# Calcium Intakes and Femoral and Lumbar Bone Density of Elderly U.S. Men and Women: National Health and Nutrition Examination Survey 2005–2006 Analysis

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**Objectives:** This analysis was aimed at assessing the benefits of total calcium intake from diet and supplements on both femoral neck and lumbar vertebral bone mineral density (BMD) in a representative sample of older U.S. women and men.

**Design:** For 1384 women and men aged 50–70 and 71+ yr, quintiles of total calcium intake were tested for their association with hip and spine BMD after adjusting for body mass index. All data in this observational study were cross-sectional.

**Data Source:** Subjects included elderly residents statistically representative of the United States, women and men aged 50 yr and older in the National Health and Nutrition Examination Survey 2005–2006 cohort.

**Main Outcome Measures:** Calcium intakes and femoral and lumbar BMD were evaluated.

**Results:** Total calcium intakes ranged from means of 400+ mg/d in quintile 1 to 2100+ in quintile 5. Little difference in hip or lumbar BMD was found in relation to total calcium consumption in women and men across five quintiles, especially for those aged 50–70, in models adjusted for body mass index only. Femoral hip BMD in men 71 and older increased slightly with high calcium intake (3.6% higher density, $P = 0.0391$), whereas femoral BMD in women 71 and older decreased slightly with high calcium intake (−3.2%, $P = 0.0132$). Lumbar BMD remained fairly consistent across all quintiles, but greater variation within each quintile was found compared with the hip.

**Conclusions:** A usual high calcium intake beyond the recommended dietary allowance of elderly women and men, most commonly achieved by calcium supplements, did not provide any benefit for hip or lumbar BMD. A dietary intake of calcium approaching or meeting the current recommendations was not related to higher BMD of the hip or lumbar spine in late life compared with lower intakes of calcium in older adults. **(*J Clin Endocrinol Metab* 97: 4531–4539, 2012)**



Calcium supplements have been strongly recommended by physicians and other health professionals over the last few decades in an effort to reduce the risk of skeletal fractures, especially those of the proximal femur (1). The prevention of fractures of older women and men by dietary or other means should not only help preserve personal lifestyles but also lower the enormous medical costs of hip fractures (2, 3). What has become clear in recent years, however, is that high calcium intakes, *i.e.* greater than current recommendations, have had little or no positive impact on the retention of hip or vertebral bone mineral density (BMD) (4–7) or on distal radial BMD (8). Also, little or no effect on the reduction of hip fractures in older adults, whether taking supplemental vitamin D or not, results from high calcium intakes (9–11). Meta-analyses confirm the limited benefit of calcium supplementation in reducing hip frac-

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Abbreviations: BMD, Bone mineral density; BMI, body mass index; NHANES, National Health and Nutrition Examination Survey; PIR, poverty income ratio; Q5, quintile 5; RDA, recommended dietary allowance.

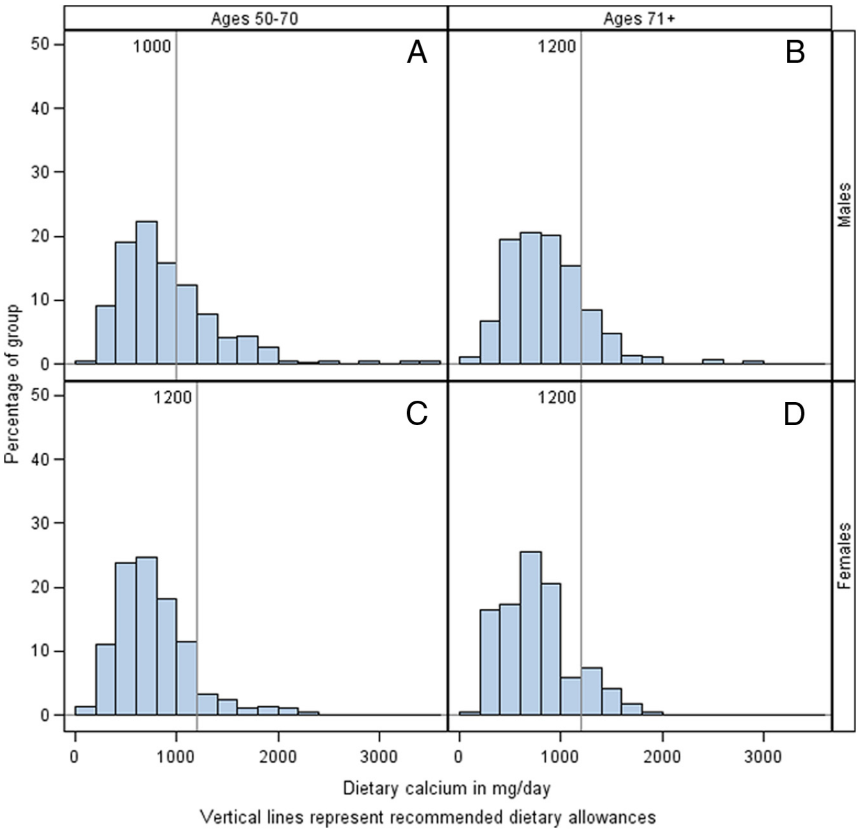


**FIG. 1.** Distributions of dietary calcium with recommended dietary allowances. A, Males ages 50–70; B, males ages 71+; C, females ages 50–70; D, ages females 71+.

tures (1, 12, 13). Exceptions to this assertion are studies in which older subjects who were truly calcium and vitamin D malnourished responded with fewer hip fractures after supplements of these bone-related nutrients (14, 15).

