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Lactation and Maternal Measures of Subclinical Cardiovascular Disease

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Abstract

OBJECTIVE—To examine the relationship between lactation and subclinical cardiovascular disease in a population free of clinical cardiovascular disease.

METHODS—We conducted a cross-sectional analysis of 297 women who reported at least one live birth on enrollment in the Study of Women Across the Nation–Heart Study. Participants were mothers aged 45–58 years who were free of clinical cardiovascular disease. History of lactation was self-reported. Electron beam tomography was used to assess coronary and aortic calcification. B-mode ultrasonography was used to assess carotid adventitial diameter, intima–media thickness, and carotid plaque. Multivariable linear and logistic regression models were used to estimate whether lactation was independently associated with markers of subclinical cardiovascular disease.

RESULTS—In unadjusted models, compared with mothers who had breastfed all of their children for at least 3 months, mothers who had not breastfed were more likely to have coronary artery calcification (17% compared with 32%), aortic calcification (17% compared with 39%), carotid plaque (10% compared with 18%), and larger carotid adventitial diameters (mean ± standard deviation 6.63±0.59 compared with 6.87±0.60 mm). After adjusting for measures of socioeconomic status and lifestyle and family history variables, mothers who had not breastfed remained more likely to have aortic calcification (odds ratio [OR] 3.85, 95% confidence interval [CI] 1.47–10.00) and coronary artery calcification (OR 2.78, 95% CI 1.05–7.14) than mothers who had consistently breastfed. After further adjustment for body mass index and traditional risk factors for cardiovascular disease, mothers who had not breastfed remained more likely to have aortic calcification than mothers who had consistently breastfed (OR 5.26, 95% CI 1.47–20.00).

CONCLUSION—Mothers who do not breastfeed their infants seem to be at increased risk of vascular changes associated with future cardiovascular disease.

Cardiovascular disease is the leading cause of death for U.S. women. As such, it is important to identify how behaviors, such as lactation, modify women's risk of cardiovascular disease.

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For a list of the clinical centers that participated in SWAN, see the Appendix online at http://links.lww.com/A155.

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Lactation increases a mother's metabolic expenditure by an estimated 480 kcal/d.[1] Mothers who do not breastfeed retain more weight in the postpartum period than women who do breastfeed.[2] In addition, lactation improves insulin requirements,[3] glucose tolerance,[4] lipid metabolism,[5] and C-reactive protein profiles in the postpartum period.[6] Recently, a number of studies have indicated longer-term effects of lactation,[7,8] including a reduced risk of midlife metabolic syndrome[9] and cardiovascular disease.[10,11] However, the mechanisms through which lactation may decrease risk of cardiovascular disease remain unclear.

Early physiologic changes that increase future risk of cardiovascular disease can be detected by a variety of methods. For example, calcified atherosclerotic plaques can be quantified by electron beam tomography[12] and have been prospectively linked to cardiovascular events,[13,14] including stroke, incident coronary heart disease, and cardiovascular disease mortality. Carotid intima–media thickness and carotid adventitial diameter[15] have also been used to identify patients at increased risk of cardiovascular disease.[16,17] The goal of this study was to estimate the relation between lactation and several measures of subclinical cardiovascular disease, including coronary artery calcification, aortic calcification, carotid plaque, carotid adventitial diameter, and carotid intima–media thickness.

MATERIALS AND METHODS

The Study of Women's Health Across the Nation (SWAN) is a community-based cohort study, conducted at seven sites in the United States, designed to characterize the menopausal transition. Details of study design and procedures have been reported previously.[18] At enrollment (1996 to 1997), SWAN participants (n=3,302) were 42 to 52 years of age, had an intact uterus and at least one ovary, were not pregnant or breastfeeding, and had menstruated within the prior 3 months. A subcohort of participants from the Pittsburgh and Chicago SWAN sites participated in SWAN-Heart, an ancillary study designed to describe cardiovascular risk during the menopausal transition. By design,[18] the Pittsburgh and Chicago sites recruited only non-Hispanic white and African-American women. In addition, women were excluded from SWAN-Heart if they used oral contraceptives or hormone replacement therapy in the 3 months before enrollment; reported pregnancy, hysterectomy, or bilateral oophorectomy; reported cardiovascular disease (history of myocardial infarction, angina, intermittent claudication, cerebral ischemia, or revascularization); or used medications for diabetes, hypertension, or heart arrhythmias. All eligible SWAN participants were invited to participate in SWAN-Heart; of these women, 76%, or a total of 608 women, completed the baseline SWAN-Heart examination once during SWAN study years 4 through 7 (2001 to 2005) within 3 months of the corresponding annual core SWAN assessment. However, 44 women who completed baseline SWAN-Heart examinations were subsequently found to be using hormone replacement therapy (n=29), to have had a vascular event (n=2), or to have had a hysterectomy (n=13), which made them ineligible for SWAN-Heart.

