Calcium absorption is significantly higher in adolescents during pregnancy than in the early postpartum period[1–3]

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ABSTRACT

Background: Early childbearing may limit skeletal consolidation and increase calcium demands in adolescents.

Objective: The purpose of this study was to characterize calcium absorption in pregnant and lactating adolescents.

Design: Fractional calcium absorption was evaluated in 23 adolescents (mean ± SD age: 16.5 ± 1.4 y) during the third trimester of pregnancy (34.7 ± 1.0 wk gestation) and again in 15 of these adolescents 31 ± 8 d after delivery. Eight adolescents were breastfeeding their infants during the follow-up study. Fractional calcium absorption was determined by using oral (^{46}Ca or ^{44}Ca) and intravenous (^{42}Ca) stable calcium isotopes. Total-body and lumbar spine bone mineral density were measured in adolescents during the postpartum period by using dual-energy X-ray absorptiometry.

Results: Fractional calcium absorption was significantly greater during pregnancy than at 3–4 wk postpartum [0.526 ± 0.152 ($n = 23$) compared with 0.297 ± 0.108 ($n = 15$); $P < 0.0001$]. Lumbar spine z scores measured 19–44 d after delivery ($n = 15$) were significantly associated with calcium intake during pregnancy ($y = -3.53 + 0.107x$; $R^2 = 0.355$, $P < 0.02$) and were inversely related to fractional calcium absorption during pregnancy ($y = 3.489 - 6.66x$; $R^2 = 0.52$, $P = 0.002$). A total of 33% (5/15) of adolescents had lumbar spine z scores that met the definition of osteopenia ($n = 3$) or osteoporosis ($n = 2$) in the early postpartum period.

Conclusions: Calcium absorption in adolescents was significantly higher during the third trimester of pregnancy than in the early postpartum period, and higher calcium intakes during pregnancy appeared to be protective against loss of trabecular bone at the lumbar spine. *Am J Clin Nutr* 2003;78:1188–93.

KEY WORDS Adolescents, pregnancy, lactation, calcium absorption, stable isotopes, bone

INTRODUCTION

Adolescent pregnancy is currently a significant public health problem. Each year, ≈10% of all 15–19-y-old women become pregnant (1). Of these, ≈52% (or more than half a million teens) bear children, and > 175 000 of these new mothers are aged ≤ 17 y (1). Despite recent decreases in birth rates (2), the 1999 birth rate for US teenagers aged 15–19 y was 49.6 per 1000 women (3). This rate was markedly higher in African American adolescents, averaging 81.1 per 1000 women aged 15–19 y compared with 34.1 per 1000 white women of a similar age (3).

Childbearing can have a substantial impact on nutrient demands, especially for nutrients such as calcium that are re-

quired for bone development. During the peak period of adolescent skeletal accretion, females deposit an average of 7.1 mmol (284 mg) Ca/d into bone (4). In pregnant adolescents, these maternal calcium requirements are coupled with the need to provide ≈1.25 mmol (50 mg) Ca/d to the fetus at 20 wk of gestation and 8.25 mmol (330 mg) Ca/d by 35 wk of gestation (5). These increased demands approximately double calcium demands in pregnant adolescents and may adversely affect attainment of peak bone mass.

To accommodate the increased calcium demands of pregnancy, fractional calcium absorption in adult women increases significantly during the third trimester of pregnancy compared with prepregnancy or postpartum values (6–9). The additional calcium demands of pregnancy may affect bone mass over the course of pregnancy. Longitudinal bone density studies in adult women typically report bone mineral density losses of 3.2–4.6% at trabecular sites over the 9-mo course of pregnancy compared with prepregnancy values (10, 11). Although losses have been reported at trabecular sites, increases in bone mineral density at cortical bone sites have also been reported during pregnancy (12). Breastfeeding also causes temporal losses of trabecular bone mineral at the spine and hip (≈3–5%) over the first 3–6 mo of lactation (13). Despite these changes, however, most studies found no relation between parity and duration of breastfeeding and subsequent risk of osteoporosis (13).