A recent report on calcium intakes across the life cycle in the U.S. population showed that most adult Americans are consuming enough calcium from foods and supplements (16) to satisfy the 2011 recommendations of the Institute of Medicine (17). For U.S. females ages 50–70, the recommended dietary allowance (RDA) for calcium was recently raised to 1200 mg/d, but not for males in this age range, for whom the recommendation remains 1000 mg/d (17). The higher calcium RDAs of females between 50 and 70 yr of age are based on the concept that they have a greater estimated average requirement for calcium than males (17). For both genders over 71 yr, the RDA has remained at 1200 mg/d, as established in 1997 (18).

Concern about calcium loading with supplements, as practiced by many health-conscious postmenopausal women, has arisen because of its potential contribution to an increase in the risk of heart and other cardiovascular diseases and of renal stones. Scientific support of increased risk of cardiovascular diseases as a result of calcium supplementation has been provided by researchers in Auckland, New Zealand (1, 12, 19), and Kuopio, Finland (20), whereas other investigators in Australia (21) and others state that high intakes of calcium are of no concern for arterial calcification.

The objectives of this analysis are to establish calcium intakes of older individuals in the National Health and Nutrition Examination Survey (NHANES) sample (2005–2006) and to assess whether calcium intakes that exceed the RDAs are needed to help maintain BMD of the femur and lumbar vertebrae among older Americans. If little or no difference actually exists in bone density measurements of similarly aged U.S. citizens across a wide range of daily calcium intakes, then excessive consumption of calcium above the recommended intakes (RDAs) does not seem warranted for supporting bone density.

## Materials and Methods

### Data

Data from the 2005–2006 NHANES cycle were used in this study (Centers for Disease Control and Prevention 2009) (22). NHANES participants age 50 or more at the time of the exam (n = 2214) were eligible for this analysis of calcium intakes of older Americans. After omitting participants with an unreliable dietary recall (n = 213) or no valid bone scan or a missing BMI, 1556 participants, 843 men and 713 women, remained in our study for femoral BMD, whereas 1384 participants, 715 men and 669 women, remained in our study for spinal BMD.

### Calcium consumption

Each person's daily calcium consumption was computed as the sum of their dietary intake and their consumption via supplements and antacids.

Two 24-h dietary recalls were administered to the NHANES population, one in person and one later by telephone interview; most people participated in both. In both recalls, information about individual foods and amounts were collected. This information was used to convert to daily aggregates of food energy and 63 nutrients/food components with the U.S. Department of Agriculture's Food and Nutrient Database for Dietary Studies version 3.0 (FNDDS version 3.0). Our study used the converted aggregate data. If a participant had two recalls that were judged to be reliable, our dietary calcium measure is the average of both. Otherwise, we used the dietary calcium measurement for the single reliable dietary recall (in 7% of our sample, all from the in-person recall). Note that a known tendency exists to underreport consumption in 24-h recalls (23), yet this method remains useful for estimating consumption.

Information on use of dietary supplements, including antacids, was obtained during each participant's in-home NHANES

**TABLE 1.** Age- and sex-specific calcium intake (milligrams per day)

| Measure | Males | | Females | |
|---|---|---|---|---|
| | 50–70 yr old | 71+ yr old | 50–70 yr old | 71+ yr old |
| Sample size (unweighted) | 556 | 287 | 494 | 219 |
| Weighted mean (SD) of dietary calcium | 990 (407) | 888 (480) | 793 (445) | 773 (407) |
| Weighted mean (SD) of supplemental calcium | 149 (464) | 277 (715) | 501 (939) | 406 (388) |
| Weighted mean (SD) of total calcium intake | 1139 (650) | 1165 (827) | 1294 (1027) | 1178 (439) |
| Quintiles of total calcium intake (lower limits) | | | | |
| Q1 | 107 | 110 | 120 | 184 |
| Q2 | 568 | 624 | 566 | 563 |
| Q3 | 771 | 867 | 828 | 841 |
| Q4 | 1020 | 1102 | 1158 | 1224 |
| Q5 | 1395 | 1395 | 1686 | 1692 |

visit, before the physical examination. Participants were asked not only what supplements they take but also how often and how much. Trained nutritionists constructed a database matching supplement product names to ingredients and amounts. This database is distributed as part of the NHANES data, allowing users to translate participant supplement information into estimated daily intake of supplement components such as calcium.

After summing each participant's calcium intake from diet and supplements, we computed quintiles of total calcium intake within each subgroup of our study (males/females, ages 50–70/71+). Quintiles were computed such that 20% of the participants within each subgroup fell between the quintile boundaries of total calcium intake; thus, within each subgroup, the quintiles are of roughly equal size in terms of number of participants. Each participant's quintile assignment shows whether he or she falls into the lowest 20% of calcium intakes for her subgroup, the second lowest 20%, and so forth.

## Bone mineral measurements

Dual-energy x-ray absorptiometry was used to scan proximal femurs and lumbar spines in NHANES 2005–2006. Trained and certified radiology technologists performed the measurements using a Hologic QDR-4500A fan-beam densitometer (Hologic, Inc., Bedford, MA). Hip measurements of only the femoral neck were used. The NHANES bone measurements provide nationally representative data except that measurement was not done on those with a self-reported weight of over 300 pounds (QDR table limitation). Also, measurement was not done on pregnant women, although few of these would be expected in our population of those aged 50 or more.

## Covariates

Other variables of interest in our study are body mass index (BMI), which is used as a covariate in our models, and socioeconomic variables, which seem to be related to whether a person is a user of calcium supplements. We considered also adjusting our models for the following covariates: total calorie intake, dietary protein, serum vitamin D, PTH, and estimated glomerular filtration rate, all variables known to affect calcium metabolism.