In addition, women were excluded from the present analyses if they had no history of live birth (n=53), if information was missing on their number of pregnancies (n=152), or if they had given birth between their baseline SWAN visit and baseline SWAN-Heart visit or we were missing information about pregnancy between visits (n=7). In addition, we excluded women missing computed tomography (CT) (n=31) or ultrasound information (n=21), or information on menopausal status (n=3). This produced a total of 297 women with baseline SWAN-Heart data that could be used for this analysis.

Participants completed a standard protocol at SWAN entry and annually thereafter, which included questionnaires, fasting blood specimens, anthropometric measures, and blood pressure readings.

Lactation history was assessed when women enrolled in SWAN by asking women who reported one or more live births, “If you breastfed, for how long did you breastfeed?” for each child. Complete lactation data were available for all women included in this analysis. Although prior studies have posited a linear relationship between lifetime duration of lactation and maternal health effects,[10,11] we hypothesize that lactation has more effect on maternal health immediately postpartum, when women are recovering from pregnancy; however, the optimal duration of lactation after each birth with regard to maternal health is unknown. As such, we considered a woman to have “consistently breastfed” if she breastfed each of her children for 3 months or more, because under the 1993 Family and Medical Leave Act, U.S. working women are granted 12 weeks of unpaid time off to care for a newborn, with the guarantee of the same job when they return.[19] Women who had breastfed any of their children for less than 3 months were considered to have “inconsistently breastfed.” In this analysis, we examined the impact of consistent, inconsistent, and no lactation on maternal measures of subclinical cardiovascular disease.

Subclinical cardiovascular disease was measured at the SWAN-Heart baseline visit. Calcification of the aorta and coronary arteries was assessed by electron beam tomography with an Imatron C-150 Ultrafast CT scanner (Imatron, South San Francisco, CA) administered by a trained technician. All scans were scored centrally at the University of Pittsburgh as has been described previously.[20] Calcification was considered present if at least three contiguous pixels showed more than 130 Hounsfield units. The coronary calcification score was obtained from the sum of the individual scores for the four major epicardial arteries. Aortic calcification produced one score. Image analysis was overseen by a single physician trained in electron beam CT to guarantee consistency in technologist readings.

Common carotid artery intima–media thickness was assessed by duplex scanning using a Toshiba SSA-270A scanner (Toshiba Corporation, Tokyo, Japan). Images were taken from the near and far walls of the distal common carotid artery, 1 cm proximal to the carotid bulb, and the lumen–intima interface and media–adventitia interface were electronically traced across a 1-cm segment. Common carotid artery adventitial diameters were measured directly as the distance from the adventitial–medial interface on the near wall to the medial–adventitial interface on the far wall at end-diastole. Plaque was defined as a focal area of increased thickening at least two times greater than that of adjacent areas. Replicate readings were performed on 20 scans from these women to evaluate reproducibility of the measures. The intraclass correlation was 0.98 for intima–media thickness and 0.99 for adventitial diameter.

Race/ethnicity, education (less than or high school, some college/vocational, college degree or higher), and parity were assessed at the baseline SWAN interview. Physical activity was assessed at the baseline visit with a modified Kaiser Permanente Health Plan Activity Survey,[21] a validated measure designed to assess physical activity among women. In addition, financial strain was assessed with the question, “How hard is it for you to pay for the very basics like food, housing, medical care, and heating? Would you say it is very hard, somewhat hard, or not very hard at all?” Daily dietary intakes of calories, dietary fiber, cholesterol, fat, and sodium and daily vitamin use were assessed using a food frequency questionnaire[22] administered at the baseline SWAN examination. Family history of diabetes, myocardial infarction, and stroke was assessed at the second annual SWAN visit and included disease in the participant’s mother, father, brother, or sister.

All other covariates were derived from the annual SWAN assessment closest in time to the baseline SWAN-Heart visit. Menopausal status was obtained annually by categorizing reported bleeding patterns over the preceding year as premenopausal/early perimenopausal

(if a woman reported bleeding in the previous 3 months) or late perimenopausal/ postmenopausal (if a woman reported more than 3 months of amenorrhea/12 months of amenorrhea). Perceived stress[23] and depressed mood were measured annually using validated instruments.[24] All lipid fractions were analyzed on ethylenediaminetetraacetic acid–treated plasma. Total cholesterol was analyzed by enzymatic methods. High-density lipoprotein (HDL) cholesterol was isolated using heparin-2M manganese chloride. Serum insulin was measured using radioimmunoassay (Coat-a-Count; Diagnostics Product Corp., Los Angeles, CA). Glucose was measured using a hexokinase-coupled reaction (Roche Molecular Biochemicals Diagnostics, Indianapolis, IN). Anthropometric measures (height, weight, systolic blood pressure, and diastolic blood pressure) were obtained annually by standard methods, with body mass index (BMI) calculated as weight in kilograms divided by height in meters squared.

