

# Lactation Among Adolescent Mothers and Subsequent Bone Mineral Density

Caroline J. Chantry, MD; Peggy Auinger, MS; Robert S. Byrd, MD, MPH

**Objective:** To investigate the association of breastfeeding during adolescence with bone mineral density (BMD) during young adulthood.

**Methods:** Secondary analysis of data from the National Health and Nutrition Examination Survey III, a nationally representative cross-sectional survey conducted from 1988 through 1994, was performed. The BMDs for 5 regions of the proximal femur as measured by dual energy x-ray absorptiometry were compared for 5 groups of women aged 20 to 25 years (n=819); the groups included those who had been: (1) adolescent mothers and had breastfed (n=94), (2) adolescent mothers and had not breastfed (n=151), (3) mothers who first gave birth as adults and breastfed (n=67), (4) mothers who first gave birth as adults and had not breastfed (n=89), and (5) nulliparous (n=418). SUDAAN software was used to account for the complex sampling design of the National Health and Nutrition Examination Survey. Adjusted mean differences in BMD were estimated using least-squares linear regression.

**Results:** During young adulthood, women who breastfed during adolescence had higher adjusted BMDs, which was statistically significant in 4 of the 5 regions, than those who had not breastfed (total proximal femur area difference, 0.049 gm/cm<sup>2</sup> [95% confidence interval, 0.002-0.095]) and BMDs equivalent to nulliparous women (total proximal femur area difference, 0.024 gm/cm<sup>2</sup> [95% confidence interval, -0.023 to 0.071]). Adjusting also for obstetric variables, women who breastfed during adolescence had higher BMDs in all 5 regions compared with their peers who had not breastfed (total proximal femur area difference, 0.053 gm/cm<sup>2</sup> [95% confidence interval, 0.029-0.077]).

**Conclusions:** In this nationally representative sample, breastfeeding by adolescent mothers was associated with greater BMD in the proximal femur during young adulthood. Lactation was not found to be detrimental and may be protective to the bone health of adolescent mothers.

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From the Department of Pediatrics at the University of California Davis Medical Center, Sacramento (Drs Chantry and Byrd); and the American Academy of Pediatrics Center for Child Health Research and the Department of Pediatrics at the University of Rochester School of Medicine and Dentistry, Rochester, NY (Ms Auinger).

**N**EARLY 500 000 ADOLESCENTS gave birth to live infants in the United States in 2002; approximately 35% of the adolescents were 17 years or younger.<sup>1</sup> Evidence that growing teenagers bear infants of lower mean birth weight than those no longer growing suggests that the pregnant adolescent's ability to meet the metabolic needs of herself and the fetus may be compromised.<sup>2</sup> Parallel information regarding adolescents' ability to breastfeed their infants without compromising their own or their infants' nutritional status is limited. Specifically, the long-term effect of breastfeeding on adolescent mothers' bone mineral density (BMD) is unknown.

The relationship between lactation and bone density in adult women is incompletely understood. During lactation, BMD decreases; bone loss during lac-

tation is physiologic, independent of dietary calcium, and associated with parathyroid hormone-related peptide produced by the mammary gland under the influence of prolactin in response to suckling.<sup>3-5</sup> A longitudinal study of 69 lactating women in Japan by Honda et al<sup>6</sup> described a decrement in mean  $\pm$  SD bone density of lumbar vertebrae measured by dual energy x-ray absorptiometry (DEXA) to 95.1%  $\pm$  0.5% of postpartum baseline at 3 months and 94.1%  $\pm$  0.7% at 6 months postpartum. This rate of BMD loss is faster than occurs postmenopausally (>4% loss during the first 3 months of lactation vs approximately 1% per year in the postmenopausal woman). Rate of bone loss during lactation varies per anatomical site; up to 9% of the bone density at trabecular rich sites may be lost.<sup>7</sup> Most studies show that bone loss occurring during lactation is reversed after resumption of menses,<sup>7-9</sup> but evidence is conflicting with some

studies showing incomplete recovery<sup>10</sup> and others a long-term increase in BMD in lactating women.<sup>11,12</sup> Recovery may take as long as 12 to 18 months and is likely to depend on the length of both lactation and postpartum amenorrhea and the specific skeletal site.<sup>13</sup> A need for further research into the relationship between lactation, BMD, and the risk of osteoporosis has been noted.<sup>14</sup>

Only 1 human study to date examined bone density in lactating teenagers.<sup>15</sup> Loss of forearm bone mineral content averaged 15% between 2 and 16 weeks postpartum in 12 lactating adolescents compared with no loss in 11 lactating adults or in 11 nonlactating adolescent mothers. Bone mineral content recovery after weaning was not assessed. This suggests that adolescents, who are still acquiring bone mass, might be more vulnerable to BMD loss than adults. The objective of this study was to use existing data to evaluate the association of breastfeeding in adolescence with subsequent BMD during young adulthood.