Participant height and weight are measured by trained personnel as a routine part of the NHANES examination, and these are used to produce the BMI value provided in the NHANES 2005–2006 database.

Socioeconomic variables for education and income were obtained from the NHANES 2005–2006 demographic data set. Poverty income ratio (PIR) is the ratio of a family's income to its appropriate poverty level threshold based on the family's size and composition. Higher values of PIR signal greater prosperity.

## Statistical analyses

NHANES uses a complex sampling design that requires the use of sample weights to adjust for the unequal probability of selection into the survey and to adjust for the possible bias resulting from nonresponse. Weights are post-stratified to U.S. Census Bureau estimates of the U.S. population. Analyses were performed with SAS version 9.2 (TS3) (SAS Institute Inc., Cary, NC), using sample weights for the 2005–2006 NHANES cycle.

Within each sex and age group (50–70, 71+), we computed the distribution of the calcium intake and quintiles of total daily calcium consumption in our study population (see Table 1). Further descriptive measures of the participant characteristics were obtained through the SAS survey procedures, which were also used for modeling.

Regression analysis was conducted to test our hypothesis about BMD and calcium intake. All models were adjusted for BMI; without adjustment for BMI, BMD means showed much greater variability than with adjustment. In two sets of models for femoral BMD and lumbar BMD, we used the following independent variables: total daily calcium intake quintiles as a categorical variable and daily dietary calcium along with a three-level supplemental calcium variable (no supplemental intake, supplement level below or equal to the subgroup median, and supplement level above the subgroup median).

**TABLE 2.** Weighted mean total calcium intakes of NHANES participants by quintile

| Age group | Male | | | Female | | |
|---|---|---|---|---|---|---|
| | n | Mean | SE | n | Mean | SE |
| 50–70 yr | | | | | | |
| Q1 | 111 | 412 | 11 | 99 | 438 | 15 |
| Q2 | 111 | 673 | 4 | 98 | 699 | 10 |
| Q3 | 112 | 890 | 8 | 100 | 1003 | 14 |
| Q4 | 111 | 1173 | 7 | 98 | 1410 | 21 |
| Q5 | 111 | 2006 | 88 | 99 | 2513 | 175 |
| 71+ yr | | | | | | |
| Q1 | 57 | 486 | 13 | 43 | 408 | 13 |
| Q2 | 58 | 751 | 8 | 44 | 724 | 12 |
| Q3 | 57 | 975 | 6 | 44 | 1009 | 27 |
| Q4 | 58 | 1236 | 9 | 44 | 1420 | 12 |
| Q5 | 57 | 2175 | 145 | 44 | 2211 | 62 |

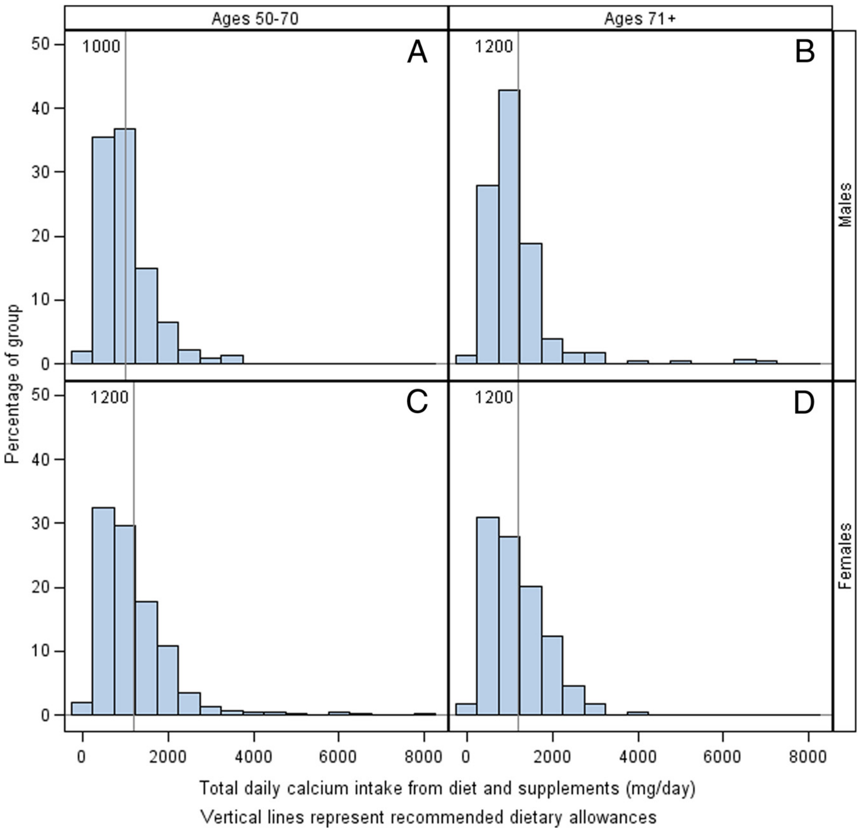


**FIG. 2.** Distributions of total calcium intake with recommended dietary allowances. A, Males ages 50–70; B, males ages 71+; C, females ages 50–70; D, ages females 71+.

## Results

Figures 1 and 2 and Tables 1–4 are based on our larger group of people with a femoral bone density measurement, but the results are very similar among the smaller group for whom there is a spinal measurement.