We used analysis of variance, Student *t* tests, and χ^2 tests to examine whether sociodemographic characteristics or measures of subclinical cardiovascular disease varied by lactation history. Because of skewing of the distributions, aortic calcification score, coronary artery calcification score, and intima–media thickness were all dichotomized at less than or equal to and greater than the 75th percentile. Carotid plaque was modeled as present compared with absent. Multiple logistic regression was used to estimate the associations between lactation history and aortic calcification, coronary artery calcification, carotid plaque, and intima–media thickness. Adventitial diameter values were approximately normally distributed (as assessed with a Kolmogorov-Smirnov statistic), so multiple linear regression was used to estimate associations between lactation and adventitial diameter. All models initially included the covariates site, age, and number of live births. We then sequentially added covariates, including race, education, financial strain, lifestyle variables (smoking [current, yes compared with no], physical activity, diet [daily kilocalories, grams of fiber, milligrams of cholesterol, and sodium intake], and vitamin supplementation), depressed mood (modeled dichotomously as Center for Epidemiologic Studies Depression Scale scores of 16 or greater compared with less than 16), perceived stress (modeled continuously), menopausal status, family history (of diabetes, myocardial infarction, or stroke), BMI, and traditional cardiovascular risk factors (systolic blood pressure, triglycerides, total cholesterol, HDL, C-reactive protein, glucose, and insulin) to subsequent models. Covariates with right-skewed distributions (eg, insulin, blood pressure) were natural log transformed for entry into regression models. Issues of collinearity were addressed by placing the measure most strongly associated with the outcome in the model (such as the inclusion of either systolic or diastolic blood pressure). Interactions of lactation history by age, race, and menopausal status were evaluated in all models, by entering a product term for the variable of interest and lactation history. Interaction statistics were considered significant if $P<.05$. Women with missing covariate data were dropped from analyses involving that covariate. Because the reference groups in the above analyses were women who never lactated, we performed similar analyses considering consistent lactation as the reference group, to formally test for differences in outcomes when women consistently or inconsistently lactated. Analyses were performed with SAS 9.2 (SAS Institute, Inc., Cary, NC). All tests were two-sided with statistical significance level at .05. The Institutional Review Board of the University of Pittsburgh and Rush University approved this study.

RESULTS

This analysis included 297 women aged 45–58 years with at least one live birth. Sociodemographic and lifestyle characteristics of the study participants, by lactation history, are shown in Table 1. Thirty-one percent of participating mothers reported no history of lactation. Women who did not breastfeed were more likely to be African American (53% compared with 37%, $P=.001$), were less likely to be college graduates (32% compared with

65%, $P<.001$), were more likely to smoke (20% compared with 12%, $P=.05$), and had significantly less dietary intake of fiber (9 compared with 12 g, $P<.001$) and higher intake of cholesterol, independent of caloric intake (224 compared with 207 mg, $P=.03$) than women who ever lactated. Family history (of diabetes, myocardial infarction, or stroke) did not vary significantly by lactation history.

On enrollment in SWAN-Heart, 38% of women were obese (BMI of 30 or higher). The average systolic blood pressure of mothers who had never breastfed was significantly higher than that of mothers who had (120 compared with 115 mm Hg, $P=.01$). Table 2 shows other unadjusted cardiovascular characteristics of participants by lactation history. On average, women who consistently breastfed had less aortic calcification, coronary calcification, and carotid plaque; thinner intima–media thickness; and smaller adventitial diameters (Table 2).

Table 3 shows the effect of lactation on aortic calcification, coronary calcification, and carotid plaque, after adjusting for relevant covariates. Table 4 shows the relationship between lactation and two other measures of subclinical cardiovascular disease, adventitial diameter and intima–media thickness. After adjustment for age, parity, and study site, significant protective relationships were seen between lactation and multiple markers of subclinical cardiovascular disease, including aortic calcification, coronary calcification, and adventitial diameter. However, after adjustment for other lifestyle and family history variables, a significant association was only seen between aortic and coronary calcification and consistent lactation for 3 months or more postpartum. After adjusting for measures of socioeconomic status, and lifestyle and family history variables, mothers who had not breastfed remained more likely to have aortic calcification (odds ratio [OR] 3.85, 95% confidence interval [CI] 1.47–10.00) and coronary artery calcification (OR 2.78, 95% CI 1.05–7.14) than mothers who had consistently breastfed. Interestingly, the association between lactation and reduced aortic calcification persisted even after further adjustment for BMI as well as traditional cardiovascular risk factors, including systolic blood pressure, triglycerides, total cholesterol, HDL, C-reactive protein, glucose, and insulin. In these fully adjusted models, mothers who had not breastfed each remained more likely to have aortic calcification than mothers who had consistently breastfed (OR 5.26, 95% CI 1.47–20.00).