## METHODS

### SUBJECT SELECTION

Secondary analysis of data from the National Health and Nutrition Examination Survey III<sup>16</sup> (NHANES III), a population-based cross-sectional survey of US household residents aged 2 months and older conducted from 1988 through 1994, was performed. The NHANES is designed to be nationally representative of the noninstitutionalized, civilian population. For this study, women aged 20 to 25 years with available DEXA information (n=819) were divided into 5 groups as follows: (1) mothers who gave birth during adolescence (<20 years) and lactated (n=94); (2) mothers who gave birth during adolescence and did not lactate (n=151); (3) mothers who first gave birth as adults (≥20 years) and lactated (n=67); (4) mothers who first gave birth as adults and did not lactate (n=89); and (5) nulliparous women (n=418). There were 305 women in the age range 20 to 25 years who were excluded because of missing DEXA information (n=278; 70 of whom reported being pregnant), current breastfeeding (n=26), or pregnancy (n=1; woman who reported being pregnant and had a DEXA scan). Bone scans were not performed if women reported being pregnant, had a positive pregnancy test, said they didn't know if they were pregnant (regardless of pregnancy test result), or had both hips broken in the past, surgically pinned or replaced with implants. These 305 women were different from the 819 women in the study in race/ethnicity, smoking, lifetime oral contraceptive use, and parity.

Further analysis compared only the 2 groups of women who had been adolescent mothers. This 2-group analysis had a total sample size of 245 women. Of the 94 mothers who gave birth as adolescents and reported having breastfed, 41 reported having given birth to more infants than they had breastfed. As these mothers potentially had breastfed during adulthood only, additional analyses were performed excluding these 41 women, resulting in a sample size of 53 in the group of mothers who breastfed as adolescents, a sample size of 778 for the 5-group comparison, and a sample size of 204 for the 2-group analysis.

### BREASTFEEDING DEFINITION

Maternal breastfeeding history was categorized as yes or no, as limited quantification of breastfeeding is provided in the

NHANES III. Exclusivity of breastfeeding (ie, use of supplemental feeds) was asked only in the second phase of the study; use of this information would therefore have further restricted our sample size. Duration of breastfeeding is provided only as more or less than 1 month, but because exclusivity was not provided, we chose not to differentiate between mothers who breastfed more or less than 1 month. Our rationale was that a dose-dependent effect would likely relate to both exclusivity and duration; for example, exclusive breastfeeding for 1 month is likely to be of equal or greater physiologic significance than token breastfeeding for 2 months.

### BONE MINERAL DENSITY

The BMDs for 5 regions of the proximal femur (femoral neck, trochanter, intertrochanter, Ward triangle, and total region) as measured by DEXA were compared. The Ward triangle was measured differently in the 2 phases of the NHANES III because of a change in the software used to process data. Accordingly, combining the Ward triangle data from the 2 phases may not be appropriate and only data for the Ward triangle from the second phase of the NHANES III (1991-1994) were used. All 5 regions were compared because they are metabolically and/or functionally distinct.

### POTENTIAL CONFOUNDING VARIABLES

Variables adjusted for in this analysis include age; race/ethnicity (white, African American, or Mexican American); socioeconomic status (family income less than the federal poverty level, near poverty [income 100% to ≤200% of the federal poverty level], or >200% of the federal poverty level); exercise (mean number of episodes per week further weighted for vigor by the NHANES<sup>17</sup>); current smoking; alcohol use (none, light [mean intake ≤1 standard drink/wk] or moderate to heavy drinking); lifetime oral contraceptive use (number of months); weight; height; diet (lifetime milk use as a child, adolescent, and adult [coded on a Likert scale from 0-6, with 0 for no milk use and 6 indicating >1 serving/d] and current intake of protein, calcium, calcium-phosphorous ratio, vitamin D, and potassium calculated from 24-hour dietary recall); and age at menarche. Additional 2-group comparison of only adolescent mothers also included parity and number of years since most recent birth. All variables were chosen either because they have been previously demonstrated to affect BMD or because they were associated with BMD in our bivariate analyses.

### STATISTICAL ANALYSIS

Taylor linearization using SUDAAN software accounted for stratum and primary sampling units in the complex sampling design of the NHANES.<sup>18</sup> Least-squares linear regression was adjusted for potentially confounding variables. Statistical comparisons were made using both the women who had been adolescent mothers and did not breastfeed and nulliparous women as referent; results are presented using the adolescent mothers who did not breastfeed as referent unless otherwise stated. To describe the association between BMD and a given variable independent of all other covariates in the model, difference in least-squares mean BMD (95% confidence interval [CI]) is presented.