### Calcium intakes

Figure 1 illustrates the distributions of calcium intake from dietary sources for the four subgroups in the study. The average intakes of calcium from dietary sources are shown in Table 1, and the mean total calcium intakes by quintile are given in Table 2. The figures show that large percentages of older adults do not achieve their RDA of calcium from diet alone. Although 33% of males ages 50–70 achieve their RDA through diet, only 9–17% of those in the other groups do so. The average intake of dietary calcium shows a decrease in both men and women as age increases. For example, the average dietary intake among men decreased from 990 mg/d for men ages 50–70 to 888 mg/d for men ages 71+.

Figure 2 shows the distributions of total calcium intake from dietary and supplemental intake. The figures show that dietary supplements help more older Americans to achieve the recommended levels as measured by total calcium intake, although the percentages are still somewhat small (ranging from 32% of males 71+ to 41% of males 50–70 and females 71+).

Table 1 summarizes calcium intake from all components for each subgroup. Interestingly, older males and younger females obtain a higher proportion of their calcium from supplements. However, variability in supplement intake is very high. The females who consume the highest amounts of calcium consume more than their male counterparts. An examination of the quintiles shows that a large proportion of the old-age population do not consume the recommended level of total calcium intake either through dietary or supplemental sources.

Table 3 shows that, as one would expect, supplement intake is what boosts many people into higher quintiles of total calcium intake. The percentage of people using supplements increases in each quintile for each subgroup. The table highlights that almost every 71+-yr-old woman (98%) in the highest quintile group uses supplemental sources to boost daily calcium intake.

**TABLE 3.** PIR, education, and percentage who are supplement users by quintile of total daily calcium intake (milligrams per day)

| | Males | | | | | |
|---|---|---|---|---|---|---|
| | 50–70 (n = 556) | | | 71+ (n = 287) | | |
| Quintile | PIR mean (weighted) | % college grad (weighted) | % supplement users (weighted) | PIR mean (weighted) | % college grad (weighted) | % supplement users (weighted) |
| Q1 | 2.8 | 16 | 17 | 2.3 | 11 | 26 |
| Q2 | 3.2 | 23 | 22 | 2.6 | 29 | 56 |
| Q3 | 3.6 | 30 | 46 | 2.7 | 17 | 67 |
| Q4 | 3.8 | 31 | 50 | 2.9 | 23 | 72 |
| Q5 | 4.1 | 44 | 74 | 3.0 | 22 | 78 |

Intake is from food and supplements, including antacids.

So who are the people in each quintile? In particular, how are those elders in higher quintiles of calcium consumption different from people in lower quintiles? This largely white population sampled by NHANES in 2005–2006 represents a truncated random sample of the U.S. population of males and females over 50 yr of age. Adjusted demographic and other variables by quintile of total daily calcium intake as well as sex and age group are provided in Table 3, *i.e.* information on PIR, education, and percentage of supplement users by quintile of total daily calcium intake (milligrams per day). Based on their high educational level and income status, consistent with another report (Anderson J. J. B., K. He, J. A. C. Delaney, G. L. Burke, A. Alonso, D. E. Bold, M. Budoff, E. D. Michos, P. J. Klemmer, unpublished data), participants in quintile 5 (Q5) with the highest calcium intakes including high amounts of calcium supplements appear to represent an unusual subpopulation compared with those in the first four quintiles. The PIR is highest in the Q5 group, as is the Q5 weighted percentage of college graduates for all subpopulations except males 71+. So, elders in the upper quintiles likely are more prosperous and better educated and more likely to use supplements.

Table 4 describes our cohort with regard to other potential covariates: self-reported health status, smoking, drinking, physical activity, and comorbidities. Table 4 confirms that the selected behavioral and health statuses did show a few statistically significant differences across the quintiles among all sex and age groups. In the younger age group (50–70), statistically significant differences were found for two variables, percent physically active and percent in good health among the quintile groups for both sexes. Females in the older age group (71+) showed a significant difference in percent physically active with the highest percentage in Q5. In general, the highest quintile group exhibited the highest percentage in both good health and being physically active in both sexes.

**TABLE 4.** Percentages (weighted) reporting selected behavioral and health statuses by sex, age, and total calcium quintile

| | Q1 | Q2 | Q3 | Q4 | Q5 | *P* value[a] |
|---|---|---|---|---|---|---|
| Males ages 50–70 | | | | | | |
| Good health | 78 | 78 | 86 | 74 | 89 | 0.07 |
| Ever smoked | 68 | 75 | 64 | 61 | 51 | 0.01 |
| Regular drinker | 55 | 53 | 50 | 44 | 46 | 0.51 |
| Physically active | 53 | 57 | 61 | 64 | 84 | 0.00 |
| Comorbidity index of 2+ | 19 | 24 | 20 | 26 | 18 | 0.74 |
| Males ages 71+ | | | | | | |
| Good health | 71 | 82 | 79 | 73 | 82 | 0.69 |
| Ever smoked | 81 | 65 | 66 | 73 | 69 | 0.45 |
| Regular drinker | 24 | 16 | 28 | 27 | 33 | 0.47 |
| Physically active | 51 | 52 | 56 | 50 | 64 | 0.74 |
| Comorbidity index of 2+ | 51 | 34 | 51 | 43 | 52 | 0.39 |
| Females ages 50–70 | | | | | | |
| Good health | 72 | 71 | 85 | 82 | 91 | 0.01 |
| Ever smoked | 57 | 43 | 46 | 43 | 51 | 0.55 |
| Regular drinker | 61 | 65 | 65 | 72 | 59 | 0.27 |
| Physically active | 52 | 72 | 66 | 67 | 85 | 0.00 |
| Comorbidity index of 2+ | 25 | 36 | 31 | 28 | 33 | 0.67 |
| Females ages 71+ | | | | | | |
| Good health | 68 | 67 | 81 | 85 | 87 | 0.16 |
| Ever smoked | 36 | 44 | 47 | 38 | 47 | 0.86 |
| Regular drinker | 26 | 43 | 59 | 39 | 51 | 0.09 |
| Physically active | 29 | 49 | 41 | 51 | 64 | 0.03 |
| Comorbidity index of 2+ | 48 | 49 | 60 | 66 | 55 | 0.19 |