In analyses designed to estimate whether outcomes differed for mothers who consistently compared with inconsistently lactated, we found that mothers who inconsistently lactated were significantly more likely than mothers who consistently lactated to have coronary artery calcification (unadjusted OR 2.02, 95% CI 1.03–3.96). However, in multivariable models, there were no significant differences between mothers who reported consistent and inconsistent lactation.

Interactions of lactation history by age, race, and menopausal status were evaluated by entering a product term for the variable of interest and lactation history into all regression models. However, no significant interactions existed between any of these variables and lactation history for any of the outcomes examined.

DISCUSSION

This study found that mothers who had not breastfed their infants were more likely to have vascular changes associated with an increased risk of cardiovascular disease. In particular, mothers who had not breastfed were significantly more likely to have aortic and coronary calcification than mothers who breastfed, even after adjusting for multiple sociodemographic, lifestyle, and family history variables. The relationship between lactation history and aortic calcification persisted even after additional adjustment for known risk factors for cardiovascular disease, such as body mass index, blood pressure, cholesterol, and

glucose. These findings build on previous work that has shown that women who do not breastfeed are at greater risk of clinical cardiovascular disease,[10,11] by providing insight in to the early effects of lactation on a mother's body.

Although we found that, after adjusting for age, parity, study site, lifestyle, and family history variables, mothers who had consistently breastfed their children were significantly less likely to have coronary artery calcification than mothers who did not breastfeed, after further adjustment for BMI and traditional cardiovascular risk factors, this relationship was no longer significant; however, the effect sizes remained similar. The wider CIs around effect estimates in successively more complex models likely reflect a loss of power with diminishing sample size due to exclusion of participants with missing data. Perhaps, if this study had included more women, or women with symptomatic cardiovascular disease among whom coronary artery calcification would have been more prevalent, more significant relationships between lactation and coronary artery calcification would have also been identified. In women, aortic calcification appears earlier than coronary artery calcification, and thus may be a more sensitive indicator of subclinical cardiovascular disease than coronary artery calcification.[25] However, a previous Dutch study[26] found no significant association between coronary calcification and whether a woman had ever compared with never breastfed.

Previous studies have demonstrated that lactation has beneficial effects on blood pressure,[27] risk of developing diabetes,[7,8] and lipid metabolism.[9] It is known that fat stores accumulate during pregnancy,[28] and prior studies have shown that in populations where breastfeeding is rare, pregnancy may increase risk of cardiovascular disease.[29] It has been hypothesized that lactation may reduce cardiovascular risk by mobilizing accumulated fat stores. However, our finding that women who consistently breastfed were less likely to have aortic calcification, even after adjustment for BMI category, and other known risk factors for cardiovascular disease indicates that lactation does more than simply reduce a woman's fat stores. Hormonal effects, such as those of prolactin and oxytocin, may have long-term effects on cardiovascular profiles. Recent studies have found that increased prolactin levels are associated with increased blood pressure[30] and accelerated preclinical atherosclerosis.[31] In contrast, oxytocin has been associated with lower blood pressure and vascular resistance during stress.[32]

Strengths of this study include the racially diverse group of women who participated in SWAN-Heart. However, our findings must be interpreted with the understanding that all observational studies may be subject to residual confounding, and that the relatively small sample size provided limited power for some analyses. Duration of lactation was self-reported. The measure of lactation used in this study does not allow estimation of the intensity or exclusivity with which women breastfed their infants. It is possible that more powerful effects would be seen with exclusive breastfeeding. Recall or reporting bias may have led to some misclassification of women's lactation history. Prior research has found that women with shorter durations of lactation tended to overreport, whereas women with longer durations tended to underreport.[33] Presuming this misclassification is nondifferential with respect to the outcomes examined, it would attenuate estimates of associations between duration of lactation and later health. Nonetheless, we observed significant associations between a history of lactation and aortic and coronary calcification, both markers of subclinical cardiovascular disease. The use of a complete case approach to missing data may also potentially bias our findings because changes in apparent associations may reflect differences in the composition of the study population between univariable and multivariable models (especially when many women were dropped as was the case when we adjusted for known risk factors for cardiovascular disease), rather than differences due to adjustment for confounders. Some have hypothesized that women who are able to prolong

breastfeeding may lead “less stressful” lives, which may decrease their risk of cardiovascular disease.[34] Notably, the association between consistent lactation and aortic and coronary calcification persisted after we controlled for factors associated with lower socioeconomic status (education, income, race, parity, and tobacco use), as well as measures of depressed mood and perceived stress. However, it remains possible that some aspects of life stress may remain unmeasured and that residual confounding may explain some of this study’s findings. In addition, studies have linked obesity and insulin resistance to difficulties with breastfeeding,[35] suggesting that decreased duration of lactation could be a marker for an existing abnormal metabolic profile. Further studies are therefore needed to assess the impact of lactation on women with known cardiovascular profiles.