## RESULTS

Demographic, lifestyle, anthropometric, and obstetric characteristics of the 5 groups are presented in **Table 1**. As expected by our study design, mothers who first gave

**Table 1. Demographic, Lifestyle, and Obstetric Variables of National Health and Nutrition Examination Survey III Women Aged 20 to 25 Years by Adolescent Birth and Breastfeeding Status\***

	Adolescent Mothers		Adult Mothers		Nulliparous Women (n = 418)
	Breastfed (n = 94)	Did Not Breastfeed (n = 151)	Breastfed (n = 67)	Did Not Breastfeed (n = 89)	
Age, y	22.6 (0.3)	22.5 (0.2)	23.3 (0.3)	23.1 (0.2)	22.2 (0.2)
Race/ethnicity, %					
White	74	44	71	63	74
African American	10	35	12	24	11
Mexican American	14	9	9	7	5
Other	2	12	8	5	10
Poverty status, %					
Below poverty level, <100%	43	37	15	24	18
Near poverty, 100% to ≤200%	34	52	30	37	19
Above poverty level, >200%	23	11	55	39	63
No. of exercise sessions/wk	3.4 (0.6)	2.8 (0.3)	3.1 (0.7)	1.7 (0.4)	3.9 (0.3)
Smoker, %	58	47	37	40	32
Alcohol intake, %					
None	65	53	50	53	36
Light†	23	13	17	23	20
≥Moderate	12	34	33	24	44
Oral contraceptive pill use, mo	26.3 (3.6)	30.7 (3.0)	22.1 (3.4)	27.5 (4.6)	29.7 (2.8)
Postpartum years	2.8 (0.2)	3.0 (0.2)	1.5 (0.2)	1.3 (0.1)	NA
Parity	1.8 (0.1)	1.8 (0.1)	1.3 (0.1)	1.3 (0.1)	NA
Age at menarche, y	12.4 (0.3)	12.4 (0.1)	13.0 (0.3)	12.9 (0.2)	12.6 (0.1)
Age at first birth, y	17.7 (0.2)	17.5 (0.1)	21.4 (0.3)	21.2 (0.2)	NA
No. of pregnancies, %					
1	30	34	62	51	72
>1	70	66	38	49	23
Weight, kg	63.7 (2.7)	67.6 (2.3)	65.4 (2.9)	62.9 (2.5)	62.4 (0.8)
Height, cm	163.6 (1.2)	162.0 (1.0)	160.4 (0.8)	162.0 (1.1)	163.7 (0.4)
Dietary intake					
Potassium, mg	2533.5 (248.7)	1967.5 (140.5)	2136.9 (160.5)	1933.6 (127.1)	2265.4 (67.5)
Protein, g	75.9 (9.9)	64.9 (4.8)	68.8 (5.7)	65.9 (4.8)	67.3 (2.5)
Calcium, mg	768.8 (69.2)	658.1 (68.9)	758.1 (68.1)	693.4 (59.7)	752.7 (35.7)
Vitamin D, mg	3.5 (0.5)	3.4 (0.5)	4.5 (0.8)	3.8 (0.4)	3.9 (0.4)
Calcium-phosphorous ratio	0.65 (0.03)	0.62 (0.02)	0.64 (0.05)	0.65 (0.04)	0.67 (0.02)
Lifetime milk‡					
Child	4.4 (0.1)	4.5 (0.1)	4.5 (0.2)	4.3 (0.1)	4.1 (0.1)
Teen	3.8 (0.2)	3.6 (0.3)	3.8 (0.2)	3.7 (0.2)	3.7 (0.1)
Adult	3.3 (0.2)	3.3 (0.2)	3.6 (0.1)	3.3 (0.3)	3.0 (0.1)

Abbreviation: NA, not applicable.

\*Values expressed as mean (SE) unless otherwise indicated.

†Light alcohol intake is defined as mean intake of 1 or fewer standard drink per week.

‡Lifetime milk is coded on a Likert scale from 0-6, with 0 for no milk use and 6 indicating more than 1 serving per day.

birth as adults (adult mothers) are slightly older than the referent group as by definition they first gave birth after their 20th birthday. Similarly, they had a lower mean parity and fewer postpartum years than adolescent mothers, but there was little difference between the 2 groups of adolescent mothers in any of the obstetric variables. Adolescent mothers who did not breastfeed had a different distribution of race/ethnicity than both groups of breastfeeding mothers and nulliparous women. Specifically, both groups of mothers who chose to breastfeed were more likely to be white and less likely to be African American than adolescent mothers who did not breastfeed, in accordance with breastfeeding patterns at other ages. Socioeconomic status also differed with less poverty among nulliparous women and both groups of adult mothers than the referent group, but there was little difference between the 2 groups of adolescent mothers. Nulliparous women exercised more and the adult mothers who did not breastfeed exercised less than their peers who

gave birth during adolescence, but again, there was little difference between the 2 groups of adolescent mothers. There were no important differences in smoking, drinking, or oral contraceptive use among the groups. There were also no notable differences among groups in dietary variables, with the exception of potassium. Mothers who had breastfed as adolescents reported greater potassium intake compared with those who had not breastfed. Statistically, only nulliparous women weighed less than the referent group; the 4 groups of mothers differed less in weight. Height did not vary substantially by group.

