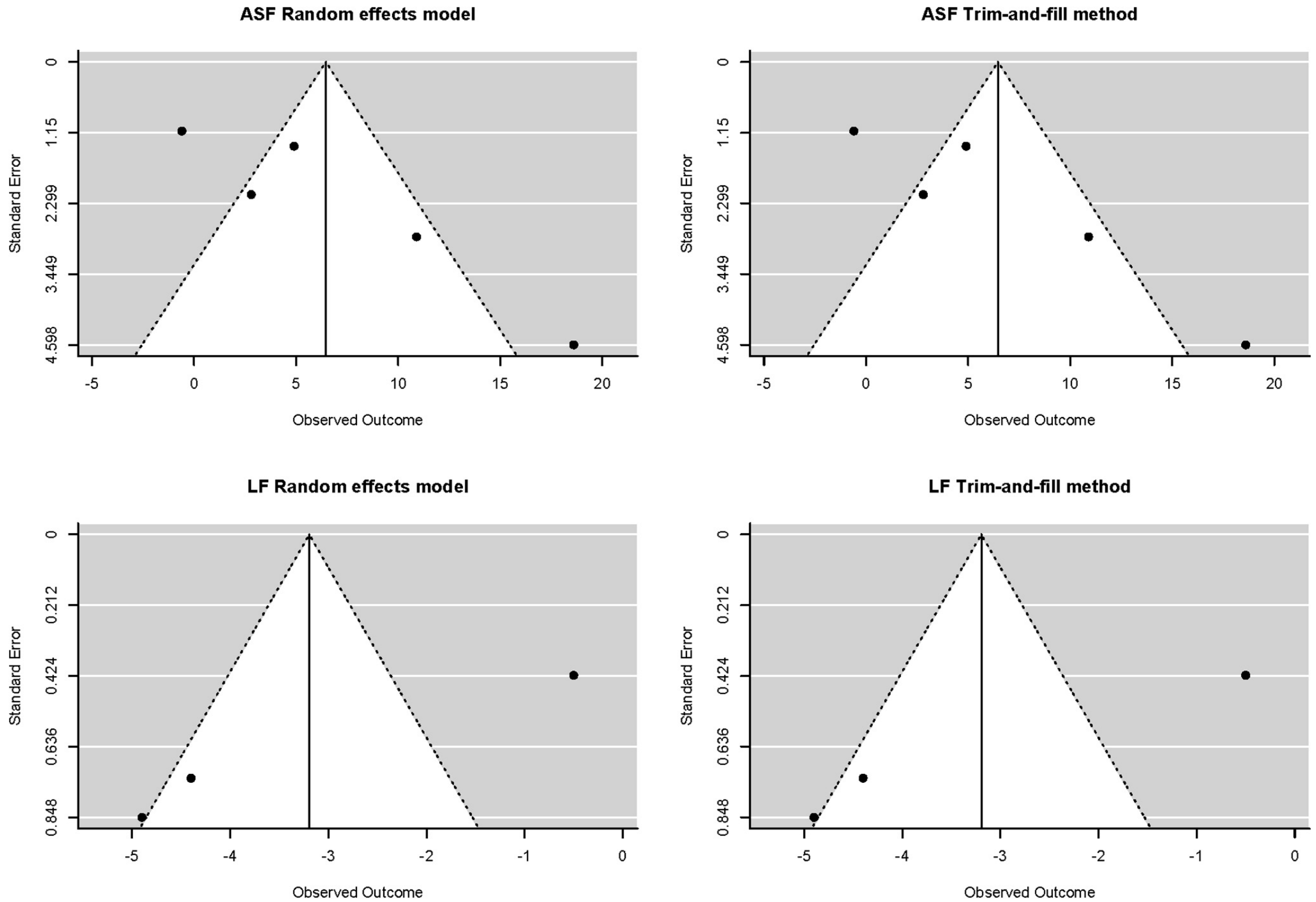
Left column, random effects model; **right column**, trim and fill method. *Filled circles* represent studies that were included in the metaanalyses; *open circles* represent possible missing studies.

AF, abdominal fat; *HC*, hip circumference; *SISF*, suprailiac skinfold thickness; *TF*, trunk fat; *VF*, visceral fat.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 20

Funnel plots for cross-sectional studies with the use of a random effects model and the trim and fill method



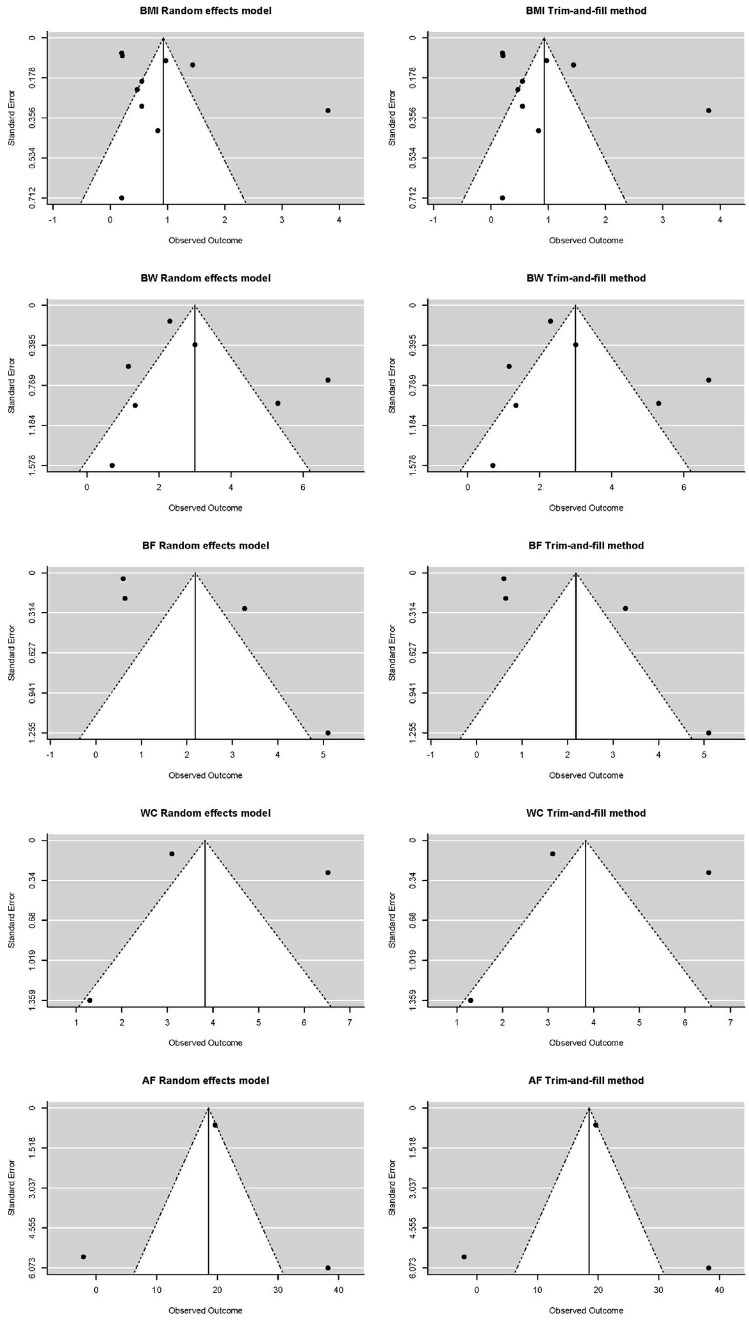
Left column, random effects model; **right column**, trim and fill method. *Filled circles* represent studies that were included in the metaanalyses; *open circles* represent possible missing studies.

ASF, abdominal skinfold thickness; *LF*, leg fat.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 21

Funnel plots for longitudinal studies with the use of a random effects model and the trim and fill method



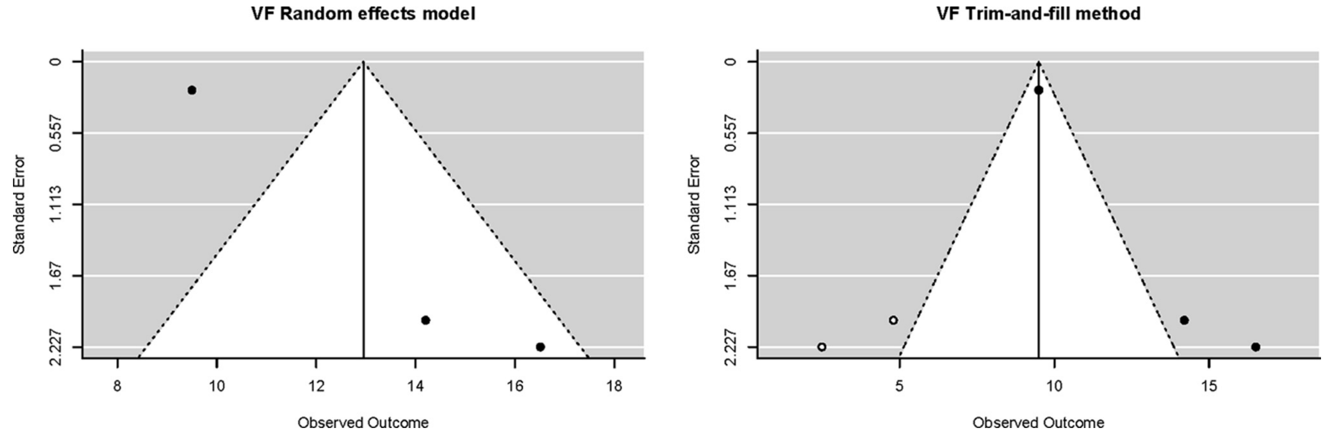
Left column, random effects model; **right column**, trim and fill method. *Filled circles* represent studies that were included in the metaanalyses; *open circles* represent possible missing studies.

AF, abdominal fat; *BF*, body fat; *BMI*, body mass index; *BW*, bodyweight; *WC*, waist circumference.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY FIGURE 22

Funnel plot for a longitudinal study with the use of a random effects model and the trim and fill method



Left column, random effects model; **right column**, trim and fill method. *Filled circles* represent studies that were included in the metaanalyses; *open circles* represent possible missing studies.

VF, visceral fat.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY TABLE 1

Definition of data elements

Data element name	Abbreviation	Unit of measurement	Type/method of measurement
Body mass index	BMI	Weight in kilograms divided by height in meters squared (kg/m^2)	Measured directly or with self-reported weight and height
Bodyweight	BW	Weight in kilograms (kg)	Measured directly or with self-report weight
Waist circumference	WC	Centimeters (cm)	According to the World Health Organization, measured at the midpoint between the lower margin of the least palpable rib and the top of the iliac crest
Hip circumference	HC	Centimeters (cm)	According to the World Health Organization, measured around the widest portion of the buttocks
Waist-to-hip ratio	WTHR	A ratio of waist circumference to hip circumference	Divide waist circumference by hip circumference
Body fat percentage	BF%	Percentage (%)	Dual energy x-ray absorptiometry (DEXA) or bioelectrical impedance analysis (BIA) or hydrodensitometry or near infrared interactance or skinfold estimates
Trunk fat percentage	TF%	Percentage (%)	Dual energy x-ray absorptiometry (DEXA) or bioelectrical impedance analysis (BIA)
Total leg fat percentage	LF%	Percentage (%)	Dual energy x-ray absorptiometry (DEXA) or bioelectrical impedance analysis (BIA)
Subcutaneous abdominal fat	AF	Centimeters cubed (cm^3)	Computed tomography (CT) scan
Visceral fat	VF	Centimeters cubed (cm^3)	Computed tomography (CT) scan
Suprailiac skinfold thickness	SISF	Millimeters (mm)	Measure the thickness of skin at the suprailiac, with the use of calipers
Abdominal skinfold thickness	ASF	Millimeters (mm)	Measure the thickness of skin at the suprailiac, with the use of calipers

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY TABLE 2
Table of study characteristics for cross-sectional studies

Study	Year	Sample size, n	Premenopausal women Mean age, y	Standard deviation	Postmenopausal women Mean age, y	Standard deviation	Body mass index	Body-weight	Waist circumference	Waist-to-hip ratio	Total body fat percentage	Hip circumference	Subcutaneous abdominal fat	Visceral fat	Suprailiac skinfold thickness	Trunk fat percentage	Abdominal skinfold thickness	Leg fat percentage
Abate et al[1]	2014	205	46.7	1.9	52.7	3.4	*	—	—	—	—	—	—	—	—	—	—	—
Abdulnour et al[2]	2012	65	52.3	0.5	54.4	2	*	*	*	—	*	—	—	—	—	—	—	—
	2012	31	50.95	1.31	52.76	2.16	*	*	*	—	*	—	*	*	—	—	—	—
Abildgaard et al[3]	2013	33	49.6	1.8	52	2	—	*	—	—	—	—	—	—	—	—	—	—
Adams-Campbell et al[4]	1996	164	39.3	6.9	58.9	10.1	*	*	—	—	—	—	—	—	—	—	—	—
Agrinier et al[5]	2010	1355	42.8	4.4	57.4	5.4	*	—	*	—	—	—	—	—	—	—	—	—
Aguado et al[6]	1996	80	38.8	8.4	60.6	9.6	*	*	—	—	—	—	—	—	—	—	—	—
Albanese et al[7]	2009	289	48.8	3.8	53.6	3.7	*	*	—	—	—	—	—	—	—	—	—	—
Allali et al[8]	2009	200	43.9	6.3	61.5	8.8	*	—	—	—	—	—	—	—	—	—	—	—
Aloia et al[9]	1995	39	37.5	5.82	54.1	7.96	*	*	—	—	—	—	—	—	—	—	—	—
	1995	125	40.2	7.2	62.5	7.81	*	*	—	—	—	—	—	—	—	—	—	—
Amankwah et al[10]	2013	1,031	46.3	6.5	62.7	7.2	*	—	*	*	—	*	—	—	—	—	—	—
Amarante et al[11]	2011	80	43.96	7.08	52.16	3.65	*	—	—	—	—	—	—	—	—	—	—	—
Amiri et al[12]	2014	340	36.8	11.52	59	7.48	*	—	*	—	—	—	—	—	—	—	—	—
Angsuwanthana et al[13]	2007	697	49.4	3.39	53.19	5.94	*	*	—	—	—	—	—	—	—	—	—	—
Armellini et al[14]	1996	72	NA		NA		—	—	*	—	—	—	—	—	—	—	—	—
Arthur et al[15]	2013	250	34.48	8.85	57.25	8.28	*	—	*	*	—	—	—	—	—	—	—	—
Aydin et al[16]	2010	1,106	48.7	2.6	54	3.4	*	—	—	—	—	—	—	—	—	—	—	—
Ayub et al[17]	2006	80	42.46	7.3	51.15	7.71	*	*	—	*	—	—	—	—	—	—	—	—
Bancroft and Cawood[18]	1996	103	47.6	3.7	55.4	3.05	*	—	—	—	—	—	—	—	—	—	—	—
Bednarek-Tupikowska et al[19]	2006	94	48.3	2.3	50.5	3	*	*	—	*	—	—	—	—	—	—	—	—
Bell et al[20]	2007	587	38.9	7.9	62.8	8.3	*	*	—	—	—	—	—	—	—	—	—	—
Ben-Ali et al[21]	2016	242	39.48	7.79	57.87	7.65	*	—	*	—	—	—	—	—	—	—	—	—
Ben-Ali et al[22]	2014	2,680	42.9	5	57.5	7.3	*	—	*	—	—	—	—	—	—	—	—	—
Ben-Ali et al[23]	2011	376	35.3	7.6	53.4	6.2	*	—	—	—	—	—	—	—	—	—	—	—