In conclusion, this study shows that women who do not breastfeed their children may be at increased risk of aortic and coronary calcification and thus subsequent cardiovascular disease. These findings support recommendations[36] that women breastfeed their infants in the interest of both maternal and child health.

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References

1. Butte NF, Wong WW, Hopkinson JM. Energy requirements of lactating women derived from doubly labeled water and milk energy output. J Nutr. 2001; 131:53–8. [PubMed: 11208938]
2. Rooney BL, Schauberger CW. Excess pregnancy weight gain and long-term obesity: one decade later. Obstet Gynecol. 2002; 100:245–52. [PubMed: 12151145]
3. Butte NF, Hopkinson JM, Mehta N, Moon JK, Smith EO. Adjustments in energy expenditure and substrate utilization during late pregnancy and lactation. Am J Clin Nutr. 1999; 69:299–307. [PubMed: 9989696]
4. Yang JQ, Xu YH, Gai MY. Breast-feeding in reducing regular insulin requirement in postpartum for insulin dependent diabetes mellitus and gestational diabetes mellitus [in Chinese]. Zhonghua Fu Chan Ke Za Zhi. 1994; 29:135–7. 188. [PubMed: 8082426]
5. Kjos SL, Henry O, Lee RM, Buchanan TA, Mishell DR Jr. The effect of lactation on glucose and lipid metabolism in women with recent gestational diabetes. Obstet Gynecol. 1993; 82:451–5. [PubMed: 8355952]
6. Williams MJ, Williams SM, Poulton R. Breast feeding is related to C reactive protein concentration in adult women. J Epidemiol Community Health. 2006; 60:146–8. [PubMed: 16415265]
7. Stuebe AM, Rich-Edwards JW, Willett WC, Manson JE, Michels KB. Duration of lactation and incidence of type 2 diabetes. JAMA. 2005; 294:2601–10. [PubMed: 16304074]
8. Villegas R, Gao YT, Yang G, Li HL, Elasy T, Zheng W, et al. Duration of breast-feeding and the incidence of type 2 diabetes mellitus in the Shanghai Women’s Health Study. Diabetologia. 2008; 51:258–66. [PubMed: 18040660]
9. Ram KT, Bobby P, Hailpern SM, Lo JC, Schocken M, Skurnick J, et al. Duration of lactation is associated with lower prevalence of the metabolic syndrome in midlife: SWAN, the Study of Women’s Health Across the Nation. Am J Obstet Gynecol. 2008; 198:268.e1–6. [PubMed: 18191796]
10. Schwarz EB, Ray RM, Stuebe AM, Allison MA, Ness RB, Freiberg MS, et al. Duration of lactation and risk factors for maternal cardiovascular disease. Obstet Gynecol. 2009; 113:974–82. [PubMed: 19384111]