In unadjusted analyses, there were no statistically significant group differences in mean BMD in 4 of the 5 regions, as presented in **Table 2**. Only the Ward triangle demonstrated statistically significant between-group differences in unadjusted BMD where it was greater in both mothers who breastfed as adolescents (mean, 0.86 g/cm<sup>2</sup> [95% CI, 0.79-0.92]) and nulliparous women

**Table 2. Unadjusted Mean Bone Mineral Density in the Proximal Femur of National Health and Nutrition Examination Survey III Women Aged 20 to 25 Years by Adolescent Birth and Breastfeeding Status\***

	Adolescent Mothers		Adult Mothers		Nulliparous Women (n = 418)
	Breastfed (n = 94)	Did Not Breastfeed (n = 151)	Breastfed (n = 67)	Did Not Breastfeed (n = 89)	
Femoral neck	0.90 (0.86 to 0.94)	0.88 (0.84 to 0.92)	0.87 (0.81 to 0.93)	0.84 (0.80 to 0.88)	0.87 (0.85 to 0.89)
Trochanter	0.73 (0.71 to 0.75)	0.71 (0.67 to 0.75)	0.70 (0.66 to 0.74)	0.68 (0.64 to 0.72)	0.72 (0.70 to 0.74)
Intertrochanter	1.14 (1.10 to 1.18)	1.11 (1.07 to 1.15)	1.09 (1.03 to 1.15)	1.07 (1.03 to 1.11)	1.11 (1.09 to 1.13)
Ward triangle	0.86 (0.79 to 0.92)	0.75 (0.69 to 0.80)	0.82 (0.73 to 0.91)	0.79 (0.73 to 0.85)	0.82 (0.80 to 0.84)
Total region	0.98 (0.94 to 1.02)	0.96 (0.92 to 1.00)	0.94 (0.88 to 1.00)	0.92 (0.53 to 1.31)	0.95 (0.93 to 0.97)

\*Values are expressed as mean (95% confidence interval). Bone mineral density is expressed in grams per centimeter squared.

**Table 3. Independent Associations With Bone Mineral Density in the Proximal Femur of National Health and Nutrition Examination Survey III Women Aged 20 to 25 Years by Adolescent Birth and Breastfeeding Status\***

	Adolescent Mothers		Adult Mothers		Nulliparous Women
	Breastfed	Did Not Breastfeed	Breastfed	Did Not Breastfeed	
Femoral neck	0.053 (0.003 to 0.104)	Referent	0.056 (-0.010 to 0.120)	-0.010 (-0.051 to 0.032)	0.024 (-0.013 to 0.062)
Trochanter	0.027 (-0.012 to 0.066)	Referent	0.031 (-0.017 to 0.079)	-0.015 (-0.057 to 0.027)	0.013 (-0.018 to 0.044)
Intertrochanter	0.059 (0.006 to 0.111)	Referent	0.052 (-0.019 to 0.123)	0.005 (-0.039 to 0.050)	0.039 (0.002 to 0.076)
Ward triangle	0.119 (0.050 to 0.188)	Referent	0.160 (0.067 to 0.253)	0.080 (0.017 to 0.144)	0.086 (0.033 to 0.140)
Total region	0.049 (0.002 to 0.095)	Referent	0.047 (-0.013 to 0.107)	-0.002 (-0.041 to 0.037)	0.025 (-0.009 to 0.058)

\*Values are expressed as the difference in mean adjusted bone mineral density (95% confidence interval) from the referent group. Breastfeeding adolescent mothers vs nulliparous women had no statistically significant difference in any region. Variables adjusted for include exercise; race/ethnicity; age; poverty level; smoking; alcohol intake; lifetime milk use; current dietary intake of calcium, potassium, protein, vitamin D, and calcium-phosphorous ratio; age at menarche; weight; height; and lifetime oral contraceptive use.