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 2

Table of study characteristics for cross-sectional studies *(continued)*

Study	Year	Sample size, n	Premenopausal women Mean age, y	Standard deviation	Postmenopausal women Mean age, y	Standard deviation	Body mass index	Body-weight	Waist circumference	Waist-to-hip ratio	Total body fat percentage	Hip circumference	Subcutaneous abdominal fat	Visceral fat	Suprailiac skinfold thickness	Trunk fat percentage	Abdominal skinfold thickness	Leg fat percentage
Berg et al[24]	2004	50	36.9	4.1	57	5.3	*	—	*	—	—	—	—	—	—	—	—	—
Berge et al[25]	1994	159	38.9	7.2	55.3	6.1	*	—	—	—	—	—	—	—	—	—	—	—
Berger et al[26]	1995	177	38.2	5	47.7	3.8	*	*	*	*	—	*	—	—	—	—	—	—
Berstad et al[27]	2010	4,041	42.83	5.1	56.42	5.46	*	—	—	—	—	—	—	—	—	—	—	—
Bhagat et al[28]	2010	214	33.77	6.57	52.16	6.27	—	—	*	—	—	—	—	—	—	—	—	—
Bhurosy and Jeewon[29]	2013	400	34	NA	53	NA	*	—	*	*	—	*	—	—	—	—	—	—
Blumenthal et al[30]	1991	46	47	2	52	3	—	*	—	—	—	—	—	—	—	—	—	—
Bonithon-Kopp et al[31]	1990	416	47.8	2.2	52.3	1.8	*	—	—	—	—	—	—	—	—	—	—	—
Caire-Juvera et al[32]	2008	238	44.8	2.39	60.1	3.59	*	*	—	—	*	—	—	—	—	*	—	—
Campesi et al[33]	2016	79	36.2	7.6	55.4	5.1	—	*	—	—	—	—	—	—	—	—	—	—
Carr et al[34]	2000	56	35.4	8.6	61	4.1	*	—	—	—	—	—	—	—	—	—	—	—
Castracane et al[35]	1998	76	27.3	0.63	55.8	0.85	*	—	—	—	—	—	—	—	—	—	—	—
Catsburg et al[36]	2014	3,320	45.8	8.9	67.9	11.2	*	—	—	—	—	—	—	—	—	—	—	—
Cecchini et al[37]	2012	12,243	46.34	4.28	60.81	7.51	*	—	—	—	—	—	—	—	—	—	—	—
Cervellati et al[38]	2009	260	38.1	6.73	48.5	6.95	*	—	—	*	*	—	—	—	—	*	—	*
Chain et al[39]	2017	266	47	5	57	7	*	*	*	*	*	*	—	—	—	—	—	—
Chang et al[40]	2000	329	36.1	6.5	61.2	6.2	*	—	*	*	*	*	—	—	—	—	—	—
Cho et al[41]	2008	1,002	40.5	7.8	59	6.6	*	*	*	—	—	—	—	—	—	—	—	—
Cifkova et al[42]	2008	662	48.9	2.39	52.1	1.92	*	—	—	—	—	—	—	—	—	—	—	—
Copeland et al[43]	2006	411	36	8.5	51.5	7.7	*	—	—	—	—	—	—	—	—	—	—	—
Cremonini et al[44]	2013	235	35.2	10.7	55.5	4.8	*	—	*	*	*	—	—	—	—	*	—	*
Cui et al[45]	2007	703	38.4	8.6	63.3	6.5	—	*	—	—	—	—	—	—	—	—	—	—
D'haeseleer et al[46]	2011	75	48.3	2.3	58.8	5.4	*	—	—	—	—	—	—	—	—	—	—	—
Da Camara et al[47]	2015	237	44.63	3.36	54.47	5.24	*	—	—	—	—	—	—	—	—	—	—	—
Dallongeville et al[48]	1995	2,167	48.3	3.4	57.4	3.9	*	—	—	—	—	—	—	—	—	—	—	—
Dancey et al[49]	2001	1,315	35	5.65	65	6.83	*	—	—	—	—	—	—	—	—	—	—	—
Davis et al[50]	1994	729	48.1	1.7	50.2	1.7	*	—	—	—	—	—	—	—	—	—	—	—

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 2

Table of study characteristics for cross-sectional studies *(continued)*

Study	Year	Sample size, n	Premenopausal women Mean age, y	Standard deviation	Postmenopausal women Mean age, y	Standard deviation	Body mass index	Body-weight	Waist circumference	Waist-to-hip ratio	Total body fat percentage	Hip circumference	Subcutaneous abdominal fat	Visceral fat	Suprailiac skinfold thickness	Trunk fat percentage	Abdominal skinfold thickness	Leg fat percentage
De Kat et al[51]	2017	53,911	36.9	8.1	55.3	7.4	*	—	—	—	—	—	—	—	—	—	—	—
Den Tonkelaar et al[52]	1990	9,491	44	3.6	57.8	7.4	*	*	*	*	—	*	—	—	—	—	—	—
Dmitruk et al[53]	2018	267	44.48	2.22	66.59	6.69	—	*	*	—	*	*	—	—	*	—	*	—
Donato et al[54]	2006	168	44.3	3.6	53.3	3.8	*	*	*	*	—	—	—	—	—	—	—	—
Douchi et al[55]	1997	324	36.6	9.4	62.1	7.7	*	*	—	—	*	—	—	—	—	—	—	—
Douchi et al[56]	2002	566	39.1	9.1	61.5	7.2	*	*	—	—	*	—	—	—	—	—	—	—
Douchi et al[57]	2007	642	39	9	61.5	7.4	*	*	—	—	*	—	—	—	—	*	—	—
Dubois et al[58]	2001	217	39	9	63	8	*	*	—	—	—	—	—	—	—	—	—	—
Engmann et al[59]	2017	184,309	46.27	3.75	61.72	7.2	*	—	—	—	—	—	—	—	—	—	—	—
Ertungealp et al[60]	1999	185	NA		NA		*	—	—	—	—	—	—	—	—	—	—	—
Feng et al[61]	2008	3,820	43.7	3	51	2.6	*	*	*	*	*	—	—	—	—	—	—	—
Formica et al[62]	1995	54	26.3	3.64	69	4.68	—	*	—	—	—	—	—	—	—	—	—	—
	1995	46	26.5	3.82	64.9	4.23	—	*	—	—	—	—	—	—	—	—	—	—
Friedenreich et al[63]	2007	285,685	41.11	6.9	58.76	6.25	*	—	*	*	—	*	—	—	—	—	—	—
Friedenreich et al[64]	2002	1,237	44.3	5.9	62.8	9	*	*	*	*	—	*	—	—	—	—	—	—
Fu et al[65]	2011	527	38	8.6	61	7.2	*	*	—	—	*	—	—	—	—	—	—	—
Fuh et al[66]	2003	997	43.6	2.9	49.4	3.8	*	—	—	—	—	—	—	—	—	—	—	—
Gambacciani et al[67]	1999	812	41.3	7.8	55	4.16	*	*	—	—	—	—	—	—	—	—	—	—
Genazzani and Gambacciani[68]	2006	1,425	42.3	9.3	53	5.95	*	*	—	—	—	—	—	—	—	—	—	—
Ghosh[69]	2008	200	40.2	6.5	55.4	5.2	*	—	*	*	—	—	—	—	—	—	—	—
Ghosh and Bhagat[70]	2010	245	32.66	5.75	52.72	5.62	*	—	*	*	*	—	—	—	—	—	—	—
Gram et al[71]	1997	3,076	44.3	3.5	51.7	3.6	*	*	—	—	—	—	—	—	—	—	—	—
Guo et al[72]	2015	132,793	45.5	3.4	59.7	5.5	*	*	*	*	*	*	—	—	—	*	—	—
Gurka et al[73]	2016	2,177	47.6	3.4	54.3	3.6	—	—	*	—	—	—	—	—	—	—	—	—
	2016	779	47.4	2.1	53.1	4.1	—	—	*	—	—	—	—	—	—	—	—	—
Hadji et al[74]	2000	434	36.5	10.4	61.8	8.9	*	*	—	—	—	—	—	—	—	—	—	—
Hagner et al[75]	2009	118	36.5	5.17	62.5	5.43	*	—	—	—	—	—	—	—	—	—	—	—

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 2

Table of study characteristics for cross-sectional studies *(continued)*

Study	Year	Sample size, n	Premenopausal women Mean age, y	Standard deviation	Postmenopausal women Mean age, y	Standard deviation	Body mass index	Body-weight	Waist circumference	Waist-to-hip ratio	Total body fat percentage	Hip circumference	Subcutaneous abdominal fat	Visceral fat	Suprailiac skinfold thickness	Trunk fat percentage	Abdominal skinfold thickness	Leg fat percentage
Han et al[76]	2006	2,105	44.1	4.6	63.4	8.9	—	*	*	—	—	—	—	—	—	—	—	—
Harting et al[77]	1984	45	33.8	8.2	50.4	3.8	—	*	—	—	*	—	—	—	—	—	—	—
	1984	47	37.9	8.2	46.1	8.2	—	*	—	—	*	—	—	—	—	—	—	—
	1984	44	36.9	8.1	47	7.3	—	*	—	—	*	—	—	—	—	—	—	—
He et al[78]	2012	4,743	45.8	3.6	54	3.6	*	—	*	*	—	—	—	—	—	—	—	—
Hirose et al[79]	2003	16,132	42.2	NA	60	NA	*	*	—	—	—	—	—	—	—	—	—	—
	2003	1,716	38	NA	61.4	NA	*	*	—	—	—	—	—	—	—	—	—	—
Hjartaker et al[80]	2005	102,469	40.7	5	45.4	4.1	*	—	—	—	—	—	—	—	—	—	—	—
Ho et al[81]	2010	161	NA		NA		—	—	—	—	*	—	—	—	—	—	—	—
Hsu et al[82]	2006	6,833	41.5	5.3	52.6	4.7	*	*	—	—	*	—	—	—	—	—	—	—
Hu et al[83]	2016	887	NA		NA		—	—	—	—	*	—	—	—	—	—	—	—
Hunter et al[84]	1996	220	36.2	9	51.5	10.2	—	*	—	—	*	—	*	*	—	—	—	—
Iida et al[85]	2011	111	47.6	3.8	61.3	6.6	*	*	—	—	*	—	—	—	—	—	—	—
Ilich-Ernst et al[86]	2002	51	33	9.2	61.9	3.3	*	*	—	—	*	—	—	—	—	—	—	—
Ito et al[87]	1994	251	38.8	10	58.6	5.8	—	*	—	—	—	—	—	—	—	—	—	—
Jaff et al[88]	2015	338	45.1	3.3	51.8	3.86	*	—	*	—	—	*	—	—	—	—	—	—
Jasienska et al[89]	2005	1,003	48.5	2.81	57.4	4.41	*	—	—	—	—	—	—	—	—	—	—	—
Jeenduang et al[90]	2014	361	42.58	6.62	58.17	9.65	*	—	*	—	—	—	—	—	—	—	—	—
Jeon et al[91]	2011	1971	49.3	8.5	51.2	9	*	*	*	—	—	—	—	—	—	—	—	—
Jurimae and Jurimae[92]	2007	91	40.8	5.7	56.7	3.6	*	*	—	*	*	—	—	—	—	—	—	—
Kadam et al[93]	2010	172	45.6	4.8	54	7.1	—	—	*	—	—	*	—	—	*	—	—	—
Kang et al[94]	2016	264	47.9	3.3	60.8	6	*	*	—	—	—	—	*	*	—	—	—	—
Kaufer-Horwitz et al[95]	2005	980	33.7	8.4	58.3	6.9	*	*	*	*	—	*	—	—	—	—	—	—
Kim et al[96]	2007	2,671	35.4	8.1	65.1	9.3	*	—	*	—	—	—	—	—	—	—	—	—
Kim et al[97]	2012	1,758	50.7	2.8	65	7.4	*	*	*	*	*	—	—	—	—	—	—	—
Kim et al[98]	2013	617	42.12	6.22	56.48	6.55	*	—	*	—	—	—	—	—	—	—	—	—
Kim et al[99]	2016	10,088	36.9	8.7	64	9.7	*	*	*	—	*	—	—	—	—	—	—	—

(continued)