11. Stuebe AM, Michels KB, Willett WC, Manson JE, Rexrode K, Rich-Edwards JW. Duration of lactation and incidence of myocardial infarction in middle to late adulthood. Am J Obstet Gynecol. 2009; 200:138.e1–8. [PubMed: 19110223]
12. Rumberger JA, Brundage BH, Rader DJ, Kondos G. Electron beam computed tomographic coronary calcium scanning: a review and guidelines for use in asymptomatic persons [published erratum appears in Mayo Clin Proc 1999;74:538]. Mayo Clin Proc. 1999; 74:243–52. [PubMed: 10089993]
13. Greenland P, LaBree L, Azen SP, Doherty TM, Detrano RC. Coronary artery calcium score combined with Framingham score for risk prediction in asymptomatic individuals [published erratum appears in JAMA 2004;291:563]. JAMA. 2004; 291:210–5. [PubMed: 14722147]
14. Iribarren C, Sidney S, Sternfeld B, Browner WS. Calcification of the aortic arch: risk factors and association with coronary heart disease, stroke, and peripheral vascular disease. JAMA. 2000; 283:2810–5. [PubMed: 10838649]
15. Sharma K, Blaha MJ, Blumenthal RS, Musunuru K. Clinical and research applications of carotid intima-media thickness. Am J Cardiol. 2009; 103:1316–20. [PubMed: 19406278]
16. Eigenbrodt ML, Sukhija R, Rose KM, Tracy RE, Couper DJ, Evans GW, et al. Common carotid artery wall thickness and external diameter as predictors of prevalent and incident cardiac events in a large population study. Cardiovasc Ultrasound. 2007; 5:11. [PubMed: 17349039]
17. Lorenz MW, Markus HS, Bots ML, Rosvall M, Sitzer M. Prediction of clinical cardiovascular events with carotid intima-media thickness: a systematic review and meta-analysis. Circulation. 2007; 115:459–67. [PubMed: 17242284]
18. Sowers, MF.; Crawford, S.; Sternfeld, B.; Morganstein, D.; Gold, EB.; Greendale, G., et al. SWAN: a multicenter, multi-ethnic, community-based cohort study of women and the menopausal transition. In: Lobo, RA.; Kelsey, J.; Marcus, R., editors. Menopause: biology and pathobiology. San Diego (CA): Academic Press; 2000. p. 175-88.
19. Employment Standards Administration. Family and Medical Leave Act. Available at: http://www.dol.gov/esa/whd/fmla/. Retrieved October 28, 2009
20. Thurston RC, Sutton-Tyrrell K, Everson-Rose SA, Hess R, Matthews KA. Hot flashes and subclinical cardiovascular disease: findings from the Study of Women's Health Across the Nation Heart Study. Circulation. 2008; 118:1234–40. [PubMed: 18765392]
21. Sternfeld B, Ainsworth BE, Quesenberry CP. Physical activity patterns in a diverse population of women. Prev Med. 1999; 28:313–23. [PubMed: 10072751]
22. Block G, Norris JC, Mandel RM, DiSogra C. Sources of energy and six nutrients in diets of low-income Hispanic-American women and their children: quantitative data from HHANES, 1982–1984. J Am Diet Assoc. 1995; 95:195–208. [PubMed: 7852686]
23. Cohen S, Kamarck T, Mermelstein R. A global measure of perceived stress. J Health Soc Behav. 1983; 24:385–96. [PubMed: 6668417]
24. Roberts RE, Vernon SW. The Center for Epidemiologic Studies Depression Scale: its use in a community sample. Am J Psychiatry. 1983; 140:41–6. [PubMed: 6847983]
25. Odink AE, van der Lugt A, Hofman A, Hunink MG, Breteler MM, Krestin GP, et al. Association between calcification in the coronary arteries, aortic arch and carotid arteries: the Rotterdam study. Atherosclerosis. 2007; 193:408–13. [PubMed: 16919637]
26. Atsma F, Bartelink ML, Grobbee DE, Rutten A, Bots ML, Prokop M, et al. Reproductive factors, metabolic factors, and coronary artery calcification in older women. Menopause. 2008; 15:899–904. [PubMed: 18779678]
27. Lee SY, Kim MT, Jee SH, Yang HP. Does long-term lactation protect premenopausal women against hypertension risk? A Korean women's cohort study. Prev Med. 2005; 41:433–8. [PubMed: 15917038]
28. Lain KY, Catalano PM. Metabolic changes in pregnancy. Clin Obstet Gynecol. 2007; 50:938–48. [PubMed: 17982337]
29. Ness RB, Harris T, Cobb J, Flegal KM, Kelsey JL, Balanger A, et al. Number of pregnancies and the subsequent risk of cardiovascular disease. N Engl J Med. 1993; 328:1528–33. [PubMed: 8267704]

30. Molinari C, Grossini E, Mary DA, Uberti F, Ghigo E, Ribichini F, et al. Prolactin induces regional vasoconstriction through the beta2-adrenergic and nitric oxide mechanisms. Endocrinology. 2007; 148:4080–90. [PubMed: 17463060]

31. Georgiopoulos GA, Stamatelopoulos KS, Lambrinoudaki I, Lykka M, Kyrkou K, Rizos D, et al. Prolactin and preclinical atherosclerosis in menopausal women with cardiovascular risk factors. Hypertension. 2009; 54:98–105. [PubMed: 19451414]

32. Light KC, Grewen KM, Amico JA, Brownley KA, West SG, Hinderliter AL, et al. Oxytocinergic activity is linked to lower blood pressure and vascular resistance during stress in postmenopausal women on estrogen replacement. Horm Behav. 2005; 47:540–8. [PubMed: 15811355]

33. Promislow JH, Gladen BC, Sandler DP. Maternal recall of breastfeeding duration by elderly women. Am J Epidemiol. 2005; 161:289–96. [PubMed: 15671261]

34. Rafanelli C, Roncuzzi R, Milaneschi Y, Tomba E, Colistro MC, Pancaldi LG, et al. Stressful life events, depression and demoralization as risk factors for acute coronary heart disease. Psychother Psychosom. 2005; 74:179–84. [PubMed: 15832069]

35. Rasmussen KM, Hilson JA, Kjolhede CL. Obesity may impair lactogenesis II. J Nutr. 2001; 131:3009S–11S. [PubMed: 11694637]