(mean, 0.82 g/cm<sup>2</sup> [95% CI, 0.80-0.84]) compared with the women who were adolescent mothers and did not breastfeed (mean, 0.75 g/cm<sup>2</sup> [95% CI, 0.69-0.80]). Adjusting for demographic, anthropometric, and lifestyle variables revealed that mothers who breastfed as adolescents had higher BMDs than women who had been non-breastfeeding adolescent mothers (difference in adjusted mean BMD in the total area, 0.049 g/cm<sup>2</sup> [95% CI, 0.002-0.095]) and BMDs equivalent to nulliparous women (difference in total area adjusted mean BMD, 0.024 g/cm<sup>2</sup> [95% CI, -0.023 to 0.071]). The difference between the 2 groups who had been adolescent mothers was statistically significant in 4 of the 5 regions in this 5-group comparison (**Table 3**).

Additional 2-group comparisons of women who gave birth as adolescents and did or did not breastfeed was also controlled for parity and postpartum interval. Mothers who had breastfed had higher adjusted mean BMDs, which was statistically significant in all 5 regions measured. **Table 4** presents the difference in mean BMD for each variable in the model when adjusting for all other covariates in the model in each of the 5 regions. In addition to breastfeeding, weight was the only variable to show a consistent association across all 5 regions. As expected, race/ethnicity was strongly associated with BMD. African American women had statistically significant higher adjusted BMDs in 4 of the 5 regions; the magnitude of the association of breastfeeding with BMD in the total area (mean BMD, 0.053 g/cm<sup>2</sup> [95% CI, 0.029-0.077]) approached that associated with being African American (mean BMD, 0.061 g/cm<sup>2</sup> [95% CI,

0.011-0.111]). Postpartum interval and exercise also had a statistically significant positive association with BMD in most of the 5 regions. Smoking and alcohol use were negatively associated and adult milk intake was positively associated with BMD only in the Ward triangle, the most metabolically active of the 5 regions. Poverty, dietary variables, and height had less consistent effects. Differences in adjusted mean BMD for the 2 groups of women who were adolescent mothers are: femoral neck, 0.063 g/cm<sup>2</sup> (95% CI, 0.034-0.092); trochanter, 0.039 g/cm<sup>2</sup> (CI 95%, 0.014-0.064); intertrochanter, 0.059 g/cm<sup>2</sup> (95% CI, 0.028-0.090); Ward triangle, 0.082 g/cm<sup>2</sup> (95% CI, 0.037-0.127); and total area, 0.053 g/cm<sup>2</sup> (95% CI, 0.029-0.077).

Further analysis excluded the 41 women who had been adolescent mothers and gave birth to more infants than they had breastfed because it could not be absolutely ascertained that they breastfed during adolescence. This analysis revealed similar results to those presented earlier, which included all women who had been adolescent mothers and ever breastfed; all 5 areas of the proximal femur demonstrated statistically significant higher adjusted BMDs in women who gave birth as adolescents and breastfed vs those who had not breastfed. In fact, with this smaller group of women who had been adolescent mothers and had breastfed all of their children (n=53), the difference in the adjusted mean when compared with their counterparts who had never breastfed was even greater in 3 of the 5 regions than in the previous analysis (femoral neck, 0.048 g/cm<sup>2</sup> [95% CI, 0.003-0.093]; trochanter, 0.049 g/cm<sup>2</sup> [95% CI, 0.015-0.084]; intertrochanter, 0.062 g/cm<sup>2</sup> [95% CI, 0.019-0.105]; Ward

**Table 4. Independent Associations With Bone Mineral Density in the Proximal Femur of National Health and Nutrition Examination Survey III Women Aged 20 to 25 Years—Adolescent Mothers Only\***