SUPPLEMENTARY TABLE 2

Table of study characteristics for cross-sectional studies *(continued)*

Study	Year	Sample size, n	Premenopausal women Mean age, y	Standard deviation	Postmenopausal women Mean age, y	Standard deviation	Body mass index	Body-weight	Waist circumference	Waist-to-hip ratio	Total body fat percentage	Hip circumference	Subcutaneous abdominal fat	Visceral fat	Suprailiac skinfold thickness	Trunk fat percentage	Abdominal skinfold thickness	Leg fat percentage
Kirchengast et al[100]	1998	77	27.1	NA	55.8	NA	*	*	—	—	*	—	—	—	—	*	—	—
Kirchengast et al[101]	1996	459	26.8	NA	52.1	NA	—	*	*	—	—	*	—	—	—	—	—	—
Knapp et al[102]	2001	409	40.3	9.5	59.9	7.5	*	*	—	—	—	—	—	—	—	—	—	—
Koh et al[103]	2008	160	44.2	2.92	54.5	4.35	*	—	*	*	*	—	*	*	—	—	—	—
Konrad et al[104]	2011	51	43	5	53	4	*	*	*	—	—	*	—	—	—	—	—	—
Kontogianni et al[105]	2004	80	47.8	3.14	54.47	5.36	*	—	—	*	*	—	—	—	—	—	—	—
Konukoglu et al[106]	2000	75	35.4	8.3	49.5	4.7	*	—	—	—	—	—	—	—	—	—	—	—
Koskova et al[107]	2007	93	42.54	2.5	59.53	2.71	*	*	*	*	—	*	—	—	*	—	*	—
Kotani et al[108]	2011	262	44.7	4.9	64.6	4.4	*	—	—	—	—	—	—	—	—	—	—	—
Kraemer et al[109]	2001	141	26.8	4.9	57.63	7.47	*	—	—	—	—	—	—	—	—	—	—	—
Kuk et al[110]	2005	251	37.6	8.6	66.7	8	*	—	*	—	*	—	—	—	—	—	—	—
Laitinen et al[111]	1991	257	36.7	9	59.6	6.4	—	*	—	—	—	—	—	—	—	—	—	—
Lejskova et al[112]	2012	480	48.6	2.4	52.2	2	*	—	*	*	—	*	—	—	—	—	—	—
Leon-Guerrero et al[113]	2017	275	43.94	6.63	58.44	8.69	*	*	*	—	—	—	—	—	—	—	—	—
Ley et al[114]	1992	131	32	6	53	5	*	*	—	—	—	—	—	—	—	—	—	—
Lin et al[115]	2006	594	46	3.6	53.1	4.4	*	*	*	—	—	—	—	—	—	—	—	—
Lindquist and Bengtsson[116]	1980	326	50	NA	50	NA	—	*	—	—	—	—	—	—	—	—	—	—
Lindsay et al[117]	1992	150	39.65	9.98	59.34	8.37	*	*	—	—	*	—	—	—	—	—	—	—
Lovejoy et al[118]	2008	85	50.2	0.3	52.1	0.3	—	*	—	—	*	—	*	*	—	—	—	—
Lyu et al[119]	2001	203	45.1	3.4	53.4	5	*	*	*	*	—	*	—	—	—	—	—	—
Maharlouei et al[120]	2013	924	46.5	5	58.6	6.7	*	—	*	*	—	—	—	—	—	—	—	—
Malacara et al[121]	2002	901	46.8	3.1	50.9	4.4	*	*	—	—	—	—	—	—	—	—	—	—
	2002	1,180	45.2	2.9	49.8	3.28	*	*	—	—	—	—	—	—	—	—	—	—
	2002	546	44.8	3.6	49.9	4.2	*	*	—	—	—	—	—	—	—	—	—	—
	2002	2,000	45.1	3.4	50.8	3.4	*	*	—	—	—	—	—	—	—	—	—	—
	2002	1,008	44.3	2.4	50.6	2.6	*	*	—	—	—	—	—	—	—	—	—	—
	2002	2,000	45.4	2.6	51	2.4	*	*	—	—	—	—	—	—	—	—	—	—

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019. *(continued)*

SUPPLEMENTARY TABLE 2

Table of study characteristics for cross-sectional studies *(continued)*

Study	Year	Sample size, n	Premeno-pausal women Mean age, y	Standard deviation	Postmeno-pausal women Mean age, y	Standard deviation	Body mass index	Body-weight	Waist circumference	Waist-to-hip ratio	Total body fat percentage	Hip circumference	Subcutaneous abdominal fat	Visceral fat	Suprailiac skinfold thickness	Trunk fat percentage	Abdominal skinfold thickness	Leg fat percentage
Manabe et al[122]	1999	254	45.7	4.2	60.3	5.5	*	*	*	*	—	*	—	—	—	—	—	—
Manjer et al[123]	2001	9,738	42.8	7.9	54.1	3	*	*	—	—	—	—	—	—	—	—	—	—
Mannisto et al[124]	1996	417	43.3	6	59.8	7.7	*	*	—	*	*	—	—	—	—	—	—	—
Martini et al[125]	1997	757	43.2	6.7	59.9	8.1	*	*	—	—	*	—	—	—	—	—	—	—
Marwaha et al[126]	2013	1,423	31	8.6	64.5	7.4	*	*	—	—	—	—	—	—	—	—	—	—
Matsushita et al[127]	2003	281	43	6.3	62.4	7.9	*	*	—	—	—	—	—	—	—	—	—	—
Matsuzaki et al[128]	2017	1,760	29.3	9.9	46.8	6.9	*	*	—	—	—	—	—	—	—	—	—	—
Matthews et al[129]	1989	138	47.3	1.5	47.8	1.6	*	*	—	—	—	—	—	—	—	—	—	—
Mesch et al[130]	2006	60	33	5.6	55	5.6	*	—	*	*	—	—	—	—	—	—	—	—
Meza-Munoz et al[131]	2006	113	40.03	7.16	53.75	4.28	*	—	—	—	—	—	—	—	—	—	—	—
Minatoya et al[132]	2014	66	NA		NA		*	—	—	—	—	—	—	—	—	—	—	—
Mo et al[133]	2017	200	41.7	6.3	59.7	6.8	*	*	—	*	*	—	—	—	—	—	—	—
	2017	200	42	5.4	59.8	7	*	*	—	*	*	—	—	—	—	—	—	—
	2017	216	42.1	6.4	60.8	8.1	*	*	—	*	*	—	—	—	—	—	—	—
	2017	244	43.2	7	60.8	7.6	*	*	—	*	*	—	—	—	—	—	—	—
Muchanga et al[134]	2014	200	44	3	53	4	*	—	*	—	—	—	—	—	—	—	—	—
Muti et al[135]	2000	576	44.5	4.8	57.7	5.1	*	—	—	*	—	—	—	—	—	—	—	—
Nitta et al[136]	2016	38,610	45.5	3.8	62.4	7.8	—	*	—	—	—	—	—	—	—	—	—	—
Noh et al[137]	2013	540	46.92	4.7	59.34	5.82	*	—	—	—	—	—	—	—	—	—	—	—
Nordin et al[138]	1992	259	43.1	7.5	59.9	8.5	—	*	—	—	—	—	—	—	—	—	—	—
Ohta et al[139]	2010	373	14.8	1.7	71.9	4.5	*	*	—	—	—	—	—	—	—	—	—	—
Oldroyd et al[140]	1998	211	37.2	8.8	61.6	7.9	—	*	—	—	—	—	—	—	—	—	—	—
Pacholczak et al[141]	2016	294	41.8	6.1	63.4	10.2	*	*	*	*	—	*	—	—	*	—	—	—
Park et al[142]	2012	1,020	37	7.25	58.5	7.7	—	*	—	—	*	—	—	—	—	—	—	*
Park et al[143]	2017	43,599	45.6	5	59.6	6.8	*	*	*	*	—	*	—	—	—	—	—	—
Pavicic Zezelj et al[144]	2010	535	45.6	6	58.79	8.2	*	*	—	—	—	—	—	—	—	—	—	—
Pavlica et al[145]	2013	160	38.87	9.81	58.42	1.01	*	*	—	—	—	—	—	—	—	—	—	—

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 2

Table of study characteristics for cross-sectional studies *(continued)*

Study	Year	Sample size, n	Premenopausal women Mean age, y	Standard deviation	Postmenopausal women Mean age, y	Standard deviation	Body mass index	Body-weight	Waist circumference	Waist-to-hip ratio	Total body fat percentage	Hip circumference	Subcutaneous abdominal fat	Visceral fat	Suprailiac skinfold thickness	Trunk fat percentage	Abdominal skinfold thickness	Leg fat percentage
Phillips et al[146]	2008	78	32.9	9.14	61.4	10.73	*	*	*	*	—	—	—	—	—	—	—	—
Polesel et al[147]	2015	311	34.83	8.4	52.63	5.72	*	—	*	—	—	—	—	—	—	—	—	—
Pollan et al[148]	2012	3,574	49	2.9	58	4.5	*	*	*	*	—	*	—	—	—	—	—	—
Portaluppi et al[149]	1997	1,376	48	3.1	53.3	4.2	*	—	—	—	—	—	—	—	—	—	—	—
Priya et al[150]	2013	65	38.65	6.21	55.32	6.32	*	*	*	*	—	*	—	—	—	—	—	—
Rantalainen et al[151]	2010	303	23	4.7	57.7	4.2	*	*	—	—	—	—	—	—	—	—	—	—
Reina et al[152]	2015	192	33	11	58.9	8.9	—	*	—	—	—	—	—	—	—	—	—	—
Revilla et al[153]	1997	151	37.4	7.2	59.9	9.7	*	*	—	—	—	—	—	—	—	—	—	—
Revilla et al[154]	1997	144	36.1	6.9	60.6	10.5	*	*	—	—	—	—	—	—	—	—	—	—
Rice et al[155]	2015	1,607	43.3	4.1	53.4	5.3	*	—	—	—	—	—	—	—	—	—	—	—
Rico et al[156]	2001	270	35.1	7.7	59.5	9.8	*	*	—	—	—	—	—	—	—	—	—	—
Rico et al[157]	2002	297	34	7	59	9	*	*	—	—	—	—	—	—	—	—	—	—
Roelfsema et al[158]	2016	91	35.83	6.84	59.08	6.81	*	—	—	—	—	—	—	—	—	—	—	—
Rosenbaum et al[159]	1996	41	27	8.94	66	9.17	*	*	—	—	*	—	—	—	—	—	—	—
Salomaa et al[160]	1995	778	47.4	2.4	57.9	4.9	*	—	—	—	—	—	—	—	—	—	—	—
Sarrafzadegan et al[161]	2013	4,143	32.15	9.22	59.8	10.39	*	*	*	*	—	—	—	—	—	—	—	—
Schaberg-Lorei et al[162]	1990	109	42.3	4.8	58.4	5.1	—	*	*	—	*	—	—	—	*	—	*	—
Schwarz et al[163]	2007	1,119	45.6	4.2	64.6	8	*	—	—	—	—	—	—	—	—	—	—	—
Shakir et al[164]	2004	4,092	53.2	1.6	56.9	2.9	—	—	—	*	—	—	—	—	—	—	—	—
Sherk et al[165]	2011	73	22.8	2.74	64	3.93	—	*	—	—	*	—	—	—	—	—	—	—
Shibata et al[166]	1979	448	46.9	1.4	47.4	1.4	*	—	—	—	—	—	—	—	—	—	—	—
Sieminska et al[167]	2006	131	28.2	4.1	53.9	3.2	*	—	—	*	—	—	—	—	—	—	—	—
Skrzypczak and Szwed[168]	2005	1,647	43.66	4.07	56.01	7.08	*	—	—	—	—	—	—	—	—	—	—	—
Skrzypczak et al[169]	2007	10,216	43.43	4.93	62.87	8.53	*	—	—	—	—	—	—	—	—	—	—	—
Soderberg et al[170]	2002	75	37.9	7.9	60.7	6.1	*	—	*	*	—	*	—	—	*	—	—	—
Son et al[171]	2015	1,470	46.8	2.5	52.2	3.1	*	—	*	—	—	—	—	—	—	—	—	—

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019. *(continued)*

SUPPLEMENTARY TABLE 2

Table of study characteristics for cross-sectional studies *(continued)*

			Premenopausal women		Postmenopausal women													
Study	Year	Sample size, n	Mean age, y	Standard deviation	Mean age, y	Standard deviation	Body mass index	Body-weight	Waist circumference	Waist-to-hip ratio	Total body fat percentage	Hip circumference	Subcutaneous abdominal fat	Visceral fat	Suprailiac skinfold thickness	Trunk fat percentage	Abdominal skinfold thickness	Leg fat percentage
Soriguer et al[172]	2009	409	36.9	7.5	64.1	5.2	*	—	*	*	—	—	—	—	*	—	—	—
Staessen et al[173]	1989	462	42.6	5.1	53	5	*	*	—	—	*	—	—	—	—	—	—	—
Suarez-Ortegon et al[174]	2012	123	42.2	5.6	51.8	6.8	*	—	*	—	*	—	—	—	—	—	—	—
Suliga et al[175]	2016	3,636	49.7	3.1	55.2	3	*	—	*	—	*	—	—	—	—	—	—	—
Sumner et al[176]	1998	65	32.6	3.7	57.8	5.9	*	*	—	—	*	—	—	—	—	—	—	—
Tanaka et al[177]	2015	464	41.4	6.5	62.8	6.8	*	*	—	—	*	—	—	—	—	*	—	—
Thomas et al[178]	2000	302	35	8.6	69.8	13.1	*	*	—	—	—	—	—	—	—	—	—	—
Torng et al[179]	2000	1,543	42.7	5.8	61.2	9.5	*	*	—	—	—	—	—	—	—	—	—	—
Toth et al[180]	2000	81	47	3	51	4	*	*	—	—	*	—	*	*	—	—	—	—
Tremollieres et al[181]	1996	168	49.3	3.2	53.8	3.1	*	*	—	—	—	—	—	—	—	—	—	—
Trikudanathan et al[182]	2013	170	49.3	3	49.4	3	*	—	*	—	—	—	*	*	—	—	—	—
Van-Pelt et al[183]	1998	31	29	4.12	61	4.36	*	*	*	—	*	—	—	—	*	—	*	—
	1998	58	30	5.48	56	5.57	*	*	*	—	*	—	—	—	*	—	*	—
Veldhuis et al[184]	2016	120	34	9.3	64	8.52	*	—	—	—	—	—	*	*	—	—	—	—
Wang et al[185]	2012	1,526	44.2	6.6	56.3	4.6	—	—	—	—	*	—	—	—	—	—	—	—
Wang et al[186]	2006	346	33.36	9.2	66.75	10.75	*	—	—	—	—	—	—	—	—	—	—	—
Wang et al[187]	2012	1,143	49.13	2.72	64.72	7.61	*	—	*	*	—	*	—	—	—	—	—	—
Wee et al[188]	2013	283	45.81	1.12	56.8	1.84	*	—	—	—	—	—	—	—	—	—	—	—
Williams et al[189]	1997	115	32.7	10.9	63.9	11.6	*	—	—	—	—	—	—	—	—	—	—	—
Wing et al[190]	1991	340	NA		NA		*	*	—	—	—	—	—	—	*	—	—	—
Xu et al[191]	2010	252	44.7	4.1	70.7	6.3	*	*	—	—	—	—	—	—	—	—	—	—
Yamatani et al[192]	2013	40	42.6	7.35	60.6	7.5	*	*	—	—	—	—	*	*	—	—	—	—
Yannakoulia et al[193]	2007	114	38.6	7.7	57.5	6.2	*	*	*	*	*	—	—	—	—	—	—	—
Yoldemir and Erenus[194]	2012	190	45.27	2.93	57.02	6.15	*	*	—	*	—	—	—	—	—	—	—	—
Yoo et al[195]	2012	358	34.2	9.7	61.1	7.7	*	*	*	*	*	—	*	*	—	—	—	—