Young maternal age may influence bone loss during pregnancy and lactation. Earlier age at first pregnancy has been associated with both lower cortical bone density in midlife or later (14, 15) and persistent reductions in adult hip bone density (16). Significantly greater bone loss at the heel has also been reported in still-growing adolescents compared with adult women (17). Moreover, increased bone loss has been reported in lactating adolescents compared with adult women (18, 19).

Few data currently exist on the ability of adolescents to modify intestinal calcium absorption during pregnancy and

lactation. The purpose of our study was to examine the efficiency of fractional calcium absorption and changes in urinary calcium and hormone concentrations between pregnancy and the early postpartum period in adolescent females.

SUBJECTS AND METHODS

Subject recruitment

Pregnant adolescents (≤ 18 y of age) were recruited from the Baltimore area between 1996 and 2002. All adolescents were healthy, had uncomplicated singleton pregnancies, and were having their first child. None had medical problems or were taking any medications known to influence calcium metabolism. Study volunteers were nonsmokers and did not have a self-reported history of drug or alcohol abuse. Informed written consent was obtained from the study participants, and the study protocol was approved by the Johns Hopkins University Institutional Review Board.

Calcium absorption studies

Pregnant adolescents were admitted to the Pediatric Clinical Research Unit (PCRU) at Johns Hopkins Hospital when they were between 32 and 36 wk of gestation. Adolescents were admitted to the PCRU the evening before the calcium infusion, and baseline weight and height measurements were obtained. The following morning, a fasting baseline blood sample was obtained for analysis of calcium-related hormones. With breakfast, each girl received either ^{46}Ca (0.0075 μmol/kg) or ^{44}Ca (0.005 mmol/kg) orally in milk; ^{42}Ca (0.025 mmol/kg) was administered intravenously immediately after breakfast. Girls remained in the PCRU in a private room for the 120 h after dosing. A 24-h urine collection was obtained postdosing, and 3 spot urine collections were obtained daily for the remainder of the study. Adolescents self-selected their foods during the 6-d study, and each food item was weighed before and after intake during the inpatient study to determine actual dietary intakes. Average calcium intake for each dietary period was determined as the mean of the five 24-h weighed-food records completed during the inpatient study. The Minnesota NUTRIENT DATABASE SYSTEM (version 2.91; University of Minnesota, Minneapolis) was used to calculate nutrient intakes. All adolescents were asked to return for a second calcium study when their infant was between 3 and 7 wk of age.

Bone mineral content

Total-body and lumbar spine bone mineral content (BMC) and body composition were measured in each adolescent during the postpartum period by using dual-energy X-ray absorptiometry (Hologic QDR 2000 W, software version 8.26a:3; Hologic Inc, Waltham, MA). Lumbar spine z scores were generated by using the Hologic database. Osteopenia at this site was defined as a z score > 1 SD below predicted values and osteoporosis as a z score > 2 SDs below predicted values.

The total-body BMC of each adolescent was compared with a total-body BMC reference database, as previously reported (20), with adjustment for height, age, sex, and ethnicity. A ratio was then derived between actual and predicted total-body BMC to determine the effect of pregnancy on predicted total-body BMC in the early postpartum period. Values > 1 SD below predicted values were defined as indicating osteopenia, and

values > 2 SDs below age-matched predictive values were defined as indicating osteoporosis.

Isotope analysis and calculations

Calcium isotope ratios were measured by using thermal ionization mass spectrometry (Finnigan Triton TI, Bremen, Germany) (21, 22). The ratio of each administered tracer to ^{48}Ca or ^{43}Ca was measured, and the degree to which this ratio was increased over the natural abundance ratio was calculated.