	Femoral Neck	Trochanter	Intertrochanter	Ward Triangle	Total Region
Breastfed†	0.063 (0.034 to 0.092)	0.039 (0.014 to 0.064)	0.059 (0.028 to 0.090)	0.082 (0.037 to 0.127)	0.053 (0.029 to 0.077)
Exercise	0.005 (−0.0002 to 0.010)	0.005 (0.0001 to 0.010)†	0.012 (0.006 to 0.018)†	−0.0001 (−0.005 to 0.005)	0.009 (0.003 to 0.01)†
Race/ethnicity					
White (referent)	0	0	0	0	0
African American	0.085 (0.040 to 0.130)†	0.039 (−0.010 to 0.087)	0.079 (0.021 to 0.138)†	0.111 (0.058 to 0.164)	0.061 (0.011 to 0.111)
Mexican American	0.046 (0.006 to 0.086)†	0.002 (−0.033 to 0.036)	0.004 (−0.046 to 0.053)	0.074 (0.027 to 0.122)	0.009 (−0.031 to 0.049)
Other	−0.010 (−0.099 to 0.080)	−0.012 (−0.089 to 0.065)	−0.048 (−0.127 to 0.032)	0.020 (−0.053 to 0.093)	−0.027 (−0.098 to 0.044)
Age, y					
20	0.009 (−0.082 to 0.101)	−0.028 (−0.088 to 0.033)	−0.010 (−0.091 to 0.071)	0.093 (0.004 to 0.182)†	−0.014 (−0.090 to 0.061)
21	0.039 (−0.028 to 0.107)	0.007 (−0.050 to 0.063)	0.036 (−0.038 to 0.109)	−0.031 (−0.096 to 0.035)	0.028 (−0.031 to 0.086)
22	0.004 (−0.046 to 0.053)	−0.014 (−0.067 to 0.040)	0.022 (−0.040 to 0.083)	−0.015 (−0.092 to 0.063)	0.012 (−0.038 to 0.062)
23	0.010 (−0.043 to 0.062)	−0.005 (−0.063 to 0.053)	0.021 (−0.048 to 0.090)	−0.035 (−0.098 to 0.029)	0.008 (−0.049 to 0.065)
24	0.006 (−0.050 to 0.061)	−0.027 (−0.079 to 0.026)	0.021 (−0.043 to 0.085)	−0.002 (−0.076 to 0.072)	0.002 (−0.049 to 0.052)
25 (referent)	0	0	0	0	0
Poverty level					
Below	0.061 (−0.002 to 0.124)	0.025 (−0.029 to 0.079)	0.072 (0.009 to 0.136)†	0.040 (−0.043 to 0.123)	0.065 (0.008 to 0.122)†
Near	0.008 (−0.056 to 0.071)	−0.028 (−0.079 to 0.022)	−0.001 (−0.056 to 0.055)	−0.111 (−0.181 to 0.042)†	−0.003 (−0.056 to 0.051)
Above (referent)	0	0	0	0	0
Smoking	0.013 (−0.025 to 0.051)	0.001 (−0.037 to 0.038)	−0.001 (−0.048 to 0.046)	0.116 (0.078 to 0.153)	−0.0002 (−0.039 to 0.038)
Alcohol					
None	0.030 (−0.030 to 0.089)	0.006 (−0.065 to 0.077)	−0.001 (−0.080 to 0.078)	−0.059 (−0.115 to −0.003)†	0.010 (−0.061 to 0.082)
Light (referent)	0	0	0	0	0
Moderate	−0.022 (−0.063 to 0.019)	−0.042 (−0.087 to 0.004)	−0.026 (−0.087 to 0.035)	−0.069 (−0.121 to −0.017)†	−0.030 (−0.080 to 0.021)
Milk use					
Child	−0.010 (−0.035 to 0.014)	−0.013 (−0.033 to 0.006)	−0.015 (−0.044 to 0.014)	−0.034 (−0.057 to −0.011)†	−0.014 (−0.038 to 0.011)
Teen	0.007 (−0.015 to 0.029)	0.015 (−0.005 to 0.036)	0.004 (−0.025 to 0.032)	0.011 (−0.010 to 0.131)	0.010 (0.016 to 0.035)
Adult	0.010 (−0.004 to 0.024)	0.001 (−0.012 to 0.014)	0.005 (−0.014 to 0.024)	0.026 (0.010 to 0.043)†	0.004 (−0.011 to 0.018)
Diet					
Calcium, mg	−0.0001 (−0.0001 to 0.00001)	−0.0001 (−0.0002 to 0.00002)†	−0.0001 (−0.0002 to 0.0002)	−0.0001 (−0.0001 to 0.00005)	−0.0001 (−0.0002 to 0.000003)
Calcium-phosphorous ratio	0.061 (−0.060 to 0.182)	0.102 (0.010 to 0.194)†	0.019 (−0.119 to 0.156)	0.103 (−0.025 to 0.230)	0.056 (−0.058 to 0.170)
Potassium, mg	−0.000002 (−0.00002 to 0.00002)	0.0001 (−0.0001 to 0.0003)	−0.00001 (−0.00003 to 0.00001)	−0.00003 (−0.001 to −0.00001)†	−0.0001 (−0.0003 to 0.0001)
Protein, g	0.001 (−0.0003 to 0.001)	0.001 (−0.0002 to 0.001)	0.001 (−0.0003 to 0.001)	0.001 (−0.0003 to 0.001)	0.001 (−0.0003 to 0.001)
Vitamin D, mg	0.006 (−0.002 to 0.013)	0.007 (0.001 to 0.012)†	0.004 (−0.003 to 0.012)	0.002 (−0.005 to 0.010)	0.005 (−0.001 to 0.012)
Postpartum years	0.019 (0.007 to 0.032)†	0.014 (0.003 to 0.024)†	0.017 (0.003 to 0.030)†	−0.006 (−0.022 to 0.100)	0.016 (0.005 to 0.028)†
Weight, kg	0.004 (0.002 to 0.005)†	0.002 (0.001 to 0.003)†	0.005 (0.004 to 0.006)†	0.002 (0.001 to 0.004)†	0.004 (0.003 to 0.005)†
Height, cm	0.004 (0.001 to 0.006)†	0.001 (−0.001 to 0.003)	0.0004 (−0.003 to 0.004)	0.002 (−0.001 to 0.004)	0.001 (−0.001 to 0.004)
Parity, No. of births					
1 (referent)	0	0	0	0	0
2	−0.005 (−0.060 to 0.050)	−0.020 (−0.076 to 0.037)	−0.018 (−0.085 to 0.048)	−0.032 (−0.091 to 0.028)	−0.020 (−0.080 to 0.40)
3	0.005 (−0.048 to 0.057)	0.002 (−0.065 to 0.069)	−0.016 (−0.079 to 0.048)	0.006 (−0.067 to 0.079)	−0.011 (−0.074 to 0.051)
≥4	−0.010 (−0.109 to 0.088)	−0.001 (−0.061 to 0.059)	0.028 (−0.076 to 0.132)	−0.056 (−0.166 to 0.054)	0.005 (−0.082 to 0.092)
Oral contraceptive use, mo	−0.0004 (−0.001 to 0.0002)	0.0001 (−0.0003 to 0.0005)	−0.0004 (−0.001 to 0.0004)	−0.0004 (−0.001 to 0.0004)	−0.0003 (−0.001 to 0.0003)
Age at menarche, y	−0.003 (−0.014 to 0.009)	0.004 (−0.006 to 0.013)	0.002 (−0.009 to 0.013)	−0.009 (−0.024 to 0.007)	0.001 (−0.009 to 0.011)