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 2

Table of study characteristics for cross-sectional studies *(continued)*

Study	Year	Sample size, n	Premenopausal women Mean age, y	Standard deviation	Postmenopausal women Mean age, y	Standard deviation	Body mass index	Body-weight	Waist circumference	Waist-to-hip ratio	Total body fat percentage	Hip circumference	Subcutaneous abdominal fat	Visceral fat	Suprailiac skinfold thickness	Trunk fat percentage	Abdominal skinfold thickness	Leg fat percentage
Yoo et al[196]	1998	306	NA		NA		*	*	—	—	—	—	—	—	—	—	—	—
Yoshimoto et al[197]	2011	278	41.8	6.2	62.1	8.2	*	*	—	—	—	—	—	—	—	—	—	—
Zhong et al[198]	2005	676	NA		NA		*	*	—	—	—	—	—	—	—	—	—	—
Zhou et al[199]	2010	729	42.2	3.8	53.8	2.8	*	—	—	—	—	—	—	—	—	—	—	—
Zhou et al[200]	2015	6,324	44.1	4.8	60	7.8	*	*	*	*	—	—	—	—	—	—	—	—
Zivkovic et al[201]	2011	271	37	5.3	54	4.5	*	—	*	—	—	—	—	—	—	—	—	—

NA, not available. The *asterisk* indicates inclusion of the measure.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY TABLE 3

Table of study characteristics for longitudinal studies

Study	Year	Sample Size	Mean age, y (standard deviation)		Body mass index	Bodyweight	Waist circumference	Total body fat percentage	Subcutaneous abdominal fat	Visceral fat
			Premenopausal	Postmenopausal						
Abdulnour et al[2]	2012	13	50.65 (2.26)	52.76 (2.16)	—	—	—	—	*	*
Akahoshi et al[202]	2001	48	39.40 (1.60)	45.30 (1.50)	*	—	—	—	—	—
	2001	388	44.20 (1.60)	50.10 (1.50)	*	—	—	—	—	—
	2001	565	48.30 (1.70)	54.20 (1.70)	*	—	—	—	—	—
Ford et al[203]	2005	74	40.07 (4.43)	45.77 (4.62)	*	—	—	—	—	—
Franklin et al[204]	2009	8	49.30 (1.70)	57.00 (2.26)	*	*	*	*	—	—
Janssen et al[205]	2008	859	46.81 (2.52)	52.29 (2.86)	*	—	*	—	—	—
Lee et al[206]	2009	69	50.60 (2.60)	54.70 (2.60)	*	*	—	*	*	*
Liu-Ambrose et al[207]	2006	53	40.50 (4.70)	53.20 (4.70)	—	*	—	—	—	—
Lovejoy et al[118]	2008	51	48.10 (0.30)	52.10 (0.30)	—	*	—	*	*	*
Macdonald et al[208]	2005	248	47.72 (1.40)	54.13 (1.52)	*	*	—	—	—	—
Razmjou et al[209]	2018	48	49.77 (1.80)	59.97 (1.78)	*	*	*	*	—	—
Soreca et al[210]	2009	48	47.98 (1.32)	67.98 (1.32)	*	*	—	—	—	—

The *asterisk* indicates inclusion of the measure.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY TABLE 4

Quality assessment of individual cross-sectional studies

Study	Year	Newcastle-Ottawa quality assessment scale (adapted)									
		Selection			Comparability				Outcome		Total score (out of 9)
		Question 1	Question 2	Question 3	Question 4a	Question 4b	Question 5	Question 6	Question 7	Question 8	
Abate et al[1]	2014	—	*	—	*	*	*	*	*	*	7
Abdulnour et al[2]	2012	*	*	—	*	*	*	*	*	*	8
Abildgaard et al[3]	2013	*	*	—	*	*	*	*	*	*	8
Adams-Campbell et al[4]	1996	*	*	*	*	—	—	—	—	*	5
Agrinier et al[5]	2010	*	*	*	*	—	*	*	*	*	8
Aguado et al[6]	1996	—	*	—	*	—	—	—	*	*	4
Albanese et al[7]	2009	*	*	—	*	*	*	*	*	*	8
Allali et al[8]	2009	*	*	—	*	—	—	—	—	—	3
Aloia et al[9]	1995	*	*	—	*	—	—	—	—	—	3
Amankwah et al[10]	2013	*	*	*	*	—	*	*	*	*	8
Amarante et al[11]	2011	—	—	—	*	*	—	*	—	*	4
Amiri et al[12]	2014	*	*	*	*	—	—	*	*	*	7
Angsuwanthana et al[13]	2007	*	*	*	*	*	*	*	*	*	9
Armellini et al[14]	1996	*	*	—	—	—	—	—	*	*	4
Arthur et al[15]	2013	*	*	—	*	—	*	*	*	*	7
Aydin et al[16]	2010	*	*	*	*	*	*	*	*	*	9
Ayub et al[17]	2006	—	—	—	*	*	—	—	*	*	4
Bancroft et al[18]	1996	*	*	*	*	*	*	*	*	*	9
Bednarek-Tupikowska et al[19]	2006	—	—	—	*	*	—	—	*	*	4
Bell et al[20]	2007	*	*	—	*	—	*	*	*	*	7
Ben-Ali et al[21]	2016	*	*	—	*	—	—	*	*	*	6
Ben-Ali et al[22]	2014	*	*	—	*	—	—	*	*	*	6
Ben-Ali et al[23]	2011	*	*	—	*	—	*	*	*	*	7
Berg et al[24]	2004	—	—	—	*	—	*	*	*	*	5
Berge et al[25]	1994	*	*	*	*	—	*	*	—	—	6
Berger et al[26]	1995	—	*	—	*	*	*	*	*	*	7
Berstad et al[27]	2010	*	*	*	*	—	*	*	—	*	7

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 4

Quality assessment of individual cross-sectional studies *(continued)*

Study	Year	Newcastle-Ottawa quality assessment scale (adapted)									Total score (out of 9)
		Selection			Comparability				Outcome		
		Question 1	Question 2	Question 3	Question 4a	Question 4b	Question 5	Question 6	Question 7	Question 8	
Bhagat et al[28]	2010	*	*	—	*	—	*	*	*	*	7
Bhurosy et al[29]	2013	*	*	—	*	—	*	*	*	*	7
Blumenthal et al[30]	1991	*	*	*	*	*	*	*	—	—	7
Bonithon-Kopp et al[31]	1990	*	*	—	*	*	*	*	—	—	6
Caire-Juvera et al[32]	2008	*	*	—	*	—	*	*	*	*	7
Campesi et al[33]	2016	—	—	—	*	—	*	*	—	—	3
Carr et al[34]	2000	*	*	—	*	—	*	*	—	—	5
Castracane et al[35]	1998	—	—	—	*	—	*	—	—	—	2
Catsburg et al[36]	2014	*	*	—	*	—	—	—	—	*	4
Cecchini et al[37]	2012	*	*	—	—	—	*	*	*	*	6
Cervellati et al[38]	2009	—	—	—	*	—	*	*	*	*	5
Chain et al[39]	2017	*	*	—	*	*	—	*	*	*	7
Chang et al[40]	2000	*	*	—	*	—	*	*	*	*	7
Cho et al[41]	2008	*	*	—	*	—	—	*	*	*	6
Cifkova et al[42]	2008	*	*	—	*	*	*	*	*	*	8
Copeland et al[43]	2006	*	*	—	*	—	*	*	*	*	7
Cremonini et al[44]	2013	*	*	—	*	—	*	*	*	*	7
Cui et al[45]	2007	*	*	—	*	—	*	*	*	*	7
D'haeseleer et al[46]	2011	—	—	*	*	*	*	*	—	*	6
Da Camara et al[47]	2015	*	*	*	*	*	*	*	*	*	9
Dallongeville et al[48]	1995	*	*	—	*	*	—	*	*	*	7
Dancey et al[49]	2001	*	*	—	*	—	*	*	—	—	5
Davis et al[50]	1994	*	*	—	*	*	*	*	—	—	6
De Kat et al[51]	2017	*	*	—	*	—	*	*	*	*	7
Den Tonkelaar et al[52]	1990	*	*	—	*	—	—	*	*	*	6
Dmitruk et al[53]	2018	*	*	—	*	—	*	*	*	*	7
Donato et al[54]	2006	*	*	*	*	*	*	*	*	*	9

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 4

Quality assessment of individual cross-sectional studies *(continued)*

		Newcastle-Ottawa quality assessment scale (adapted)									
		Selection			Comparability				Outcome		Total score
Study	Year	Question 1	Question 2	Question 3	Question 4a	Question 4b	Question 5	Question 6	Question 7	Question 8	(out of 9)
Douchi et al[55]	1997	*	*	—	*	—	*	—	*	*	6
Douchi et al[56]	2002	*	*	—	*	—	*	*	*	*	7
Douchi et al[57]	2007	*	*	—	*	—	—	*	*	*	6
Dubois et al[58]	2001	—	*	—	*	—	*	*	—	—	4
Engmann et al[59]	2017	*	*	—	*	—	*	*	—	*	6
Ertungealp et al[60]	1999	*	—	—	—	—	—	—	—	—	1
Feng et al[61]	2008	*	*	*	*	—	*	*	*	*	8
Formica et al[62]	1995	*	*	—	*	—	—	—	—	—	3
Friedenreich et al[63]	2007	*	*	—	*	—	*	*	*	*	7
Friedenreich et al[64]	2002	*	*	*	*	—	*	*	*	*	8
Fu et al[65]	2011	*	*	—	*	—	*	*	*	*	7
Fuh et al[66]	2003	*	*	—	*	*	*	*	*	*	8
Gambacciani et al[67]	1999	*	*	—	*	—	*	*	*	*	7
Genazzani et al[68]	2006	*	*	—	*	—	*	*	*	*	7
Ghosh et al[69]	2008	*	*	—	*	—	*	*	*	*	7
Ghosh et al[70]	2010	*	*	—	*	—	*	*	*	*	7
Gram et al[71]	1997	*	*	—	*	*	—	*	*	*	7
Guo et al[72]	2015	*	*	—	*	—	*	*	*	*	7
Gurka et al[73]	2016	*	*	*	*	*	*	*	—	—	7
Hadji et al[74]	2000	*	*	—	*	—	*	*	*	*	7
Hagner et al[75]	2009	*	*	—	*	—	*	*	*	*	7
Han et al[76]	2006	*	*	—	*	—	—	*	*	*	6
Harting et al[77]	1984	*	*	—	*	—	*	—	—	—	4
He et al[78]	2012	*	*	—	*	*	*	*	*	*	8
Hirose et al[79]	2003	*	*	—	*	—	—	—	—	*	4
Hjartaker et al[80]	2005	*	*	—	*	*	*	*	—	*	7
Ho et al[81]	2010	*	*	*	—	—	*	*	*	*	7

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 4

Quality assessment of individual cross-sectional studies *(continued)*

		Newcastle-Ottawa quality assessment scale (adapted)									
		Selection			Comparability				Outcome		Total score (out of 9)
Study	Year	Question 1	Question 2	Question 3	Question 4a	Question 4b	Question 5	Question 6	Question 7	Question 8	
Hsu et al[82]	2006	*	*	—	*	—	—	—	*	*	5
Hu et al[83]	2016	*	*	—	—	—	—	—	*	*	4
Hunter et al[84]	1996	*	*	—	*	—	—	*	*	*	6
Iida et al[85]	2011	*	*	—	*	—	—	—	*	*	5
Ilich-Ernst et al[86]	2002	—	—	—	*	—	—	—	*	*	3
Ito et al[87]	1994	—	—	—	*	—	*	*	—	—	3
Jaff et al[88]	2015	*	*	—	*	*	*	*	*	*	8
Jasienska et al[89]	2005	*	*	—	*	*	—	—	*	*	6
Jeenduang et al[90]	2014	*	*	—	*	—	—	*	*	*	6
Jeon et al[91]	2011	*	*	—	*	*	*	*	*	*	8
Jurimae et al[92]	2007	—	—	—	*	—	*	*	*	*	5
Kadam et al[93]	2010	*	*	—	*	*	*	*	*	*	8
Kang et al[94]	2016	*	*	—	*	—	—	—	*	*	5
Kaufer-Horwitz et al[95]	2005	*	*	—	*	—	*	*	*	*	7
Kim et al[96]	2007	*	*	—	*	—	—	*	*	*	6
Kim et al[97]	2012	*	*	—	*	—	—	—	*	*	5
Kim et al[98]	2013	*	*	*	*	—	—	*	*	*	7
Kim et al[99]	2016	*	*	—	*	—	—	—	*	*	5
Kirchengast et al[100]	1996	*	*	*	*	—	*	*	*	*	8
Kirchengast et al[101]	1998	*	*	*	*	—	*	*	*	*	8
Knapp et al[102]	2001	*	—	—	*	—	—	—	—	—	2
Koh et al[103]	2008	*	*	—	*	—	*	*	*	*	7
Konrad et al[104]	2011	*	*	—	*	*	—	*	*	*	7
Kontogianni et al[105]	2004	*	*	*	*	*	—	*	*	*	8
Konukoglu et al[106]	2000	—	—	*	*	—	—	*	—	—	3
Koskova et al[107]	2007	*	*	*	*	—	*	*	*	*	8
Kotani et al[108]	2011	—	—	—	*	—	—	*	*	*	4

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019. *(continued)*

SUPPLEMENTARY TABLE 4

Quality assessment of individual cross-sectional studies *(continued)*

		Newcastle-Ottawa quality assessment scale (adapted)									
		Selection			Comparability				Outcome		Total score
Study	Year	Question 1	Question 2	Question 3	Question 4a	Question 4b	Question 5	Question 6	Question 7	Question 8	(out of 9)
Kraemer et al[109]	2001	*	*	—	*	—	—	—	—	—	3
Kuk et al[110]	2005	*	*	—	*	—	—	—	*	*	5
Laitinen et al[111]	1991	*	*	—	*	—	—	—	—	—	3
Lejskova et al[112]	2012	*	*	—	*	*	*	*	*	*	8
Leon-Guerrero et al[113]	2017	*	*	—	*	—	*	*	*	*	7
Ley et al[114]	1992	*	*	—	*	—	*	*	*	*	7
Lin et al[115]	2006	*	*	—	*	*	—	*	*	*	7
Lindquist et al[116]	1980	*	*	*	*	*	*	*	*	*	9
Lindsay et al[117]	1992	*	*	—	*	—	—	—	*	*	5
Lovejoy et al[118]	2008	*	*	*	*	*	—	*	*	*	8
Lyu et al[119]	2001	*	*	—	*	*	—	*	*	*	7
Maharlouei et al[120]	2013	*	*	—	*	—	*	*	*	*	7
Malacara et al[121]	2002	*	*	*	*	*	*	*	—	*	8
Manabe et al[122]	1999	—	*	—	*	—	—	—	*	*	4
Manjer et al[123]	2001	*	*	—	*	—	*	*	*	*	7
Mannisto et al[124]	1996	*	*	*	*	—	—	—	*	*	6
Martini et al[125]	1997	*	*	—	*	—	—	*	*	*	6
Marwaha et al[126]	2013	*	*	—	*	—	*	*	*	*	7
Matsushita et al[127]	2003	*	*	—	*	—	*	—	*	*	6
Matsuzaki et al[128]	2017	*	*	—	*	—	—	—	*	*	5
Matthews et al[129]	1989	*	*	*	*	*	*	*	—	—	7
Mesch et al[130]	2006	—	—	—	*	—	*	*	*	*	5
Meza-Munoz et al[131]	2006	*	*	—	*	—	*	*	*	*	7
Minatoya et al[132]	2014	*	*	—	—	—	—	—	—	—	2
Mo et al[133]	2017	*	*	—	*	—	—	—	*	*	5
Muchanga et al[134]	2014	*	*	*	*	*	*	*	*	*	9
Muti et al[135]	2000	*	*	—	*	—	—	*	*	*	6