Fractional calcium absorption was determined as the relative recovery of the oral and the intravenous tracer in the 24-h urine collection postdosing. Total calcium concentrations in urine were measured by using atomic absorption spectrophotometry (Perkin Elmer model 3300; Perkin Elmer, Norwalk, CT). The equations used in these determinations were reported previously (23). True calcium absorption was calculated as the product of fractional calcium absorption and the average 5-d calcium intake. Endogenous fecal calcium losses were estimated to be 1.5 mg $\cdot$ kg^{-1} $\cdot$ d^{-1} on the basis of data suggesting that these losses were not affected by pregnancy (9). Calcium balance was determined by subtracting the sum of urinary and estimated endogenous fecal calcium losses from true calcium absorption.

Hormone analysis

Serum concentrations of 25-hydroxyvitamin D and 1,25-dihydroxyvitamin D were measured by using radioimmunoassays (Diasorin, Inc, Stillwater, MN). Samples from the same individual were run in the same assay to reduce intraassay variation, which was within 10% for both assays. Serum estradiol was measured with an enzyme immunoabsorbant assay (DSL Laboratories, Webster, TX).

Serum N-telopeptide concentrations were measured in baseline serum samples, and urinary N-telopeptide was measured in the 24-h urine collection obtained for each calcium intake period by using enzyme-linked immunoabsorbant assays (Ostex International, Inc, Seattle). Urinary creatinine concentrations were measured in 24-h urine samples by using a colorimetric assay (Quidel Corporation, Santa Clara, CA).

Statistical analyses

Statistical analyses were carried out by using STATVIEW data analysis software (version 5.0.1; SAS Institute Inc, Berkeley, CA). Paired t tests were used to determine significant differences between pregnancy and postpartum periods for each of the measured variables in adolescents who completed both studies. Student's t test was used to determine significant differences between lactating and nonlactating adolescents. Analysis of variance was used to address group contrasts between the pregnancy and the postpartum study and to examine potential differences in measured variables between the lactating and nonlactating adolescents. Simple regression analysis was used to examine potential relations between calcium absorption and other measured variables. Results were considered significant if P values were < 0.05.

RESULTS

The characteristics of the study population are presented in **Table 1**. The age of the adolescents averaged 16.5 ± 1.4 y at

TABLE 1
Characteristics of the adolescents during pregnancy and in the postpartum period

	Pregnancy ($n = 23$)	Postpartum, nonlactating ($n = 7$)	Postpartum, lactating ($n = 8$)
Age (y)	16.5 ± 1.4^1	15.6 ± 1.6	17.2 ± 1.1^2
Weight (kg)	75.7 ± 18.4	70.1 ± 17.4	68.4 ± 16.8
Height (cm)	162.6 ± 5.1	161.3 ± 4.2	162.4 ± 6.0
BMI (kg/m^2)	28.7 ± 7.3	30.0 ± 6.2	27.7 ± 7.0
Time of gestation (wk)	34.7 ± 1.0	—	—
Racial group (n)			
African American	20	4	8
White	3	3	0
Time postpartum (d)	—	28.6 ± 7.9	32.1 ± 7.7

[1] $\bar{x} \pm$ SD.
[2] Significantly different from the nonlactating postpartum group, $P < 0.05$ (Student's t test).

the time of entry into the study (range: 13.5–18.3 y). Of the 23 adolescents, 20 were African American and 3 were white. A total of 15 of the 23 adolescents returned for the second study 19–44 d after giving birth. Of these, 53% were breastfeeding their infants. All breastfeeding adolescents were African American. There were no significant differences in baseline characteristics (age, height, weight, body mass index, or week of gestation) between the adolescents who returned for the postpartum study and those who did not.

Variables related to calcium balance for the pregnancy and postpartum studies are presented in **Table 2**. Calcium intakes were based on self-selected diets and included the contribution of calcium in prenatal supplements (5 mmol). Despite daily reminders from the dietary staff of the PCRU, only 39% (9/23) and 40% (6/15) of the adolescents took prenatal supplements during the pregnancy and postpartum studies, respectively, and if consumed, supplements were frequently not consumed daily.