36. Gartner LM, Morton J, Lawrence RA, Naylor AJ, O'Hare D, Schanler RJ, et al. Breastfeeding and the use of human milk. Pediatrics. 2005; 115:496–506. [PubMed: 15687461]

Table 1

Sociodemographic Characteristics of Mothers Enrolling in the Study of Women Across the Nation–Heart Study*

	Consistent Lactation (n=121)	Inconsistent Lactation (n=84)	No Lactation (n=92)	*P*
Age (y)	50±3	51±3	51±3	.09
Live births	2±1	3±1	2±1	.03
Late perimenopausal/postmenopausal†	40 (33)	42 (50)	44 (48)	.02
African American	37 (26)	44 (52)	49 (53)	<.001
Education				<.001
High school or less	7 (6)	12 (14)	27 (29)	
Some college	27 (22)	26 (31)	36 (39)	
More than college graduate	87 (72)	46 (55)	29 (32)	
Financial strain	2 (2)	7 (8)	7 (8)	.04
Current smoker	11 (10)	11 (14)	18 (20)	.11
Physical activity	8.3±2	7.8±2	8.0±2	.09
Daily dietary intake				
Calories (kcal)	1,872 (1,453–2,246)	1,872 (1,394–2,352)	1,787 (1,424–2,353)	.94
Cholesterol (mg)	201 (143–264)	208 (144–254)	224 (163–304)	.10
Fat (g)	68 (51–86)	66 (43–85)	69 (51–92)	.80
Fiber (g)	12 (10–15)	11 (8–16)	9 (7–13)	<.001
Sodium (mg)	2,396 (1,826–2,973)	2,156 (1,546–2,826)	2,137 (1,567–2,575)	.07
Vitamin supplement	62 (53)	45 (59)	46 (53)	.67

Data are mean±standard deviation, n (%), or median (lower–upper interquartile range) unless otherwise specified.

P values are from analysis of variance, Kruskal-Wallis test, Student *t* tests, and χ^2 tests, as appropriate.

*Consistent lactation=breastfed all children for 3 months or more; inconsistent lactation=breastfed any child for less than 3 months.

†Amenorrhea for 3 or more consecutive months.

Table 2

Unadjusted Cardiovascular Characteristics of Mothers Enrolling in the Study of Women Across the Nation–Heart Study*

	Consistent Lactation (n=121)	Inconsistent Lactation (n=84)	No Lactation (n=92)	*P*
Aortic calcification greater than 79.5 Hounsfield units	20 (17)	18 (20)	36 (39)	<.001
Coronary calcification greater than 8.24 Hounsfield units	20 (17)	24 (29)	29 (32)	.03
Carotid plaque (% with any plaque)	12 (10)	14 (17)	17 (18)	.17
Adventitial diameter (mm)	6.63±0.59	6.72±0.62	6.87±0.60	.02
Intima–media thickness greater than 0.7225 (mm)	23 (19)	23 (27)	28 (30)	.13
Body mass index (kg/m^2)	24 (23–29)	26 (24–31)	27 (24–31)	.03
Systolic blood pressure (mm Hg)	115 (107–126)	113 (106–128)	120 (111–131)	.03
Diastolic blood pressure, median (mm Hg)	72 (68–81)	74 (68–81)	78 (72–84)	.02
Insulin (microunits/mL)	8 (7–13)	11 (8–15)	10 (8–15)	.03
Glucose (mg/dL)	87 (80–94)	90 (84–98)	88 (83–97)	.05
Total cholesterol (mg/dL)	193 (173–212)	192 (171–233)	197 (177–226)	.53
C-reactive protein (mg/dL)	1.5 (0.6–4.3)	2.0 (0.8–5.6)	2.3 (1.0–6.6)	.19

Data are n (%), mean±standard deviation, or range unless otherwise specified.

P values are from analysis of variance, Kruskal-Wallis test, Student *t* tests, and χ^2 tests, as appropriate.

*Consistent lactation=breastfed all children for 3 months or more; inconsistent lactation=breastfed any child for less than 3 months.