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 4

Quality assessment of individual cross-sectional studies *(continued)*

Study	Year	Newcastle-Ottawa quality assessment scale (adapted)									
		Selection			Comparability				Outcome		Total score (out of 9)
		Question 1	Question 2	Question 3	Question 4a	Question 4b	Question 5	Question 6	Question 7	Question 8	
Nitta et al[136]	2016	*	*	—	*	—	—	—	—	—	3
Noh et al[137]	2013	*	*	*	*	—	*	*	*	*	8
Nordin et al[138]	1992	—	—	—	*	—	—	—	—	—	1
Ohta et al[139]	2010	*	*	*	*	—	—	—	*	*	6
Oldroyd et al[140]	1998	—	—	—	*	—	—	—	—	—	1
Pacholczak et al[141]	2016	*	*	—	*	—	—	*	*	*	6
Park et al[142]	2012	*	*	—	*	—	—	—	*	*	5
Park et al[143]	2017	*	*	—	*	—	*	*	—	*	6
Pavicic et al[144]	2010	*	*	—	*	—	*	*	*	*	7
Pavlica et al[145]	2013	*	*	—	*	—	—	—	*	*	5
Phillips et al[146]	2008	*	*	—	*	—	—	*	*	*	6
Polesel et al[147]	2015	*	*	*	*	—	*	*	*	*	8
Pollan et al[148]	2012	*	*	—	*	*	*	*	*	*	8
Portaluppi et al[149]	1997	—	*	*	*	*	*	*	*	*	8
Priya et al[150]	2013	*	*	—	*	—	—	*	*	*	6
Rantalainen et al[151]	2010	—	—	—	*	—	*	—	*	*	4
Reina et al[152]	2015	—	*	—	*	—	—	—	—	—	2
Revilla et al[153]	1997	*	—	—	*	—	*	*	*	*	6
Revilla et al[154]	1997	*	*	—	*	—	*	*	*	*	7
Rice et al[155]	2015	*	*	—	*	—	*	*	—	*	6
Rico et al[156]	2001	*	—	*	*	—	*	*	*	*	7
Rico et al[157]	2002	*	—	*	*	—	*	*	*	*	7
Roelfsema et al[158]	2016	*	—	—	*	—	*	*	*	*	6
Rosenbaum et al[159]	1996	—	—	—	*	—	*	*	*	*	5
Salomaa et al[160]	1995	*	*	—	*	—	*	*	*	*	7
Sarrafzadegan et al[161]	2013	*	*	—	*	—	—	—	*	*	5
Schaberg-Lorei et al[162]	1990	—	—	—	*	—	—	—	*	*	3

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 4
Quality assessment of individual cross-sectional studies *(continued)*

Study	Year	Newcastle-Ottawa quality assessment scale (adapted)									
		Selection			Comparability				Outcome		Total score (out of 9)
		Question 1	Question 2	Question 3	Question 4a	Question 4b	Question 5	Question 6	Question 7	Question 8	
Schwarz et al[163]	2007	*	*	—	*	—	*	*	*	*	7
Shakir et al[164]	2004	*	*	*	*	*	*	*	*	*	9
Sherk et al[165]	2011	—	—	—	*	—	—	—	*	*	3
Shibata et al[166]	1979	—	*	—	*	*	—	—	—	—	3
Sieminska et al[167]	2006	—	—	—	*	—	*	*	—	—	3
Skrzypczak et al[168]	2005	*	*	—	*	—	*	*	*	*	7
Skrzypczak et al[169]	2007	*	*	—	*	—	*	*	*	*	7
Soderberg et al[170]	2002	*	*	—	*	—	*	*	*	*	7
Son et al[171]	2015	*	*	—	*	*	*	*	*	*	8
Soriguer et al[172]	2009	*	*	—	*	—	—	*	*	*	6
Staessen et al[173]	1989	—	—	—	*	—	—	*	*	*	4
Suarez-Ortegon et al[174]	2012	—	—	—	*	*	—	—	*	*	4
Suliga et al[175]	2016	*	*	—	*	*	—	*	*	*	7
Sumner et al[176]	1998	—	—	—	*	—	—	*	*	*	4
Tanaka et al[177]	2015	—	—	—	*	—	*	*	*	*	5
Thomas et al[178]	2000	*	*	—	*	—	—	*	*	*	6
Torng et al[179]	2000	*	*	—	*	—	—	*	*	*	6
Toth et al[180]	2000	—	*	*	*	*	*	*	*	*	8
Tremollieres et al[181]	1996	*	*	*	*	*	—	*	*	*	8
Trikudanathan et al[182]	2013	*	*	*	*	*	—	*	*	*	8
Van-Pelt et al[183]	1998	—	—	*	*	—	*	*	*	*	6
Veldhuis et al[184]	2016	*	*	*	*	—	—	*	*	*	7
Wang et al[185]	2012	*	*	—	*	—	—	—	*	*	5
Wang et al[186]	2006	*	*	—	*	—	—	*	*	*	6
Wang et al[187]	2012	*	*	—	*	—	*	*	—	*	6
Wee et al[188]	2013	—	*	—	*	—	*	*	*	*	6
Williams et al[189]	1997	*	*	—	*	—	*	*	*	*	7

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

(continued)

SUPPLEMENTARY TABLE 4

Quality assessment of individual cross-sectional studies *(continued)*

		Newcastle-Ottawa quality assessment scale (adapted)									
		Selection			Comparability				Outcome		Total score (out of 9)
Study	Year	Question 1	Question 2	Question 3	Question 4a	Question 4b	Question 5	Question 6	Question 7	Question 8	
Wing et al[190]	1991	*	*	—	—	—	*	*	*	*	6
Xu et al[191]	2010	*	*	*	*	—	*	*	*	*	8
Yamatani et al[192]	2013	*	*	*	*	—	—	*	*	*	7
Yannakoulia et al[193]	2007	*	*	*	*	—	*	*	*	*	8
Yoldemir et al[194]	2012	*	*	*	*	—	*	*	*	*	8
Yoo et al[195]	2012	*	*	*	*	—	—	*	*	*	7
Yoo et al[196]	1998	*	*	*	—	—	*	*	*	*	7
Yoshimoto et al[197]	2011	*	*	—	*	—	—	—	—	—	3
Zhong et al[198]	2005	*	*	—	—	—	—	—	*	*	4
Zhou et al[199]	2010	*	*	*	*	—	*	*	*	*	8
Zhou et al[200]	2015	*	*	—	*	—	—	*	*	*	6
Zivkovic et al[201]	2011	*	*	—	*	—	—	*	*	*	6

The *asterisk* indicates inclusion of the measure.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY TABLE 5

Quality assessment of individual longitudinal studies

		Newcastle-Ottawa quality assessment scale (adapted)									
		Selection			Comparability				Outcome		
Study	Year	Question 1	Question 2	Question 3	Question 4a	Question 4b	Question 5	Question 6	Question 7	Question 8	Total score (of 9)
Abdulnour et al[2]	2012	*	*	—	*	*	*	*	*	*	8
Akahoshi et al[202]	2001	*	*	*	*	*	*	*	*	*	9
Ford et al[203]	2005	*	—	*	*	*	*	*	*	*	8
Franklin et al[204]	2009	—	—	—	*	*	—	*	*	—	4
Janssen et al[205]	2008	*	*	—	*	*	*	*	*	*	8
Lee et al[206]	2009	*	*	—	*	*	*	*	*	*	8
Liu-Ambrose et al[207]	2006	*	*	—	*	*	*	*	*	*	8
Lovejoy et al[118]	2008	*	*	*	*	*	—	*	*	*	8
Macdonald et al[208]	2005	*	*	—	*	*	*	*	*	*	8
Razmjou et al[209]	2018	*	*	—	*	*	*	*	*	*	8
Soreca et al[210]	2009	*	*	—	*	*	*	—	*	*	7

The *asterisk* indicates the study met the criterion for the question.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY TABLE 6

Output for cross-sectional studies

Data element name	Studies, n (samples)	Total sample size, n		Mean age, y (standard deviation)[a]		Mean fat mass, ●●●● (standard deviation)[a]		Estimate, ●●●● (95% confidence interval)			
		Premenopausal	Postmenopausal	Premenopausal	Postmenopausal	Premenopausal	Postmenopausal	Unstandardized	*P* value	Standardized	*P* value
Body mass index	171 (181)	453,036	523,796	41.96 (3.69)	59.42 (3.06)	24.75 (1.60)	26.64 (1.25)	1.14 (0.95—1.32)[b]	<.0001	0.28 (0.23—0.33)[b]	<.0001
Bodyweight	109 (122)	113,603	204,845	43.36 (4.71)	59.55 (3.27)	64.82 (7.91)	66.12 (9.17)	1.00 (0.44—1.57)[b]	.0005	0.08 (0.03—0.14)[b]	.0040
Waist circumference	70 (72)	214,712	326,639	42.28 (3.65)	59.07 (1.91)	78.58 (4.24)	83.61 (3.19)	4.63 (3.90—5.35)[b]	<.0001	0.45 (0.37—0.52)[b]	<.0001
Waist-to-hip ratio	47 (50)	199,140	309,797	42.39 (3.44)	59.09 (1.42)	0.78 (0.03)	0.81 (0.03)	0.04 (0.03—0.05)[b]	<.0001	0.65 (0.52—0.77)[b]	<.0001
Total body fat percentage	46 (52)	58,605	113,226	43.81 (4.67)	59.55 (3.81)	32.44 (3.47)	35.69 (3.84)	2.88 (2.13—3.63)[b]	<.0001	0.90 (0.09—1.71)[b]	.0292
Hip circumference	25 (25)	185,885	297,189	42.48 (3.08)	59.15 (0.95)	100.30 (2.66)	102.73 (2.25)	2.01 (1.36—2.65)[b]	<.0001	0.20 (0.13—0.27)[b]	<.0001
Subcutaneous abdominal fat	10 (10)	696	833	41.01 (6.96)	57.48 (5.36)	194.05 (23.65)	221.21 (32.09)	28.73 (8.56—48.91)[b]	.0053	0.85 (—0.50—2.21)	.2176
Visceral fat	10 (10)	696	833	41.01 (6.96)	57.48 (5.36)	69.22 (15.75)	104.36 (13.92)	26.90 (13.12—40.68)[b]	.0001	0.59 (0.20—0.98)[b]	.0028
Suprailiac skinfold thickness	9 (10)	1,103	745	39.76 (4.41)	61.89 (4.77)	22.16 (7.04)	24.55 (9.90)	2.65 (0.45—4.85)[b]	.0181	0.28 (0.05—0.50)[b]	.0149
Trunk fat percentage	7 (7)	39,335	95,756	45.28 (6.61)	59.68 (3.41)	31.27 (4.78)	33.74 (5.36)	5.49 (3.91—7.06)[b]	<.0001	0.68 (0.52—0.83)[b]	<.0001
Abdominal skinfold thickness	4 (5)	199	359	40.64 (6.32)	62.99 (5.16)	26.65 (8.14)	29.43 (9.82)	6.46 (0.51—12.42)[b]	.0335	0.61 (0.05—1.18)[b]	.0338
Total leg fat percentage	3 (3)	991	524	36.96 (1.13)	55.18 (5.17)	36.33 (5.47)	36.00 (2.62)	—3.19 (—5.98 to —0.41)[b]	.0246	—0.51 (—0.95 to —0.07)[b]	.0227

[a] Computed as weighted means and weighted standard deviations, taking into account sample size; [b] Indicates significance at the $P<.05$ level.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY TABLE 7
Output for longitudinal studies

Data element name	Studies, n (samples)	Total sample size, n	Mean age, y (standard deviation)[a]		Mean fat mass, ●●●● (standard deviation)[a]		Estimate, ●●●● (95% confidence interval)			
			Premenopausal	Postmenopausal	Premenopausal	Postmenopausal	Unstandardized	*P* value	Standardized	*P* value
Body mass index	8 (10)	2355	46.67 (2.53)	52.80 (3.71)	24.30 (1.97)	25.03 (2.37)	0.93 (0.26—1.59)[b]	.0061	0.21 (0.07—0.35)[b]	.0036
Bodyweight	7 (7)	525	47.64 (3.06)	55.76 (5.08)	66.11 (3.89)	69.19 (3.71)	2.99 (1.36—4.63)[b]	.0003	0.39 (0.12—0.66)[b]	.0049
Total body fat percentage	4 (4)	176	49.59 (1.24)	55.49 (3.65)	36.29 (4.88)	37.84 (3.33)	2.18 (0.21—4.16)[b]	.0299	0.28 (0.13—0.42)[b]	.0001
Waist circumference	3 (3)	915	46.99 (2.04)	52.73 (5.17)	80.79 (3.62)	84.06 (2.61)	3.82 (0.87—6.77)[b]	.0111	0.38 (—0.07—0.84)	.1004
Subcutaneous abdominal fat	3 (3)	133	49.65 (1.61)	53.51 (1.64)	215.14 (66.15)	242.28 (77.34)	18.53 (—3.64—40.69)	.1014	0.52 (—0.31—1.35)	.2168
Visceral fat	3 (3)	133	49.65 (1.61)	53.51 (1.64)	78.63 (14.45)	92.23 (12.77)	12.95 (8.65—17.25)[b]	<.0001	0.49 (—0.03—1.01)	.0629

[a] Computed as weighted means and weighted standard deviations, taking into account sample size; [b] Indicates significance at the $P<.05$ level.

Ambikairajah. Fat mass changes during menopause. Am J Obstet Gynecol 2019.

SUPPLEMENTARY REFERENCES (TABLES 2–5)

1. Abate M, Schiavone C, Di Carlo L, Salini V. Prevalence of and risk factors for asymptomatic rotator cuff tears in postmenopausal women. Menopause 2014;21:275–80.

2. Abdulnour J, Doucet E, Brochu M, et al. The effect of the menopausal transition on body composition and cardiometabolic risk factors: a Montreal-Ottawa New Emerging Team group study. Menopause 2012;19:760–7.