Within the group of 23 pregnant adolescents, fractional calcium absorption tended to be higher in adolescents with higher urinary N-telopeptide concentrations ($R^2 = 0.157$, $P = 0.09$, $n = 19$). Fractional calcium absorption was unrelated to other biochemical indicators. No significant relation was evident between fractional calcium absorption and calcium intake during either pregnancy or the postpartum period across the range of intakes consumed by these adolescents (13–45 mmol/d). However, a relation of fractional absorption to intake may have been difficult to detect in this group, because 70% of adolescents consumed > 25 mmol/d and only 4 adolescents consumed < 20 mmol/d (range: 12.5–18 mmol/d). Similarly,

fractional calcium absorption during pregnancy or in the early postpartum period was not significantly affected by age across the age range of 13–18 y. Higher calcium intakes were related to a significantly higher estimated calcium balance during pregnancy ($P < 0.005$, $R^2 = 0.332$, $n = 23$) and lactation ($P < 0.05$, $R^2 = 0.406$, $n = 14$); calcium intake was not significantly related to urinary calcium excretion during pregnancy or lactation in this age group.

Significant alterations in hormonal concentrations and markers of bone turnover were observed during pregnancy compared with the postpartum period, irrespective of lactation status (**Table 3**). During pregnancy, serum 1,25-dihydroxyvitamin D (163.1 ± 94.5 pmol/L; $P < 0.0001$, paired t test, $n = 14$) and estradiol (14.1 ± 5.9 nmol/L; $P < 0.0001$, paired t test, $n = 13$) concentrations were significantly higher and serum N-telopeptide (-5.229 ± 4.965 nmol bone collagen equivalents; $P < 0.002$, paired t test, $n = 14$) concentrations were significantly lower in the adolescents who went on to complete both studies, irrespective of lactation status. No significant differences in hormone concentrations or in other study variables were evident between the nonlactating and lactating adolescents. Despite the small number of white adolescents, 25-hydroxyvitamin D concentrations were significantly lower in the African American adolescents than in the white adolescents during both pregnancy [44.5 ± 16.2 ($n = 20$) compared with 90.2 ± 13.0 ($n = 3$) nmol/L; $P < 0.001$] and the postpartum [38.4 ± 19.6 ($n = 13$) compared with 92.4 ± 1.0 ($n = 2$) nmol/L; $P < 0.005$] studies.

TABLE 2
Calcium absorption and estimated balance in adolescents during pregnancy and in the postpartum period[1]

	Pregnancy ($n = 23$)	Postpartum, nonlactating ($n = 7$)	Postpartum, lactating ($n = 8$)[2]
Calcium intake (mmol/d)	29.65 ± 9.40	24.59 ± 11.07	33.86 ± 9.83
Fractional absorption (%)	0.526 ± 0.152^a	0.329 ± 0.114^b	0.268 ± 0.101^b
Calcium absorbed (mmol/d)	15.30 ± 5.54^a	8.09 ± 5.18^b	9.03 ± 2.81^b
Urinary calcium (mmol/d)	6.44 ± 2.13^a	1.25 ± 0.72^b	1.82 ± 0.89^b
Estimated balance (mmol/d)[3]	6.03 ± 5.15	4.21 ± 5.27	4.65 ± 2.82

[1] $\bar{x} \pm$ SD. Values within a row with different superscript letters are significantly different, $P < 0.05$ (ANOVA with Bonferroni-Dunn multiple-comparison test).
[2] $n = 7$ for calcium intake, calcium absorbed, and estimated balance because calcium intake data were not available for 1 adolescent.
[3] Assumes endogenous fecal losses of 1.5 mg · kg^{-1} · d^{-1}; derived as calcium absorbed − urinary calcium − endogenous fecal losses. No significant differences in estimated balance were evident by using ANOVA with Bonferroni-Dunn multiple-comparison tests, but differences approached significance between the pregnancy and postpartum studies when using paired t tests ($P = 0.09$).