\*Values are expressed as the difference in the mean adjusted bone mineral density (95% confidence interval).

†Statistically significant difference.

triangle, 0.079 g/cm<sup>2</sup> [95% CI, 0.024-0.133]; and total area, 0.056 g/cm<sup>2</sup> [95% CI, 0.020-0.093]).

### COMMENT

Young women who had breastfed as adolescent mothers in this nationally representative sample had a greater adjusted BMD in all 5 regions of the proximal femur compared with those who were adolescent mothers and did not breastfeed. This difference was statistically significant in all 5 areas and suggests that adolescent mothers who breastfeed subsequently replete their BMD, perhaps even to an extent greater than that at baseline. Adjusted BMD between ages 20 and 25 years was actually 5% to 10% higher in the women who breastfed as adolescents compared with their counterparts who did not breastfeed. The femoral neck may have the most functional significance because it is the area most commonly fractured in the elderly population with osteoporosis.<sup>19</sup> The trochanter, mostly cortical bone and metabolically less active, is the second most commonly

fractured area.<sup>20</sup> The Ward triangle is a primarily trabecular, metabolically active bone and therefore is affected earlier and more dramatically when physiologic changes result in either loss or gain of bone mineral. The total region is affected most similarly to the intertrochanter region because the latter is the largest region of the proximal femur.

Five percent to 10% is a large difference in BMD that could have a substantial effect on osteoporosis as these women age. It is commonly accepted that higher peak BMD achieved during adolescence protects against postmenopausal osteoporosis,<sup>21</sup> and there is a strong inverse relationship between BMD and incidence of fracture in postmenopausal women.<sup>22</sup> Adolescent habits are particularly critical for peak BMD in the hip; different skeletal sites achieve peak bone mass at different ages, the hip being earliest to peak at 16 to 18 years of age.<sup>23</sup> Our findings suggest that an adolescent mother who breastfeeds will subsequently have, on average, 7% higher BMD in her femoral neck, thereby protecting against hip fractures for as many postmenopausal years during which women lose approxi-

mately 1% of BMD per year.<sup>24,25</sup> Epidemiological evidence to support such protection is noted in a case-control study in the United States of 23 cases of postmenopausal women with hip fractures and nearly 500 controls, which reported an adjusted odds ratio of 0.5 (95% CI, 0.2-0.9) per 12-month increase in lifetime breastfeeding.<sup>26</sup> Similarly, the bulk of evidence suggests a positive association between breastfeeding history and BMD in the femoral neck, total hip, and lumbar spine,<sup>27-29</sup> although some controlled studies have not demonstrated such an association.<sup>30-32</sup> Our findings lend credence to longitudinal studies that report full recovery or even an increase in BMD in adult women after lactation.<sup>7-9,11,12</sup> The study by Polatti et al<sup>12</sup> in Italy notes a slightly greater percentage increase in spine and radial BMD in more than 200 lactating women vs nonlactating women with a mean age of approximately 30 years at 18 months postpartum (12 months after weaning); Laskey and Prentice<sup>11</sup> in the United Kingdom demonstrated increased whole-body bone mineral in 59 women who had breastfed and were at least 3 months postweaning, with variation in degree of recovery at different sites (incomplete, partial, or greater than baseline). Of note is a longitudinal study in a nonhuman primate model of adolescent human pregnancy and lactation that demonstrated young primates restore bone mass after weaning to values similar to those in the nulliparous group.<sup>33</sup>