3. Abildgaard J, Pedersen AT, Green CJ, et al. Menopause is associated with decreased whole body fat oxidation during exercise. Am J Physiol Endocrinol Metab 2013;304:E1227–36.

4. Adams-Campbell LL, Kim KS, Dunston G, Laing AE, Bonney G, Demenais F. The relationship of body mass index to reproductive factors in pre- and postmenopausal African-American women with and without breast cancer. Obes Res 1996;4:451–6.

5. Agrinier N, Cournot M, Dallongeville J, et al. Menopause and modifiable coronary heart disease risk factors: a population based study. Maturitas 2010;65:237–43.

6. Aguado F, Revilla M, Hernandez ER, Villa LF, Rico H. Behavior of bone mass measurements: dual energy x-ray absorptiometry total body bone mineral content, ultrasound bone velocity, and computed metacarpal radiogrammetry, with age, gonadal status, and weight in healthy women. Invest Radiol 1996;31:218–22.

7. Albanese CV, Cepollaro C, de Terlizzi F, Brandi ML, Passariello R. Performance of five phalangeal QUS parameters in the evaluation of gonadal-status, age and vertebral fracture risk compared with DXA. Ultrasound Med Biol 2009;35:537–44.

8. Allali F, El Mansouri L, Abourazzak F, et al. The effect of past use of oral contraceptive on bone mineral density, bone biochemical markers and muscle strength in healthy pre and post menopausal women. BMC Womens Health 2009;9:31.

9. Aloia JF, Vaswani A, Ma R, Flaster E. To what extent is bone mass determined by fat-free or fat mass? Am J Clin Nutr 1995;61:1110–4.

10. Amankwah EK, Friedenreich CM, Magliocco AM, et al. Anthropometric measures and the risk of endometrial cancer, overall and by tumor microsatellite status and histological subtype. Am J Epidemiol 2013;177:1378–87.

11. Amarante F, Vilodre LC, Maturana MA, Spritzer PM. Women with primary ovarian insufficiency have lower bone mineral density. Braz J Med Biol Res 2011;44:78–83.

12. Amiri P, Deihim T, Nakhoda K, Hasheminia M, Montazeri A, Azizi F. Metabolic syndrome and health-related quality of life in reproductive age and post-menopausal women: Tehran Lipid and Glucose Study. Arch Iran Med 2014;17:423–8.

13. Angsuwathana S, Leerasiri P, Rattanachaiyanont M, et al. Health check-up program for pre/postmenopausal women at Siriraj Menopause Clinic. J Med Assoc Thai 2007;90:1–8.

14. Armellini F, Zamboni M, Perdichizzi G, et al. Computed tomography visceral adipose tissue volume measurements of Italians: predictive equations. Eur J Clin Nutr 1996;50:290–4.

15. Arthur FK, Adu-Frimpong M, Osei-Yeboah J, Mensah FO, Owusu L. The prevalence of metabolic syndrome and its predominant components among pre-and post-menopausal Ghanaian women. BMC Res Notes 2013;6:446.

16. Aydin ZD. Determinants of age at natural menopause in the Isparta Menopause and Health Study: premenopausal body mass index gain rate and episodic weight loss. Menopause 2010;17:494–505.

17. Ayub N, Khan SR, Syed F. Leptin levels in pre and post menopausal Pakistani women. J Pak Med Assoc 2006;56:3–5.

18. Bancroft J, Cawood EH. Androgens and the menopause; a study of 40-60-year-old women. Clin Endocrinol 1996;45:577–87.

19. Bednarek-Tupikowska G, Filus A, Kuliczkowska-Plaksej J, Tupikowski K, Bohdanowicz-Pawlak A, Milewicz A. Serum leptin concentrations in pre- and postmenopausal women on sex hormone therapy. Gynecol Endocrinol 2006;22:207–12.

20. Bell RJ, Davison SL, Papalia MA, McKenzie DP, Davis SR. Endogenous androgen levels and cardiovascular risk profile in women across the adult life span. Menopause 2007;14:630–8.

21. Ben Ali S, Belfki-Benali H, Ahmed DB, et al. Postmenopausal hypertension, abdominal obesity, apolipoprotein and insulin resistance. Clin Exper Hypertens 2016;38:370–4.

22. Ben Ali S, Belfki-Benali H, Aounallah-Skhiri H, et al. Menopause and metabolic syndrome in tunisian women. BioMed Res Int 2014;2014:457131.

23. Ben Ali S, Jemaa R, Ftouhi B, et al. Relationship of plasma leptin and adiponectin concentrations with menopausal status in Tunisian women. Cytokine 2011;56:338–42.

24. Berg G, Mesch V, Boero L, et al. Lipid and lipoprotein profile in menopausal transition. Effects of hormones, age and fat distribution. Horm Metab Res 2004;36:215–20.

25. Berge LN, Bonaa KH, Nordoy A. Serum ferritin, sex hormones, and cardiovascular risk factors in healthy women. Arterioscler Thromb 1994;14:857–61.

26. Berger GM, Naidoo J, Gounden N, Gouws E. Marked hyperinsulinaemia in postmenopausal, healthy Indian (Asian) women. Diabet Med 1995;12:788–95.

27. Berstad P, Coates RJ, Bernstein L, et al. A case-control study of body mass index and breast cancer risk in white and African-American women. Cancer Epidemiol Biomarkers Prev 2010;19:1532–44.

28. Bhagat M, Mukherjee S, De P, et al. Clustering of cardiometabolic risk factors in Asian Indian women: Santiniketan women study. Menopause 2010;17:359–64.

29. Bhurosy T, Jeewon R. Food habits, socioeconomic status and body mass index among premenopausal and post-menopausal women in Mauritius. J Hum Nutr Diet 2013;26(suppl1):114–22.

30. Blumenthal JA, Fredrikson M, Matthews KA, et al. Stress reactivity and exercise training in premenopausal and postmenopausal women. Health Psychol 1991;10:384–91.

31. Bonithon-Kopp C, Scarabin PY, Darne B, Malmejac A, Guize L. Menopause-related changes in lipoproteins and some other cardiovascular risk factors. Int J Epidemiol 1990;19:42–8.

32. Caire-Juvera G, Arendell LA, Maskarinec G, Thomson CA, Chen Z. Associations between mammographic density and body composition in Hispanic and non-Hispanic white women by menopause status. Menopause 2008;15:319–25.

33. Campesi I, Occhioni S, Tonolo G, et al. Ageing/menopausal status in healthy women and ageing in healthy men differently affect cardiometabolic parameters. Int J Med Sci 2016;13:124–32.

34. Carr MC, Kim KH, Zambon A, et al. Changes in LDL density across the menopausal transition. J Investig Med 2000;48:245–50.

35. Castracane VD, Kraemer RR, Franken MA, Kraemer GR, Gimpel T. Serum leptin concentration in women: effect of age, obesity, and estrogen administration. Fertil Steril 1998;70:472–7.

36. Catsburg C, Kirsh VA, Soskolne CL, et al. Associations between anthropometric characteristics, physical activity, and breast cancer risk in a Canadian cohort. Breast Cancer Res Treat 2014;145:545–52.

37. Cecchini RS, Costantino JP, Cauley JA, et al. Body mass index and the risk for developing invasive breast cancer among high-risk women in NSABP P-1 and STAR breast cancer prevention trials. Cancer Prev Res 2012;5:583–92.

38. Cervellati C, Pansini FS, Bonaccorsi G, et al. Body mass index is a major determinant of abdominal fat accumulation in pre-, peri- and post-menopausal women. Gynecol Endocrinol 2009;25:413–7.

39. Chain A, Crivelli M, Faerstein E, Bezerra FF. Association between fat mass and bone mineral density among Brazilian women differs by menopausal status: The Pro-Saude Study. Nutrition 2017;33:14–9.

40. Chang CJ, Wu CH, Yao WJ, Yang YC, Wu JS, Lu FH. Relationships of age, menopause and central obesity on cardiovascular disease risk factors in Chinese women. Int J Obes Relat Metab Disord 2000;24:1699–704.

41. Cho GJ, Lee JH, Park HT, et al. Postmenopausal status according to years since menopause as an independent risk factor for the metabolic syndrome. Menopause 2008;15:524–9.

42. Cifkova R, Pitha J, Lejskova M, Lanska V, Zecova S. Blood pressure around the menopause: a population study. J Hyperten 2008;26:1976–82.

43. Copeland AL, Martin PD, Geiselman PJ, Rash CJ, Kendzor DE. Predictors of

pretreatment attrition from smoking cessation among pre- and postmenopausal, weight-concerned women. Eating Behav 2006;7:243–51.
44. Cremonini E, Bonaccorsi G, Bergamini CM, et al. Metabolic transitions at menopause: in post-menopausal women the increase in serum uric acid correlates with abdominal adiposity as assessed by DXA. Maturitas 2013;75:62–6.
45. Cui LH, Shin MH, Kweon SS, et al. Relative contribution of body composition to bone mineral density at different sites in men and women of South Korea. J Bone Miner Metab 2007;25:165–71.
46. D'Haeseleer E, Depypere H, Claeys S, Van Lierde KM. The relation between body mass index and speaking fundamental frequency in premenopausal and postmenopausal women. Menopause 2011;18:754–8.
47. Da Camara SM, Zunzunegui MV, Pirkle C, Moreira MA, Maciel AC. Menopausal status and physical performance in middle aged women: a cross-sectional community-based study in Northeast Brazil. PLoS One 2015;10:e0119480.
48. Dallongeville J, Marecaux N, Isorez D, Zylbergberg G, Fruchart JC, Amouyel P. Multiple coronary heart disease risk factors are associated with menopause and influenced by substitutive hormonal therapy in a cohort of French women. Atherosclerosis 1995;118:123–33.
49. Dancey DR, Hanly PJ, Soong C, Lee B, Hoffstein V. Impact of menopause on the prevalence and severity of sleep apnea. Chest 2001;120:151–5.
50. Davis CE, Pajak A, Rywik S, et al. Natural menopause and cardiovascular disease risk factors:the Poland and US Collaborative Study on Cardiovascular Disease Epidemiology. Ann Epidemiol 1994;4:445–8.
51. De Kat AC, Dam V, Onland-Moret NC, Eijkemans MJ, Broekmans FJ, van der Schouw YT. Unraveling the associations of age and menopause with cardiovascular risk factors in a large population-based study. BMC Med 2017;15:2.
52. Den Tonkelaar I, Seidell JC, van Noord PA, Baanders-van Halewijn EA, Ouwehand IJ. Fat distribution in relation to age, degree of obesity, smoking habits, parity and estrogen use: a cross-sectional study in 11,825 Dutch women participating in the DOM-project. Int J Obes 1990;14:753–61.
53. Dmitruk A, Czeczelewski J, Czeczelewska E, Golach J, Parnicka U. Body composition and fatty tissue distribution in women with various menstrual status. Rocz Panstw Zakl Hig 2018;69:95–101.
54. Donato GB, Fuchs SC, Oppermann K, Bastos C, Spritzer PM. Association between menopause status and central adiposity measured at different cutoffs of waist circumference and waist-to-hip ratio. Menopause 2006;13:280–5.
55. Douchi T, Oki T, Nakamura S, Ijuin H, Yamamoto S, Nagata Y. The effect of body composition on bone density in pre- and postmenopausal women. Maturitas 1997;27:55–60.
56. Douchi T, Yamamoto S, Yoshimitsu N, Andoh T, Matsuo T, Nagata Y. Relative contribution of aging and menopause to changes in lean and fat mass in segmental regions. Maturitas 2002;42:301–6.
57. Douchi T, Yonehara Y, Kawamura Y, Kuwahata A, Kuwahata T, Iwamoto I. Difference in segmental lean and fat mass components between pre- and postmenopausal women. Menopause 2007;14:875–8.
58. Dubois EF, van den Bergh JP, Smals AG, van de Meerendonk CW, Zwinderman AH, Schweitzer DH. Comparison of quantitative ultrasound parameters with dual energy X-ray absorptiometry in pre- and postmenopausal women. Neth J Med 2001;58:62–70.
59. Engmann NJ, Golmakani MK, Miglioretti DL, Sprague BL, Kerlikowske K. Population-attributable risk proportion of clinical risk factors for breast cancer. JAMA Oncol 2017;3:1228–36.
60. Ertungealp E, Seyisoglu H, Erel CT, Senturk LM, Gezer A. Changes in bone mineral density with age, menopausal status and body mass index in Turkish women. Climacteric 1999;2:45–51.
61. Feng Y, Hong X, Wilker E, et al. Effects of age at menarche, reproductive years, and menopause on metabolic risk factors for cardiovascular diseases. Atherosclerosis 2008;196:590–7.
62. Formica C, Loro ML, Gilsanz V, Seeman E. Inhomogeneity in body fat distribution may result in inaccuracy in the measurement of vertebral bone mass. J Bone Miner Res 1995;10:1504–11.
63. Friedenreich C, Cust A, Lahmann PH, et al. Anthropometric factors and risk of endometrial cancer: the European prospective investigation into cancer and nutrition. Cancer Causes Control 2007;18:399–413.
64. Friedenreich CM, Courneya KS, Bryant HE. Case-control study of anthropometric measures and breast cancer risk. Int J Cancer 2002;99:445–52.
65. Fu X, Ma X, Lu H, He W, Wang Z, Zhu S. Associations of fat mass and fat distribution with bone mineral density in pre- and postmenopausal Chinese women. Osteoporos Int 2011;22:113–9.
66. Fuh JL, Wang SJ, Lee SJ, Lu SR, Juang KD. Quality of life and menopausal transition for middle-aged women on Kinmen island. Quality Life Res 2003;12:53–61.
67. Gambacciani M, Ciaponi M, Cappagli B, Benussi C, De Simone L, Genazzani AR. Climacteric modifications in body weight and fat tissue distribution. Climacteric 1999;2:37–44.
68. Genazzani AR, Gambacciani M. Effect of climacteric transition and hormone replacement therapy on body weight and body fat distribution. Gynecol Endocrinol 2006;22:145–50.
69. Ghosh A. Comparison of risk variables associated with the metabolic syndrome in pre- and postmenopausal Bengalee women. Cardiovasc J S Afr 2008;19:183–7.
70. Ghosh A, Bhagat M. Anthropometric and body composition characteristics in pre- and postmenopausal Asian Indian women: Santiniketan women study. Anthropol Anz 2010;68:1–10.
71. Gram IT, Funkhouser E, Tabar L. Anthropometric indices in relation to mammographic patterns among peri-menopausal women. Int J Cancer 1997;73:323–6.
72. Guo W, Bradbury KE, Reeves GK, Key TJ. Physical activity in relation to body size and composition in women in UK Biobank. Ann Epidemiol 2015;25:406–13.e6.
73. Gurka MJ, Vishnu A, Santen RJ, DeBoer MD. Progression of metabolic syndrome severity during the menopausal transition. J Am Heart Assoc 2016;5.
74. Hadji P, Hars O, Bock K, et al. The influence of menopause and body mass index on serum leptin concentrations. Eur J Endocrinol 2000;143:55–60.
75. Hagner W, Hagner-Derengowska M, Wiacek M, Zubrzycki IZ. Changes in level of VO2max, blood lipids, and waist circumference in the response to moderate endurance training as a function of ovarian aging. Menopause 2009;16:1009–13.
76. Han D, Nie J, Bonner MR, et al. Lifetime adult weight gain, central adiposity, and the risk of pre- and postmenopausal breast cancer in the Western New York exposures and breast cancer study. Int J Cancer 2006;119:2931–7.
77. Harting GH, Moore CE, Mitchell R, Kappus CM. Relationship of menopausal status and exercise level to HDL-cholesterol in women. Exp Aging Res 1984;10:13–8.
78. He L, Tang X, Li N, et al. Menopause with cardiovascular disease and its risk factors among rural Chinese women in Beijing: a population-based study. Maturitas 2012;72:132–8.
79. Hirose K, Tajima K, Hamajima N, et al. Impact of established risk factors for breast cancer in nulligravid Japanese women. Breast Cancer 2003;10:45–53.
80. Hjartaker A, Adami HO, Lund E, Weiderpass E. Body mass index and mortality in a prospectively studied cohort of Scandinavian women: the women's lifestyle and health cohort study. Eur J Epidemiol 2005;20:747–54.
81. Ho S, Wu S, Chan S, Sham A. Menopausal transition and changes of body composition: a prospective study in Chinese perimenopausal women. Int J Obes 2010;34:1265.
82. Hsu YH, Venners SA, Terwedow HA, et al. Relation of body composition, fat mass, and serum lipids to osteoporotic fractures and bone mineral density in Chinese men and women. Am J Clin Nutr 2006;83:146–54.
83. Hu X, Pan X, Ma X, et al. Contribution of a first-degree family history of diabetes to increased serum adipocyte fatty acid binding protein levels independent of body fat content and distribution. Int J Obes 2016;40:1649–54.
84. Hunter G, Kekes-Szabo T, Treuth M, Williams M, Goran M, Pichon C. Intra-abdominal adipose tissue, physical activity and cardiovascular risk in pre-and post-menopausal women. Int J Obes Relat Metab Dis 1996;20:860–5.