Table 3

Effect of Lactation on Maternal Aortic, Coronary, and Carotid Arteries*

Lactation	Aortic Calcification	Coronary Calcification	Carotid Plaque
Univariable (n=297)			
None	1.00 (ref)	1.00 (ref)	1.00 (ref)
Inconsistent	0.42 (0.22–0.83)	0.87 (0.46–1.66)	0.88 (0.41–1.92)
Consistent	0.31 (0.16–0.58)	0.43 (0.22–0.83)	0.49 (0.22–1.08)
Adjusted for age, parity, site (n=297)			
None	1.00 (ref)	1.00 (ref)	1.00 (ref)
Inconsistent	0.47 (0.24–0.93)	0.83 (0.43–1.61)	0.98 (0.44–2.22)
Consistent	0.32 (0.17–0.62)	0.45 (0.23–0.87)	0.57 (0.25–1.29)
Additionally adjusted† (n=247)			
None	1.00 (ref)	1.00 (ref)	1.00 (ref)
Inconsistent	0.61 (0.24–1.55)	0.71 (0.28–1.81)	1.46 (0.50–4.26)
Consistent	0.26 (0.10–0.68)	0.36 (0.14–0.95)	0.73 (0.23–2.32)
Additionally adjusted for body mass index‡ (n=245)			
None	1.00 (ref)	1.00 (ref)	1.00 (ref)
Inconsistent	0.56 (0.21–1.49)	0.72 (0.26–2.00)	1.35 (0.46–3.97)
Consistent	0.25 (0.09–0.69)	0.42 (0.15–1.21)	0.70 (0.22–2.23)
Additionally adjusted for traditional CV risk factors§ (n=206)			
None	1.00 (ref)	1.00 (ref)	1.00 (ref)
Inconsistent	0.34 (0.09–1.28)	0.96 (0.28–3.27)	0.75 (0.18–3.23)
Consistent	0.19 (0.05–0.68)	0.43 (0.13–1.49)	0.45 (0.11–1.84)

ref, reference; CV, cardiovascular.

Data are odds ratio (95% confidence interval).

*Consistent lactation=breastfed all children for 3 months or more; inconsistent lactation=breastfed any child for less than 3 months.

†Additionally adjusted for race, education, financial strain, smoking, menopausal status, physical activity, daily dietary intake (kcal) (natural log), daily dietary intake of fiber (g) (natural log), daily dietary intake of cholesterol (mg) (natural log), daily dietary intake of sodium (mg) (natural log), vitamin supplementation, perceived stress, depressed mood, and family history of diabetes, myocardial infarction, and stroke.

‡Body mass index categories were less than 25, 25–30, and 30 or greater.

§Traditional risk factor variables for cardiovascular disease include systolic blood pressure (natural log), triglycerides (natural log), total cholesterol, high-density lipoprotein (natural log), C-reactive protein (natural log), glucose (natural log), and insulin (natural log).

Table 4

Effect of Lactation on Maternal Measures of Carotid Wall Thickness*

Lactation	Adventitial Diameter (β)	Intima–Media Thickness
Univariable (n=297)		
None	1.00 (ref)	1.00 (ref)
Inconsistent	−0.15 (−0.33 to 0.03)	0.86 (0.45 to 1.66)
Consistent	−0.24 (−0.40 to −0.07)	0.54 (0.28 to 1.01)
Adjusted for age, parity, site (n=297)		
None	1.00 (ref)	1.00 (ref)
Inconsistent	−0.16 (−0.34 to 0.01)	0.78 (0.40 to 1.55)
Consistent	−0.22 (−0.38 to −0.06)	0.57 (0.29 to 1.09)
Additionally adjusted† (n=247)		
None	1.00 (ref)	1.00 (ref)
Inconsistent	−0.21 (−0.41 to −0.01)	0.68 (0.29 to 1.61)
Consistent	−0.13 (−0.32 to 0.06)	0.77 (0.33 to 1.78)
Additionally adjusted for body mass index‡ (n=245)		
None	1.00 (ref)	1.00 (ref)
Inconsistent	−0.19 (−0.38 to 0.004)	0.68 (0.28 to 1.69)
Consistent	−0.10 (−0.29 to 0.09)	0.75 (0.31 to 1.81)
Additionally adjusted for traditional CV risk factors§ (n=206)		
None	1.00 (ref)	1.00 (ref)
Inconsistent	−0.12 (−0.35 to 0.11)	0.79 (0.27 to 2.32)
Consistent	−0.04 (−0.26 to 0.18)	0.93 (0.33 to 2.67)

ref, reference; CV, cardiovascular.

Data are odds ratio (95% confidence interval).

*Consistent lactation=breastfed all children for 3 months or more; inconsistent lactation=breastfed any child for less than 3 months.

†Additionally adjusted for race, education, financial strain, smoking, menopausal status, physical activity, daily dietary intake (kcal) (natural log), daily dietary intake of fiber (g) (natural log), daily dietary intake of cholesterol (mg) (natural log), daily dietary intake of sodium (mg) (natural log), vitamin supplementation, perceived stress, depressed mood, and family history of diabetes, myocardial infarction, and stroke.

‡Body mass index categories were less than 25, 25–30, and 30 or greater.

§Traditional risk factor variables for cardiovascular disease include systolic blood pressure (natural log), triglycerides (natural log), total cholesterol, high-density lipoprotein (natural log), C-reactive protein (natural log), glucose (natural log), and insulin (natural log).