TABLE 3
Calcium-related hormones and bone turnover markers in adolescents during pregnancy and in the postpartum period[1]

	Pregnancy	Postpartum, nonlactating	Postpartum, lactating
25-Hydroxyvitamin D (nmol/L)	50.5 ± 4.6 [23]	52.7 ± 10.9 [7]	39.3 ± 8.5 [8]
1,25-Dihydroxyvitamin D (pmol/L)	232.3 ± 20.1 [23][a]	93.2 ± 7.7 [7][b]	81.4 ± 7.9 [7][b]
Serum *N*-telopeptide (nmol BCE)	23.6 ± 1.2 [23]	26.9 ± 7.4 [7]	26.4 ± 2.0 [7]
Urinary *N*-telopeptide (nmol BCE/mmol creatinine)	813.6 ± 147.2 [19]	1196.7 ± 226.2 [6]	1163.5 ± 303.1 [8]
Estradiol (nmol/L)	13.7 ± 1.2 [22][a]	0.453 ± 0.151 [7][b]	0.618 ± 0.136 [7][b]

[1] $\bar{x}$ ± SEM; *n* in brackets. BCE, bone collagen equivalent. Values within a row with different superscript letters are significantly different, $P < 0.001$ (ANOVA with Bonferroni-Dunn multiple comparison test).

Among all subjects who completed both studies, total-body BMC fell below 98% of the predicted value in 5 of 15 adolescents (33%); in these 5 adolescents (3 lactating and 2 nonlactating), total-body BMC was 8 ± 3.6% lower than expected given the age, height, and ethnicity of the adolescent. Site-specific decreases in BMC were also evident. Lumbar spine *z* scores averaged −0.075 and ranged between −2.33 and 2.39. With the use of lumbar spine *z* scores, 3 girls in the study would have been considered osteopenic (*z* score < −1), and 2 girls would have been considered osteoporotic (*z* score < −2), ie, 33% of the study population had evidence of deficits in trabecular skeletal mass in the early postpartum period. Although there were no significant differences in physical characteristics or calcium intake between the lactating and nonlactating adolescents, lumbar spine *z* scores were on average −0.9 SD lower (NS) in lactating adolescents (**Table 4**).

Of the variables measured, lumbar spine *z* scores were inversely related to fractional calcium absorption during pregnancy ($y = 3.489 - 6.66x$; $R^2 = 0.520$, $P = 0.002$, $n = 15$; **Figure 1**). Lumbar spine *z* scores in the early postpartum period were also significantly positively influenced by calcium intake assessed during the third trimester of pregnancy ($y = -3.53 + 0.107x$; $R^2 = 0.355$, $P < 0.02$) but were not related to calcium intakes during the early postpartum period. There were no significant relations between the length of time that had elapsed between the pregnancy and postpartum studies and either lumbar spine *z* scores or the percentage of predicted total-body BMC.

DISCUSSION

The extent of the increase in calcium absorption in response to pregnancy has not been previously examined in adolescents. In our study population of pregnant adolescents, percentage calcium absorption averaged 53% during pregnancy and was nearly 60% higher than values measured 3–4 wk after delivery. Even though adolescents in this age range are unlikely to have achieved peak bone mass, calcium absorption in this age group did not markedly differ from data reported for pregnant adults (6, 7, 9). Previous studies in pregnant women in their third trimester (consuming calcium intakes ranging from 931 to 1350 mg/d) found similar calcium absorption values, averaging 56.0 ± 2.0% [$n = 4$ (6)], 53.8 ± 11.3% [$n = 14$ (7)], and 47.4 ± 13.3% [$n = 8$ (9)]. Moreover, within our population, calcium absorption was not significantly affected by age across the range of 13–18 y, nor did average absorption in adolescents aged ≤ 15 y ($n = 7$) differ significantly from that observed in adolescents aged ≥ 16 y. We are aware of no other studies focusing on calcium absorption in pregnant adolescents. One early study reported calcium absorption data in 15 pregnant females (aged 15–28 y) and 9 healthy control subjects, but sample size constraints in the younger cohort precluded the authors from delineating possible age-related changes from those occurring as the result of the pregnancy itself (9).