Good health means that general health condition is excellent, very good, or good. Ever smoked means smoked at least 100 cigarettes in life. Regular drinks means subject averages two or more drinks per day for men or one or more drinks per day for women. Physically active means subject did moderate or vigorous activity in the last 30 d. Comorbity index of 2+ includes self-reported asthma, congestive heart failure, coronary heart disease, angina, heart attack, stroke, emphysema, chronic bronchitis, liver condition, thyroid problem, and cancer.

[a] *P* value based on Rao-Scott $\chi^2$ statistic.

## Femoral bone density and lumbar bone density and calcium intake

To return to our primary question, do the elderly benefit in terms of their femoral and lumbar bone density from increased calcium intake? Regression models were run fitting femoral neck bone density to calcium intake, all by sex



**TABLE 3.** Continued

| Females | | | | | |
|---|---|---|---|---|---|
| 50–70 (n = 494) | | | 71+ (n = 219) | | |
| PIR mean (weighted) | % college grad (weighted) | % supplement users (weighted) | PIR mean (weighted) | % college grad (weighted) | % supplement users (weighted) |
| 2.9 | 13 | 20 | 2.3 | 6 | 34 |
| 3.2 | 17 | 48 | 2.3 | 18 | 29 |
| 3.2 | 18 | 64 | 2.5 | 9 | 69 |
| 3.6 | 35 | 86 | 2.3 | 12 | 84 |
| 3.7 | 40 | 95 | 2.8 | 20 | 98 |

**TABLE 5.** Total calcium intake quintile as predictor of femoral BMD after controlling for BMI

| | Males 71+ | | | | Females 71+ | | | |
|---|---|---|---|---|---|---|---|---|
| Quintile | Predicted mean | Estimate | SE | *P* value | Predicted mean | Estimate | SE | *P* value |
| Q1 | 0.7159 | −0.08 | 0.03 | 0.02 | 0.6599 | 0.04 | 0.03 | 0.17 |
| Q2 | 0.7791 | −0.01 | 0.04 | 0.70 | 0.6768 | 0.05 | 0.02 | 0.01 |
| Q3 | 0.7853 | −0.01 | 0.03 | 0.79 | 0.6570 | 0.03 | 0.02 | 0.19 |
| Q4 | 0.7082 | −0.09 | 0.03 | 0.02 | 0.6366 | 0.01 | 0.02 | 0.57 |
| Q5 (reference) | 0.7938 | | | | 0.6234 | | | |
| Overall | | | | 0.02 | | | | 0.04 |

and age group and controlling for BMI. Similar models were run for lumbar bone density and calcium.

Using total calcium quintile as a categorical variable, no clear trend of femoral BMD was evident. For males 50–70 and females 50–70, we found no significant differences in femoral density among the five quintile groups. However, for both males 71+ and females 71+, total calcium quintile was a significant predictor of femoral neck density after controlling for BMI, as shown by the significant overall *P* values in Table 5, but the effects were in different directions. In males 71+, those with lower calcium consumption had lower density (but significantly lower only in some quintiles). In females 71+, those with lower calcium consumption had higher density (significantly higher in only one quintile) (Table 5). The results from this regression analysis are summarized by a plot of predicted means by calcium intake quintiles in Fig. 3. The figures clearly show the lack of change in average femoral BMD across the quintile groups in those aged 50–70. However, among those aged 71+, men show an upward trend across the quintiles, whereas women show a downward trend.

Total calcium intake across quintiles was not a significant predictor of lumbar BMD in any sex and age group. However, Table 6 and Fig. 4B show that for males 71+, spinal density in the lowest quintile, Q1, was significantly lower than in the other quintiles.

An additional set of models was run to predict femoral neck bone density, again after controlling for BMI, using dietary calcium as a continuous variable and supplemental calcium as a categorical variable. The three supplemental calcium categories were none (no supplements taken), supplement intake less than or equal to the median intake for the sex/age group, and supplement intake greater than the median for the sex/age group. In these models, dietary calcium was not a significant predictor of bone density for any group, whereas supplemental calcium was significant for both males 71+ (significant at the 10% level) and females 71+. As in the initial regression models described above, directions of influence were in opposite directions for men and women. For males 71+, supplement intake above the group median was associated with 3.6% higher density ($P = 0.0391$). For females 71+, supplement intake above the group median was associated with 3.2% lower density ($P = 0.0132$). In a parallel set of models for spinal BMD, an association was found only for males 71+, for whom supplement intake above the group median was associated with 7.5% higher density ($P = 0.05$).