It is plausible that the effect of breastfeeding may be dependent on the age at which one breastfeeds. The mechanism of BMD repletion postweaning is not well delineated but is presumed to be due to reversal of the hormonal alterations that cause bone loss during lactation (eg, restoration of normal estrogen levels) and reduction in the parathyroid hormone-related peptide and prolactin levels.<sup>34</sup> Additionally, levels of parathormone and 1,25-dihydroxyvitamin D have inconsistently been found to be elevated postweaning.<sup>12,35,36</sup> Perhaps, the physiologic effect of these fluxes is more dramatic at an age when bone mineral is normally still accruing.

There were few associations between reported dietary intake and BMD in this study. Other studies have reported like findings,<sup>37</sup> noting that failure to find a relationship between bone mass and diet in a generally well-nourished population does not mean that adequate intakes are unimportant for bone health. Also, measurement of intake by dietary recall has known limitations.<sup>38,39</sup> For example, potassium intake has been shown to be associated with BMD.<sup>40</sup> But 1 study in prepubertal children reports an association between urinary potassium levels and BMD and between urinary potassium levels and potassium intake but not directly between potassium intake and BMD.<sup>41</sup> The interpretation of this was that the food frequency questionnaire had inadequate accuracy to detect a causal association in this instance.

This study has several limitations; the first is there may be a confounding variable for which we have not controlled. One such possibility would be whether these women were breastfed themselves, as suggested by a report that notes 8-year-old children who were breastfed longer than 3 months have higher BMDs than their formula-fed counterparts.<sup>42</sup> We were unable to control for this variable but attempted to control for all other po-

### What This Study Adds

There is a physiologic loss of BMD during lactation, previously noted to be greater in adolescent than adult mothers. There is conflicting evidence in adult mothers and no evidence in adolescent mothers regarding the degree of recovery after weaning and association of lactation with subsequent BMD and risk for osteoporosis in later life.

This is the first study to evaluate the association of breastfeeding history and BMD in young women who were adolescent mothers. We report adjusted BMD in young women who were adolescent mothers and lactated to be greater in all 5 areas of the proximal femur compared with their peers who did not lactate and equivalent to that of nulliparous women. This evidence documents that breastfeeding in adolescence poses no risk to, and may protect, the bone health of young mothers.

tentially confounding demographic and lifestyle variables that have been shown to be significant in previous studies. Caffeine was not included as the bulk of evidence now indicates it is not associated independently with BMD<sup>43,44</sup>; furthermore, caffeine intake was not different among our 5 groups of women.

A second limitation of this study is the cross-sectional nature of the NHANES III. The cross-sectional design of our study limits the ability to determine causation. Longitudinal studies will be necessary to confirm long-term changes in BMD attributable to breastfeeding in adolescent mothers. There could possibly be bias introduced by the exclusion of women who did not have available DEXA information. Another limitation of this study is the moderate sample size of breastfeeding teenagers (n=94). Sample size for the Ward triangle was further limited by the change in methods (n=45) and may explain why most of the unexpected associations with BMD were in this region.

Our ability to control for dietary factors is also limited. As mentioned earlier, dietary variables were based on 24-hour dietary recall, a method known to have limitations in accuracy, and self-report of milk use as a child, adolescent, and adult, likely to have greater limitations. Furthermore, current diet may not accurately reflect previous diet. This inaccuracy may contribute to some of the unexpected negative associations between BMD and diet in this study. Finally, it is also limiting that breastfeeding duration is poorly quantified for mothers in the NHANES III. It would be important to know if a minimum amount (exclusivity and/or duration) of breastfeeding is required to significantly affect BMD for an individual adolescent.

Extensive research documents diverse advantages of breastfeeding for both mother and infant.<sup>45-47</sup> Improved bone remineralization post partum and reducing the risk for osteoporosis for the mother are often cited as advantages, but actual evidence has been conflicting, as described earlier. This study provides evidence that breastfeeding among adolescent mothers poses no risk to BMD and may result in substantial long-term benefit to their bone health.

## CONCLUSIONS

Young adult women who were mothers as adolescents in this nationally representative sample and who breastfed had statistically significant greater BMDs than those who did not breastfeed and BMDs equivalent to nulliparous women. These findings confirm that lactation is not detrimental to the bone health of adolescents and may be protective. This protective effect should be confirmed by future longitudinal studies.

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Correspondence: Caroline J. Chantry, MD, Department of Pediatrics, University of California Davis Medical Center, 2516 Stockton Blvd, Sacramento, CA 95817 (caroline.chantry@ucdmc.ucdavis.edu).

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