Self-selected calcium intakes in the adolescents in the present study averaged 30 ± 9 mmol/d during the third trimester of pregnancy. Although these intakes are comparable with the 1997 adequate intake recommendation (32.5 mmol/d), they are substantially higher than intakes typical of nonpregnant adolescents (≈22.2 mmol/d) (24). This intake coupled with the improved efficiency of intestinal calcium absorption provided an average of 15.3 mmol (612 mg) Ca to offset urinary, endogenous fecal, and fetal calcium demands in these adolescents. As expected, significant increases in urinary calcium excretion occurred, which is consistent with the physiologic changes that occur during pregnancy in response to plasma volume expansion and an increased glomerular filtration rate (25). Assuming that endogenous fecal calcium losses do not change during pregnancy (9), average calcium retention was 6

TABLE 4
Bone mineral content in adolescents during the postpartum period[1]

	Nonlactating ($n = 7$)	Lactating ($n = 8$)
TBBMC (g)	2119.5 ± 280.9 (1771.2–2673.1)[2]	2270.3 ± 226.0 (1937.3–2612.6)
Predicted TBBMC (g)	2020.4 ± 191.7 (1816.1–2360.6)	2276.8 ± 231.0[3] (1939.7–2583.6)
BMC:BMCp	1.102 ± 0.136 (0.898–1.289)	1.001 ± 0.090 (0.882–1.127)
LS *z* score	0.399 ± 1.716 (−2.33–2.39)	−0.489 ± 1.315 (−2.130–1.38)
Osteopenic: LS *z* score < −1 (*n*)	2	1
Osteoporotic: LS *z* score < −2 (*n*)	1	1

[1] TBBMC, total-body bone mineral content; BMC:BMCp, ratio of measured to predicted TBBMC (22); LS, lumbar spine.

[2] $\bar{x}$ ± SD; range in parentheses.

[3] Significantly different from the nonlactating group, $P < 0.05$ (Student's *t* test).
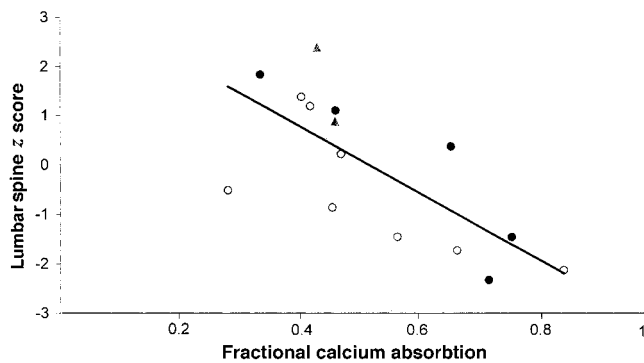
FIGURE 1. Calcium absorption was measured with stable calcium isotopes during the third trimester of pregnancy (35 ± 1 wk gestation) in 2 nonlactating white adolescents (▲) and 13 African American adolescents [$n = 5$ nonlactating (●) and $n = 8$ lactating (○)]. Lumbar spine z scores were measured on average 30 d postpartum by use of dual-energy X-ray absorptiometry. A significant inverse relation was evident between fractional calcium absorption and lumbar spine z scores: $y = 3.489 - 6.66x$ ($R^2 = 0.520$, $P = 0.002$, $n = 15$). In this group, 33% of the adolescents were either osteopenic (lumbar spine z score > -1; $n = 3$) or osteoporotic (lumbar spine z score > -2; $n = 2$) in the early postpartum period.

mmol (240 mg) in these adolescents. Because peak rates of fetal skeletal accretion during the third trimester have been reported to range from 6 to 7.5 mmol/d (25), the degree of calcium retention achieved by these adolescents does not appear to be sufficient to support peak rates of fetal calcium accretion and still allow for any appreciable amount of adolescent skeletal accretion.