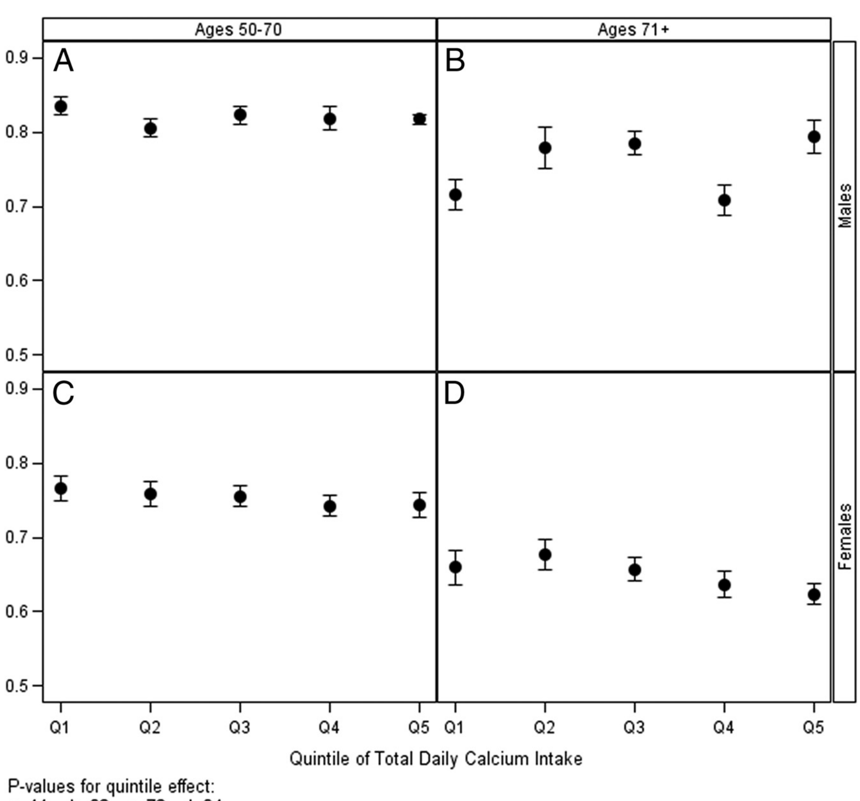


**FIG. 3.** Least-squares means and SE of femoral BMD. A, Males ages 50–70; B, males ages 71+; C, females ages 50–70; D, ages females 71+.

## Discussion

The major finding of this cross-sectional study is that little or no difference in femoral or lumbar bone density mea-

**TABLE 6.** Total calcium intake quintile as predictor of lumbar BMD after controlling for BMI

| | Males 71+ | | | Females 71+ | | |
|---|---|---|---|---|---|---|
| Quintile | Estimate | SE | *P* value | Estimate | SE | *P* value |
| Q1 | −0.07 | 0.04 | 0.07 | 0.02 | 0.05 | 0.68 |
| Q2 | 0.00 | 0.04 | 0.91 | 0.02 | 0.05 | 0.73 |
| Q3 | −0.01 | 0.03 | 0.76 | 0.00 | 0.02 | 1.00 |
| Q4 | −0.00 | 0.05 | 0.97 | 0.01 | 0.04 | 0.76 |
| Q5 (reference) | | | | | | |
| Overall | | | 0.31 | | | 0.99 |

surements exists across a wide range of daily calcium intakes, from a mean of 400+ mg/d (Q1) to 2000+ mg/d (Q5). These data corroborate results from studies with small numbers of elderly research subjects (4–8) and two meta-analyses (11, 12) and, based on a Swedish longitudinal cohort study (10), imply that fracture rates would not be different across the quintiles. Another important finding of this representative cross-sectional U.S. sample is that more than 50% of the older NHANES participants in 2005–2006 failed to achieve the calcium RDA, even with supplements, a percentage that differs somewhat from a recent report (16).

These results suggest that, as the bone density measurements of aging men and women naturally decline, an increase in calcium consumption via supplements by health-conscious older individuals to try to counteract this downward trend is a questionable strategy for trying to improve bone density or to prevent fractures. Our cross-sectional analysis shows that higher doses of calcium intake do not appear to be associated with higher femoral BMD (Fig. 3) or lumbar BMD (Fig. 4) in either older women or men. Older men appear to lose hip bone density at a slower rate than older women (Fig. 3, B *vs.* D).

The high calcium consumption of Q5 may be expected by some to have a substantial beneficial effect on retention of the hip and lumbar bone, assuming that high calcium intakes from foods and supplements have been occurring over the last few years or longer, but a skeletal BMD benefit was not observed in Q5 or any quintile with calcium intakes approaching the RDA in these cross-sectional NHANES data. Similar findings have previously been published (see above). The question arises as to where the large daily load of calcium is going in the bodies of those individuals in Q5 and in the other higher quintiles? Our data suggest that little calcium is going to bone mineral and being retained in the skeleton. Although not measured in this study, urinary losses of calcium would be expected to be highest in Q5 and gradually decline in the remaining quintiles (24). The possibility exists that urinary calcium resulting from excessive intakes in Q5 may contribute to renal stones, as observed in the Women's Health Trial (25). Fecal calcium losses likely are also increased. Finally, another possible site where calcium may go is in atherosclerotic plaques of arteries and heart valves, which presumes ectopic ossification (26). The potentially higher calcium × phosphate ion product existing in the serum of Q5 subjects, and possibly in the other relatively high-calcium quintiles, is presumed to support the initiation and advancement of arterial calcification (9, 20).