85. Iida T, Domoto T, Takigawa A, et al. Relationships among blood leptin and adiponectin levels, fat mass, and bone mineral density in Japanese pre-and postmenopausal women. Hiroshima J Med Sci 2011;60:71–8.
86. Ilich-Ernst J, Brownbill RA, Ludemann MA, Fu R. Critical factors for bone health in women across the age span: how important is muscle mass? Medscape Womens Health 2002;7:2.
87. Ito M, Hayashi K, Uetani M, Yamada M, Ohki M, Nakamura T. Association between anthropometric measures and spinal bone mineral density. Investig Radiol 1994;29:812–6.
88. Jaff NG, Norris SA, Snyman T, Toman M, Crowther NJ. Body composition in the Study of Women Entering and in Endocrine Transition (SWEET): A perspective of African women who have a high prevalence of obesity and HIV infection. Metabolism 2015;64: 1031–41.
89. Jasienska G, Ziomkiewicz A, Gorkiewicz M, Pajak A. Body mass, depressive symptoms and menopausal status: an examination of the "Jolly Fat" hypothesis. Womens Health Issues 2005;15:145–51.
90. Jeenduang N, Trongsakul R, Inhongsa P, Chaidach P. The prevalence of metabolic syndrome in premenopausal and postmenopausal women in Southern Thailand. Gynecol Endocrinol 2014;30:573–6.
91. Jeon YK, Lee JG, Kim SS, et al. Association between bone mineral density and metabolic syndrome in pre- and postmenopausal women. Endocrine J 2011;58:87–93.
92. Jurimae J, Jurimae T. Plasma adiponectin concentration in healthy pre- and postmenopausal women: relationship with body composition, bone mineral, and metabolic variables. Am J Physiol Endocrinol Metab 2007;293:E42–7.
93. Kadam N, Chiplonkar S, Khadilkar A, Divate U, Khadilkar V. Low bone mass in urban Indian women above 40 years of age: prevalence and risk factors. Gynecol Endocrinol 2010;26:909–17.
94. Kang EK, Park HW, Baek S, Lim JY. The association between trunk body composition and spinal bone mineral density in Korean males versus females: a Farmers' Cohort for Agricultural Work-Related Musculoskeletal Disorders (FARM) study. J Korean Med Sci 2016;31: 1595–603.
95. Kaufer-Horwitz M, Pelaez-Robles K, Lazzeri-Arteaga P, Goti-Rodriguez LM, Avila-Rosas H. Hypertension, overweight and abdominal adiposity in women: an analytical perspective. Arch Med Res 2005;36:404–11.
96. Kim HM, Park J, Ryu SY, Kim J. The effect of menopause on the metabolic syndrome among Korean women: the Korean National Health and Nutrition Examination Survey, 2001. Diabetes Care 2007;30:701–6.
97. Kim JH, Choi HJ, Kim MJ, Shin CS, Cho NH. Fat mass is negatively associated with bone mineral content in Koreans. Osteoporos Int 2012;23:2009–16.
98. Kim S, Lee JY, Im JA, et al. Association between serum osteocalcin and insulin resistance in postmenopausal, but not premenopausal, women in Korea. Menopause 2013;20: 1061–6.
99. Kim YM, Kim SH, Kim S, Yoo JS, Choe EY, Won YJ. Variations in fat mass contribution to bone mineral density by gender, age, and body mass index: the Korea National Health and Nutrition Examination Survey (KNHANES) 2008-2011. Osteoporos Int 2016;27:2543–54.
100. Kirchengast S, Gruber D, Sator M, Huber J. Impact of the age at menarche on adult body composition in healthy pre- and postmenopausal women. Am J Phys Anthropol 1998;105:9–20.
101. Kirchengast S, Hartmann B, Huber J. Serum levels of sex hormones, thyroid hormones, growth hormone, IGF I, and cortisol and their relations to body fat distribution in healthy women dependent on their menopausal status. Zeit Morphol Anthropol 1996;81:223–34.
102. Knapp KM, Blake GM, Spector TD, Fogelman I. Multisite quantitative ultrasound: precision, age- and menopause-related changes, fracture discrimination, and T-score equivalence with dual-energy X-ray absorptiometry. Osteoporos Int 2001;12:456–64.
103. Koh SJ, Hyun YJ, Choi SY, et al. Influence of age and visceral fat area on plasma adiponectin concentrations in women with normal glucose tolerance. Clin Chim Acta 2008;389: 45–50.
104. Konrad T, Bär F, Schneider F, et al. Factors influencing endothelial function in healthy pre- and post-menopausal women of the EU-RISC study. Diabet Vasc Dis Res 2011;8:229–36.
105. Kontogianni MD, Dafni UG, Routsias JG, Skopouli FN. Blood leptin and adiponectin as possible mediators of the relation between fat mass and BMD in perimenopausal women. J Bone Miner Res 2004;19:546–51.
106. Konukoglu D, Serin O, Ercan M. Plasma leptin levels in obese and non-obese postmenopausal women before and after hormone replacement therapy. Maturitas 2000;36:203–7.
107. Koskova I, Petrasek R, Vondra K, et al. Weight, body composition and fat distribution of Czech women in relation with reproductive phase: a cross-sectional study. Prague Med Rep 2007;108:13–26.
108. Kotani K, Chen JT, Taniguchi N. The relationship between adiponectin and blood pressure in premenopausal and postmenopausal women. Clin Investig Med 2011;34:E125–30.
109. Kraemer RR, Synovitz LB, Gimpel T, Kraemer GR, Johnson LG, Castracane VD. Effect of estrogen on serum DHEA in younger and older women and the relationship of DHEA to adiposity and gender. Metabolism 2001;50: 488–93.
110. Kuk JL, Lee S, Heymsfield SB, Ross R. Waist circumference and abdominal adipose tissue distribution: influence of age and sex. Am J Clin Nutr 2005;81:1330–4.
111. Laitinen K, Valimaki M, Keto P. Bone mineral density measured by dual-energy X-ray absorptiometry in healthy Finnish women. Calcif Tissue Int 1991;48:224–31.
112. Lejskova M, Alusik S, Valenta Z, Adamkova S, Pitha J. Natural postmenopause is associated with an increase in combined cardiovascular risk factors. Physiol Res 2012;61: 587–96.
113. Leon Guerrero RT, Novotny R, Wilkens LR, et al. Risk factors for breast cancer in the breast cancer risk model study of Guam and Saipan. Cancer Epidemiol 2017;50:221–33.
114. Ley CJ, Lees B, Stevenson JC. Sex- and menopause-associated changes in body-fat distribution. Am J Clin Nutr 1992;55:950–4.
115. Lin WY, Yang WS, Lee LT, et al. Insulin resistance, obesity, and metabolic syndrome among non-diabetic pre- and post-menopausal women in North Taiwan. Int J Obes 2006;30: 912–7.
116. Lindquist O, Bengtsson C. Serum lipids, arterial blood pressure and body weight in relation to the menopause: results from a population study of women in Goteborg, Sweden. Scand J Clin Lab Investig 1980;40:629–36.
117. Lindsay R, Cosman F, Herrington BS, Himmelstein S. Bone mass and body composition in normal women. J Bone Miner Res 1992;7:55–63.
118. Lovejoy JC, Champagne CM, de Jonge L, Xie H, Smith SR. Increased visceral fat and decreased energy expenditure during the menopausal transition. Int J Obes 2008;32: 949–58.
119. Lyu LC, Yeh CY, Lichtenstein AH, Li Z, Ordovas JM, Schaefer EJ. Association of sex, adiposity, and diet with HDL subclasses in middle-aged Chinese. Am J Clin Nutr 2001;74: 64–71.
120. Maharlouei N, Bellissimo N, Ahmadi SM, Lankarani KB. Prevalence of metabolic syndrome in pre- and postmenopausal Iranian women. Climacteric 2013;16:561–7.
121. Malacara JM, Canto de Cetina T, Bassol S, et al. Symptoms at pre- and postmenopause in rural and urban women from three states of Mexico. Maturitas 2002;43:11–9.
122. Manabe E, Aoyagi K, Tachibana H, Takemoto T. Relationship of intra-abdominal adiposity and peripheral fat distribution to lipid metabolism in an island population in western Japan: gender differences and effect of menopause. Tohoku J Exp Med 1999;188:189–202.
123. Manjer J, Kaaks R, Riboli E, Berglund G. Risk of breast cancer in relation to anthropometry, blood pressure, blood lipids and glucose metabolism: a prospective study within the Malmo Preventive Project. Eur J Cancer Prev 2001;10:33–42.
124. Mannisto S, Pietinen P, Pyy M, Palmgren J, Eskelinen M, Uusitupa M. Body-size indicators and risk of breast cancer according to menopause and estrogen-receptor status. Int J Cancer 1996;68:8–13.
125. Martini G, Valenti R, Giovani S, Nuti R. Age-related changes in body composition of healthy and osteoporotic women. Maturitas 1997;27: 25–33.

126. Marwaha RK, Garg MK, Tandon N, Mehan N, Sastry A, Bhadra K. Relationship of body fat and its distribution with bone mineral density in Indian population. J Clin Densitom 2013;16:353–9.

127. Matsushita H, Kurabayashi T, Tomita M, Kato N, Tanaka K. Effects of uncoupling protein 1 and beta3-adrenergic receptor gene polymorphisms on body size and serum lipid concentrations in Japanese women. Maturitas 2003;45:39–45.

128. Matsuzaki M, Kulkarni B, Kuper H, et al. Association of Hip Bone Mineral Density and Body Composition in a Rural Indian Population: The Andhra Pradesh Children and Parents Study (APCAPS). PLoS One 2017;12:e0167114.

129. Matthews KA, Meilahn E, Kuller LH, Kelsey SF, Caggiula AW, Wing RR. Menopause and risk factors for coronary heart disease. N Engl J Med 1989;321:641–6.

130. Mesch VR, Boero LE, Siseles NO, et al. Metabolic syndrome throughout the menopausal transition: influence of age and menopausal status. Climacteric 2006;9:40–8.

131. Meza-Munoz DE, Fajardo ME, Perez-Luque EL, Malacara JM. Factors associated with estrogen receptors-alpha (ER-alpha) and -beta (ER-beta) and progesterone receptor abundance in obese and non obese pre- and post-menopausal women. Steroids 2006;71:498–503.

132. Minatoya M, Kutomi G, Shima H, et al. Relation of serum adiponectin levels and obesity with breast cancer: a Japanese case-control study. Asian Pac J Cancer Prev 2014;15:8325–30.

133. Mo D, Hsieh P, Yu H, et al. The relationship between osteoporosis and body composition in pre- and postmenopausal women from different ethnic groups in China. Ethn Health 2017;22:295–310.

134. Muchanga Sifa MJ, Lepira FB, Longo AL, et al. Prevalence and predictors of metabolic syndrome among Congolese pre- and postmenopausal women. Climacteric 2014;17:442–8.

135. Muti P, Stanulla M, Micheli A, et al. Markers of insulin resistance and sex steroid hormone activity in relation to breast cancer risk: a prospective analysis of abdominal adiposity, sebum production, and hirsutism (Italy). Cancer Causes Control 2000;11:721–30.

136. Nitta J, Nojima M, Ohnishi H, et al. Weight gain and alcohol drinking associations with breast cancer risk in Japanese postmenopausal women: results from the Japan Collaborative Cohort (JACC) Study. Asian Pac J Cancer Prev 2016;17:1437–43.

137. Noh HM, Song YM, Park JH, Kim BK, Choi YH. Metabolic factors and breast cancer risk in Korean women. Cancer Causes Control 2013;24:1061–8.

138. Nordin BE, Need AG, Bridges A, Horowitz M. Relative contributions of years since menopause, age, and weight to vertebral density in postmenopausal women. J Clin Endocrinol Metab 1992;74:20–3.

139. Ohta H, Kuroda T, Onoe Y, et al. Familial correlation of bone mineral density, birth data and lifestyle factors among adolescent daughters, mothers and grandmothers. J Bone Miner Metab 2010;28:690–5.

140. Oldroyd B, Stewart SP, Truscott JG, Westmacott CF, Smith MA. Age related changes in body composition. Applied Radiat Isot 1998;49:589–90.