In this group of pregnant adolescents, a 30-g transfer of calcium to the fetus over a 266-d gestation period would correspond to 4% of the adolescents' average total-body calcium content. This additional requirement for calcium may have adversely affected total-body BMC in the early postpartum period, as evidenced by the finding that total-body BMC was on average 8% lower than predicted in 33% (5/15) of the adolescents. Assuming that 32.2% of total-body BMC reflects calcium (26), an 8% deficit in total-body BMC in these 5 adolescents would correspond with a net deficit of ≈54 g Ca. Because we do not have baseline bone density data, we are unable to ascertain how much of this deficit may have been apparent before pregnancy, nor can we ascertain the relative partitioning of losses between pregnancy and the early postpartum period. Despite the variability in the timing of the postpartum study, no significant relations existed between the time elapsed between the pregnancy and postpartum studies and either lumbar spine z scores or the magnitude of deficit in total-body BMC across the 19–44-d range studied. Previous studies found significantly higher losses of trabecular bone at the heel in adolescents who continued to grow over the course of pregnancy than in adult women (17). Similarly, significantly greater losses of BMC were reported at the distal left radius in lactating adolescents (aged ≤ 18 y) than in women aged > 18 y (19). Studies in adults found either nonsignificant losses in total-body BMC between the postdelivery measure and that obtained after 2 mo of lactation (7) or significant losses in total-body BMC after 6 mo of lactation (27).

In addition to adolescents having lower-than-predicted total-body BMC, 33% of the adolescents were osteopenic or osteoporotic on the basis of their lumbar spine z scores. Higher

dietary calcium intakes during pregnancy were significantly related to maternal lumbar spine z scores in the early postpartum period, and higher calcium intakes were significantly associated with improvements in estimated calcium balance, which suggests that higher calcium intakes were protective against bone loss over the course of pregnancy. In addition, adolescents with the highest calcium absorption during pregnancy had significantly greater deficits in lumbar spine bone mass, suggesting that despite maximal increases in intestinal calcium absorption, sufficient substrate was not available to prevent maternal bone loss at the lumbar spine. This hypothesis is consistent with the tendency for urinary N-telopeptide concentrations (an indirect marker of bone resorption) to be higher in adolescents with higher fractional calcium absorption during pregnancy.

The potential competition for calcium required for both adolescent and fetal skeletal accretion may adversely affect both maternal bone density and fetal bone development. We recently found that low calcium intake (as assessed by maternal dairy product intake at entry into prenatal care) was significantly associated with decreased fetal femur length in utero in a group of 350 pregnant African American adolescents (28). Other studies found that calcium supplementation (≤ 2 g/d) significantly increased neonatal bone density in infants born to women with suboptimal calcium intakes (29).

We were unable to address potential racial differences in calcium absorption, hormone status, or bone loss between the white and African American adolescents because of the limited size of our white cohort. Recruitment of pregnant white adolescents was severely hampered by a much higher prevalence of self-reported cigarette use during pregnancy in white adolescents, consistent with national data detailing a higher prevalence of cigarette smoking in white than in African American adolescents (30). The degree of osteopenia evident in the adolescents studied is of interest because most of the adolescents were African American, and the risk of osteoporosis is known to be substantially lower in black women than in white women (31). Moreover, although studies have reported higher rates of calcium absorption in postmenarcheal black than in white adolescents (32), the fractional calcium absorption observed in the pregnant African American adolescents in the present study was comparable with that reported for pregnant adult white women (7).

In conclusion, calcium absorption in adolescents was significantly higher during the third trimester of pregnancy than during the early postpartum period. Thirty-three percent of the adolescents had lumbar spine z scores that met the definition of osteopenia or osteoporosis in the early postpartum period. The relative partitioning of bone loss at this site over the course of pregnancy and the early postpartum period is not known. However, in these adolescents, increased calcium intake during pregnancy appeared to be protective against maternal loss of trabecular bone at the lumbar spine. More research is needed in adolescents to address the effect of habitual calcium intake on maternal bone loss during pregnancy. Moreover, longer-term studies are needed to address the magnitude of bone loss over a longer course of lactation and the ability to regain bone loss after the resumption of menses to ensure that early childbearing does not have long-term adverse consequences on bone mineral acquisition and attainment of peak bone mass.

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