Concern regarding skeletal health of subjects in Q1 with the lowest mean total calcium intake remains despite femoral BMD measurements roughly the same as those in the other quintiles. Bone mineral density may not be a measure of bone quality in this and other quintiles. Because the calcium intakes of these elderly men and women in Q1 are considerably lower than their RDAs, they may be at increased risk of greater morbidity and mortality because of generally poor diets. Our cross-sectional data on calcium intakes across the quintiles do not show

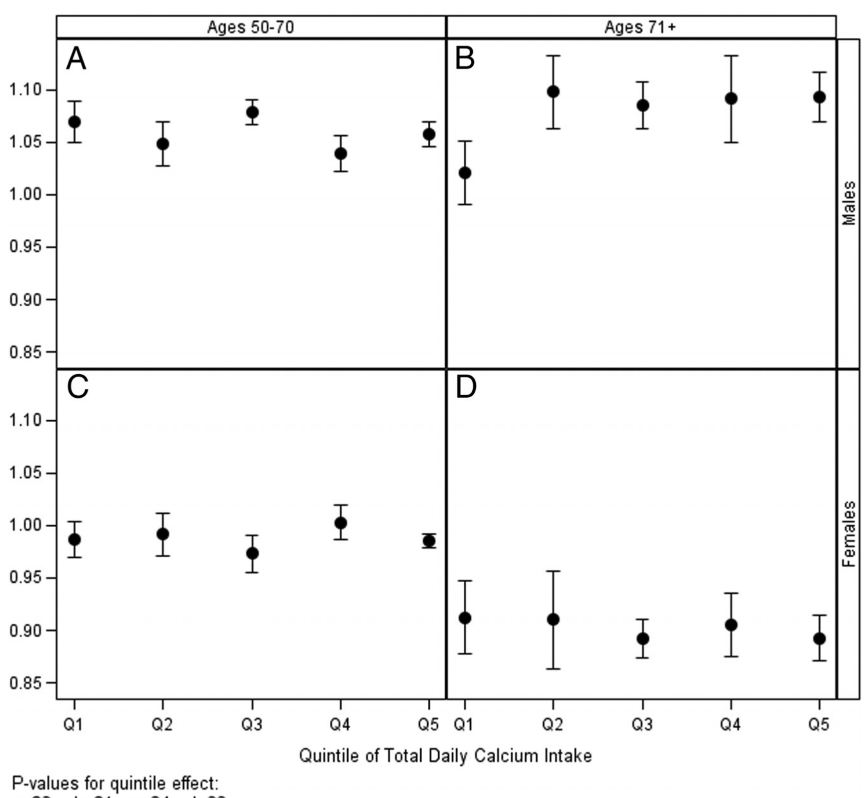


**FIG. 4.** Least-squares means and SE of lumbar BMD. A, Males ages 50–70; B, males ages 71+; C, females ages 50–70; D, ages females 71+.

that lower intakes of calcium are associated with lower hip or lumbar vertebral BMD in older adults.

Supplement user percentages varied greatly from Q1 to Q5 in all gender and age groups (Table 3). Both men and women in Q5 who were 50–70 yr or greater than 70 yr of age had significantly greater percentages who were generally healthy and were physically active (Table 4). Subjects in Q5 appear to be more concerned about their health because they have higher percentages of practitioners of health promotion than in the other quintiles of calcium intake.

Limitations of this study include cross-sectional data rather than prospective data and the inherent nature of the NHANES truncated random design of sampling the U.S. population in 2005 and 2006. No hip or lumbar fracture data have been assessed in this sample. On the other hand, this study is strengthened by use of a weighted-sample representative of the entire nation and by analytic adjustment for only BMI, among many other variables that had little or no impact in adjusted regression models. Calcium intakes in the NHANES population subgroup are representative of 50- to 70+-yr-old U.S. adults (16), but greater percentages of men and women did not achieve adequate intakes, *i.e.* RDAs, in our population sample compared with the sample examined by Bailey *et al.* (16). Limitations of 24-h dietary recalls have been raised, especially potential short-term memory issues of the elderly and accuracy about portion sizes (27). This dietary assessment tool used over 2 d is considered to provide reasonably representative mean intakes and appropriate variability of the means within a population, and furthermore, it is routinely administered in NHANES examinations because of its relative ease and efficiency. The coefficient of variation for dietary calcium means in this sample approximated 50% of the mean. A larger sample size may have yielded slightly lower variability in mean BMD values than shown in Figs. 3 and 4. Bone measurements were performed using the latest technology, but the BMD calculations are based on cross-sectional bone mass measurements that have a relatively small error of repeatability, *i.e.* 1–2%. Lumbar bone measurements had a higher variability than measurements of the proximal femur.

In conclusion, the data presented in this report from a representative national survey of older U.S. adults confirms earlier reports (11, 12) that suggest that calcium loading, *i.e.* high intakes typically provided by supplements that total more than the current RDAs, has little or no effect on femoral or lumbar bone density in older adults. In addition, concern exists that excessive total calcium intake may have a negative health effect as a potential risk factor for cardiovascular diseases and renal stones, and health professional advice regarding calcium may need to be modified. Older adults with higher levels of education and income are more likely to be in the higher quintiles of calcium consumption and also are more health-conscious. Recommendations for calcium intake may need to be tailored to the usual daily intake of this essential mineral, without supplements, and the renal function of older subjects should be routinely monitored to avoid additional risk of ectopic calcification and stones.