141. Pacholczak R, Klimek-Piotrowska W, Kuszmiersz P. Associations of anthropometric measures on breast cancer risk in pre- and postmenopausal women: a case-control study. J Physiol Anthropol 2016;35:7.

142. Park JH, Song YM, Sung J, et al. The association between fat and lean mass and bone mineral density: the Healthy Twin Study. Bone 2012;50:1006–11.

143. Park YM, White AJ, Nichols HB, O'Brien KM, Weinberg CR, Sandler DP. The association between metabolic health, obesity phenotype and the risk of breast cancer. Int J Cancer 2017;140:2657–66.

144. Pavicic Zezelj S, Cvijanovic O, Micovic V, Bobinac D, Crncevic-Orlic Z, Malatestinic G. Effect of menopause, anthropometry, nutrition and lifestyle on bone status of women in the northern Mediterranean. West Indian Med J 2010;59:494–502.

145. Pavlica T, Mikalacki M, Matic R, et al. Relationship between BMI and skinfold thicknesses to risk factors in premenopausal and postmenopausal women. Coll Antropol 2013;37(suppl2):119–24.

146. Phillips GB, Jing T, Heymsfield SB. Does insulin resistance, visceral adiposity, or a sex hormone alteration underlie the metabolic syndrome? Studies in women. Metabolism 2008;57:838–44.

147. Polesel DN, Hirotsu C, Nozoe KT, et al. Waist circumference and postmenopause stages as the main associated factors for sleep apnea in women: a cross-sectional population-based study. Menopause 2015;22:835–44.

148. Pollan M, Lope V, Miranda-Garcia J, et al. Adult weight gain, fat distribution and mammographic density in Spanish pre- and post-menopausal women (DDM-Spain). Breast Cancer Res Treat 2012;134:823–38.

149. Portaluppi F, Pansini F, Manfredini R, Mollica G. Relative influence of menopausal status, age, and body mass index on blood pressure. Hypertension 1997;29:976–9.

150. Priya T, Chowdhury MG, Vasanth K, et al. Assessment of serum leptin and resistin levels in association with the metabolic risk factors of pre- and post-menopausal rural women in South India. Diabet Metab Synd 2013;7:233–7.

151. Rantalainen T, Nikander R, Heinonen A, et al. Neuromuscular performance and body mass as indices of bone loading in premenopausal and postmenopausal women. Bone 2010;46:964–9.

152. Reina P, Cointry GR, Nocciolino L, et al. Analysis of the independent power of age-related, anthropometric and mechanical factors as determinants of the structure of radius and tibia in normal adults: a pQCT study. J Musculoskelet Neuronal Interact 2015;15:10–22.

153. Revilla M, Villa LF, Hernandez ER, Sanchez-Atrio A, Cortes J, Rico H. Influence of weight and gonadal status on total and regional bone mineral content and on weight-bearing and non-weight-bearing bones, measured by dual-energy X-ray absosorptiometry. Maturitas 1997;28:69–74.

154. Revilla M, Villa LF, Sanchez-Atrio A, Hernandez ER, Rico H. Influence of body mass index on the age-related slope of total and regional bone mineral content. Calcif Tissue Int 1997;61:134–8.

155. Rice MS, Bertrand KA, Lajous M, et al. Reproductive and lifestyle risk factors and mammographic density in Mexican women. Ann Epidemiol 2015;25:868–73.

156. Rico H, Aguado F, Arribas I, et al. Behavior of phalangeal bone ultrasound in normal women with relation to gonadal status and body mass index. Osteoporos Int 2001;12:450–5.

157. Rico H, Arribas I, Casanova FJ, Duce AM, Hernandez ER, Cortes-Prieto J. Bone mass, bone metabolism, gonadal status and body mass index. Osteoporos Int 2002;13:379–87.

158. Roelfsema F, Veldhuis JD. Growth hormone dynamics in healthy adults are related to age and sex and strongly dependent on body mass index. Neuroendocrinology 2016;103:335–44.

159. Rosenbaum M, Nicolson M, Hirsch J, et al. Effects of gender, body composition, and menopause on plasma concentrations of leptin. J Clinical Endocrinol Metab 1996;81:3424–7.

160. Salomaa V, Rasi V, Pekkanen J, et al. Association of hormone replacement therapy with hemostatic and other cardiovascular risk factors. The FINRISK Hemostasis Study. Arterioscler Thromb Vasc Biol 1995;15:1549–55.

161. Sarrafzadegan N, Khosravi-Boroujeni H, Esmaillzadeh A, Sadeghi M, Rafieian-Kopaei M, Asgary S. The association between hypertriglyceridemic waist phenotype, menopause, and cardiovascular risk factors. Arch Iran Med 2013;16:161–6.

162. Schaberg-Lorei G, Ballard JE, McKeown BC, Zinkgraf SA. Body composition alterations consequent to an exercise program for pre and postmenopausal women. J Sports Med Phys Fit 1990;30:426–33.

163. Schwarz S, Volzke H, Alte D, et al. Menopause and determinants of quality of life in women at midlife and beyond: the study of health in pomerania (SHIP). Menopause 2007;14:123–34.

164. Shakir YA, Samsioe G, Nyberg P, Lidfeldt J, Nerbrand C. Cardiovascular risk factors in middle-aged women and the association with use of hormone therapy: results from a population-based study of Swedish women. The Women's Health in the Lund Area (WHILA) Study. Climacteric 2004;7:274–83.

165. Sherk VD, Malone SP, Bemben MG, Knehans AW, Palmer IJ, Bemben DA. Leptin, fat mass, and bone mineral density in healthy pre- and postmenopausal women. J Clin Densitom 2011;14:321–5.
166. Shibata H, Matsuzaki T, Hatano S. Relationship of relevant factors of atherosclerosis to menopause in Japanese women. Am J Epidemiol 1979;109:420–4.
167. Sieminska L, Wojciechowska C, Foltyn W, et al. The relation of serum adiponectin and leptin levels to metabolic syndrome in women before and after the menopause. Endokrynol Polska 2006;57:15–22.
168. Skrzypczak M, Szwed A. Assessment of the body mass index and selected physiological parameters in pre- and post-menopausal women. Homo 2005;56:141–52.
169. Skrzypczak M, Szwed A, Pawlińska-Chmara R, Skrzypulec V. Assessment of the BMI, WHR and W/Ht in pre-and post-menopausal women. Anthropol Rev 2007;70: 3–13.
170. Soderberg S, Ahren B, Eliasson M, Dinesen B, Olsson T. The association between leptin and proinsulin is lost with central obesity. J Intern Med 2002;252:140–8.
171. Son MK, Lim NK, Lim JY, et al. Difference in blood pressure between early and late menopausal transition was significant in healthy Korean women. BMC Womens Health 2015;15: 64.
172. Soriguer F, Morcillo S, Hernando V, et al. Type 2 diabetes mellitus and other cardiovascular risk factors are no more common during menopause: longitudinal study. Menopause 2009;16:817–21.
173. Staessen J, Bulpitt CJ, Fagard R, Lijnen P, Amery A. The influence of menopause on blood pressure. J Hum Hypertens 1989;3:427–33.
174. Suarez-Ortegon MF, Arbelaez A, Mosquera M, Mendez F, Aguilar-de Plata C. C-reactive protein, waist circumference, and family history of heart attack are independent predictors of body iron stores in apparently healthy premenopausal women. Biol Trace Elem Res 2012;148:135–8.
175. Suliga E, Koziel D, Ciesla E, Rebak D, Gluszek S. Factors associated with adiposity, lipid profile disorders and the metabolic syndrome occurrence in premenopausal and postmenopausal women. PLoS One 2016;11: e0154511.
176. Sumner AE, Falkner B, Kushner H, Considine RV. Relationship of leptin concentration to gender, menopause, age, diabetes, and fat mass in African Americans. Obes Res 1998;6:128–33.
177. Tanaka NI, Hanawa S, Murakami H, et al. Accuracy of segmental bioelectrical impedance analysis for predicting body composition in pre- and postmenopausal women. J Clin Densitom 2015;18:252–9.
178. Thomas T, Burguera B, Melton LJ 3rd, et al. Relationship of serum leptin levels with body composition and sex steroid and insulin levels in men and women. Metabolism 2000;49: 1278–84.
179. Torng PL, Su TC, Sung FC, et al. Effects of menopause and obesity on lipid profiles in middle-aged Taiwanese women: the Chin-Shan Community Cardiovascular Cohort Study. Atherosclerosis 2000;153:413–21.
180. Toth MJ, Tchernof A, Sites CK, Poehlman ET. Effect of menopausal status on body composition and abdominal fat distribution. Int J Obes Relat Metab Dis 2000;24: 226–31.
181. Tremollieres FA, Pouilles JM, Ribot CA. Relative influence of age and menopause on total and regional body composition changes in postmenopausal women. Am J Obstet Gynecol 1996;175:1594–600.
182. Trikudanathan S, Pedley A, Massaro JM, et al. Association of female reproductive factors with body composition: the Framingham Heart Study. J Clin Endocrinol Metab 2013;98: 236–44.
183. Van Pelt RE, Davy KP, Stevenson ET, et al. Smaller differences in total and regional adiposity with age in women who regularly perform endurance exercise. Am J Physiol 1998;275: E626–34.
184. Veldhuis JD, Dyer RB, Trushin SA, Bondar OP, Singh RJ, Klee GG. Interleukins 6 and 8 and abdominal fat depots are distinct correlates of lipid moieties in healthy pre- and postmenopausal women. Endocrine 2016;54: 671–80.
185. Wang F, Ma X, Hao Y, et al. Serum glycated albumin is inversely influenced by fat mass and visceral adipose tissue in Chinese with normal glucose tolerance. PLoS One 2012;7: e51098.
186. Wang W, Zhao LJ, Liu YZ, Recker RR, Deng HW. Genetic and environmental correlations between obesity phenotypes and age at menarche. Int J Obes 2006;30:1595–600.
187. Wang WS, Wahlqvist ML, Hsu CC, Chang HY, Chang WC, Chen CC. Age- and gender-specific population attributable risks of metabolic disorders on all-cause and cardiovascular mortality in Taiwan. BMC Public Health 2012;12:111.
188. Wee J, Sng BY, Shen L, Lim CT, Singh G, Das De S. The relationship between body mass index and physical activity levels in relation to bone mineral density in premenopausal and postmenopausal women. Arch Osteoporos 2013;8:162.
189. Williams PT, Krauss RM. Associations of age, adiposity, menopause, and alcohol intake with low-density lipoprotein subclasses. Arterioscler Thromb Vasc Biol 1997;17:1082–90.
190. Wing RR, Matthews KA, Kuller LH, Meilahn EN, Plantinga PL. Weight gain at the time of menopause. Arch Intern Med 1991;151: 97–102.
191. Xu L, Nicholson P, Wang QJ, Wang Q, Alen M, Cheng S. Fat mass accumulation compromises bone adaptation to load in Finnish women: a cross-sectional study spanning three generations. J Bone Miner Res 2010;25: 2341–9.
192. Yamatani H, Takahashi K, Yoshida T, Takata K, Kurachi H. Association of estrogen with glucocorticoid levels in visceral fat in postmenopausal women. Menopause 2013;20: 437–42.
193. Yannakoulia M, Melistas L, Solomou E, Yiannakouris N. Association of eating frequency with body fatness in pre- and postmenopausal women. Obesity 2007;15:100–6.
194. Yoldemir T, Erenus M. The prevalence of metabolic syndrome in pre- and postmenopausal women attending a tertiary clinic in Turkey. Eur J Obstet Gynecol Reprod Biol 2012;164:172–5.
195. Yoo HJ, Park MS, Yang SJ, et al. The differential relationship between fat mass and bone mineral density by gender and menopausal status. J Bone Miner Metab 2012;30:47–53.
196. Yoo KY, Kim H, Shin HR, et al. Female sex hormones and body mass in adolescent and postmenopausal Korean women. J Korean Med Sci 1998;13:241–6.
197. Yoshimoto N, Nishiyama T, Toyama T, et al. Genetic and environmental predictors, endogenous hormones and growth factors, and risk of estrogen receptor-positive breast cancer in Japanese women. Cancer Sci 2011;102: 2065–72.
198. Zhong N, Wu XP, Xu ZR, et al. Relationship of serum leptin with age, body weight, body mass index, and bone mineral density in healthy mainland Chinese women. Clin Chim Acta 2005;351:161–8.
199. Zhou JL, Lin SQ, Shen Y, Chen Y, Zhang Y, Chen FL. Serum lipid profile changes during the menopausal transition in Chinese women: a community-based cohort study. Menopause 2010;17:997–1003.
200. Zhou Y, Zhou X, Guo X, et al. Prevalence and risk factors of hypertension among pre- and post-menopausal women: a cross-sectional study in a rural area of northeast China. Maturitas 2015;80:282–7.
201. Zivkovic TB, Vuksanovic M, Jelic MA, et al. Obesity and metabolic syndrome during the menopause transition in Serbian women. Climacteric 2011;14:643–8.
202. Akahoshi M, Soda M, Nakashima E, et al. Effects of age at menopause on serum cholesterol, body mass index, and blood pressure. Atherosclerosis 2001;156:157–63.
203. Ford K, Sowers M, Crutchfield M, Wilson A, Jannausch M. A longitudinal study of the predictors of prevalence and severity of symptoms commonly associated with menopause. Menopause 2005;12:308–17.
204. Franklin RM, Ploutz-Snyder L, Kanaley JA. Longitudinal changes in abdominal fat distribution with menopause. Metabolism 2009;58:311–5.
205. Janssen I, Powell LH, Crawford S, Lasley B, Sutton-Tyrrell K. Menopause and the metabolic syndrome: the Study of Women's Health Across the Nation. Arch Intern Med 2008;168:1568–75.

206. Lee CG, Carr MC, Murdoch SJ, et al. Adipokines, inflammation, and visceral adiposity across the menopausal transition: a prospective study. J Clin Endocrinol Metab 2009;94:1104–10.

207. Liu-Ambrose T, Kravetsky L, Bailey D, et al. Change in lean body mass is a major determinant of change in areal bone mineral density of the proximal femur: a 12-year observational study. Calcif Tissue Int 2006;79:145–51.

208. Macdonald HM, New SA, Campbell MK, Reid DM. Influence of weight and weight change on bone loss in perimenopausal and early postmenopausal Scottish women. Osteoporos Int 2005;16:163–71.

209. Razmjou S, Abdulnour J, Bastard J-P, et al. Body composition, cardiometabolic risk factors, physical activity, and inflammatory markers in premenopausal women after a 10-year follow-up: a MONET study. Menopause 2018;25:89–97.

210. Soreca I, Rosano C, Jennings JR, et al. Gain in adiposity across 15 years is associated with reduced gray matter volume in healthy women. Psychosom Med 2009;71:485–90.