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## References

1. **Reid IR, Bolland MJ, Grey A** 2008 Effect of calcium supplementation on hip fractures. Osteoporos Int 19:1119–1123
2. **Cooper C** 1999 Epidemiology of osteoporosis. Osteoporos Int 9(Suppl 2):S2–S8
3. **U.S. Department of Health and Human Services** 2004 Bone health and osteoporosis: a report of the Surgeon General. Rockville, MD: U.S. Department of Health and Human Services
4. **Riggs BL, O'Fallon WM, Muhs J, O'Connor MK, Kumar R, Melton 3rd LJ** 1998 Long-term effects of calcium supplementation on serum parathyroid hormone level, bone turnover, and bone loss in elderly women. J Bone Miner Res 13:168–174
5. **Reid IR, Mason B, Horne A, Ames R, Reid HE, Bava U, Bolland MJ, Gamble GD** 2006 Randomized controlled trial of calcium in healthy older women. Am J Med 119:777–785
6. **Barger-Lux MJ, Davies KM, Heaney RP** 2005 Calcium supplementation does not augment bone gain in young women consuming diets moderately low in calcium. J Nutr 135:2362–2366
7. **Atalar E, Aydin G, Keles I, Inal E, Zog G, Arslan A, Orkun S** 2009 Factors affecting bone mineral density in men. Rheumatol Int 29: 1025–1030
8. **Reed JA, Anderson JJB, Tylavsky FA, Gallagher Jr PN** 1994 Comparative changes in radial-bone density of elderly female lactoovovegetarians and omnivores. Am J Clin Nutr 59:1197S–1202S
9. **Bolland MJ, Barber PA, Doughty RN, Mason B, Horne A, Ames R, Gamble GD, Grey A, Reid IR** 2008 Vascular events in healthy older women receiving calcium supplementation: randomized controlled trial. BMJ 336:262–266
10. **Warensjö E, Byberg L, Melhus H, Gedeborg R, Mallmin H, Wolk A, Michaëlsson K** 2011 Dietary calcium intake and risk of fracture and osteoporosis: prospective longitudinal cohort study. BMJ 342: d1473
11. **Rabenda V, Bruyère O, Reginster JY** 2011 Relationship between bone mineral density changes and risk of fractures among patients

receiving calcium with r without vitamin D supplementation: a meta-regression. Osteoporos Int 22:893–901
12. **Shea B, Wells G, Cranney A, Zytaruk N, Robinson V, Griffith L, Ortiz Z, Peterson J, Adachi J, Tugwell P, Guyatt G; Osteoporosis Methodology Group and The Osteoporosis Research Advisory Group** 2002 Meta-analysis of calcium supplementation for the prevention of postmenopausal osteoporosis. VII. Meta-analysis of calcium supplementation for the prevention of postmenopausal osteoporosis. Endocr Rev 23:552–559
13. **Bolland MJ, Avenell A, Baron JA, Grey A, MacLennan GS, Gamble GD, Reid IR** 2010 Effect of calcium supplements on risk of myocardial infarction and cardiovascular events: meta-analysis. BMJ 341:c3691
14. **Chapuy MC, Arlot ME, Duboeuf F, Brun J, Crouzet B, Arnaud S, Delmas PD, Meunier PJ** 1992 Vitamin D3 and calcium to prevent hip fractures in elderly women. N Engl J Med 327:1637–1642
15. **Tang BM, Eslick GD, Nowson C, Smith C, Bensoussan A** 2007 Use of calcium or calcium in combination wih vitamin D supplementation to prevent fractures and bone loss in people aged 50 years and older: a meta-analysis. Lancet 370:657–666
16. **Bailey RL, Gahche JJ, Lentino CV, Dwyer JT, Engel JS, Thomas PR, Betz JM, Sempos CT, Picciano MF** 2011 Dietary supplement use in the United States, 2003–2006. J Nutr 141:261–266
17. **Institute of Medicine, National Academies** 2011 Dietary reference intakes: calcium and vitamin D. Washington, DC: National Academies Press
18. **Institute of Medicine, National Academy of Sciences** 1997 Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride. Washington, D.C., National Academies Press
19. **Wang TK, Bolland MJ, van Pelt NC, Horne AM, Mason BH, Ames RW, Grey AB, Ruygrok PN, Gamble GD, Reid IR** 2010 Relationship between vascular calcification, calcium metabolism, bone density, and fractures. J Bone Miner Res 25:2777–2785
20. **Pentti K, Tuppurainen MT, Honkanen R, Sandini L, Kröger H, Alhava E, Saarikoski S** 2009 Use of calcium supplements and the risk of coronary heart disease in 52–62-year-old women: the Kuopio Osteoporosis Risk Factor and Prevention Study. Maturitas 63: 73–78
21. **Nordin BE, Lewis JR, Daly RM, Horowitz J, Metcalfe A, Lange K, Prince RL** 2011 The calcium scare: what would Austin Bradford Hill have thought? Osteoporos Int 22:3073–3077
22. **Centers for Disease Control and Prevention** http://www.cdc.gov/nchs/nhanes/nhanes2005-2006/nhanes05_06.htm/
23. **Cameron ME, van Staveren WA** 1988 Manual on methodology for food consumption studies. New York: Oxford University Press
24. **Robertson WG** 1976 Urinary excretion. In: Nordin, BE, ed. Calcium, phosphate and magnesium metabolism. Edinburgh: Churchill Livingstone; 113–161
25. **Jackson RD, LaCroix AZ, Gass M, Wallace RB, Robbins J, Lewis CE, Bassford T, Beresford SA, Black HR, Blanchette P, Bonds DE, Brunner RL, Brzyski RG, Caan B, Cauley JA, Chlebowski RT, Cummings SR, Granek I, Hays J, Heiss G, Hendrix SL, Howard BV, Hsia J, Hubbell FA, Johnson KC, *et al.*** 2006 Calcium plus vitamin D supplementation and the risk of fractures. N Engl J Med 354:669–683
26. **Demer LL, Sage AP, Tintut Y** 2008 Nanoscale architecture in atherosclerotic calcification. Arterioscler Thromb Vasc Biol 28:1882–1884
27. **van Staveren WA, Ocke MC** 2006 Estimation of dietary intake. In: Bowman BA, Russell RM, eds. Present knowledge in nutrition. 9th ed. Washington DC: International Life Sciences Institute; 795–806