# Seasonal changes in plasma 25-hydroxyvitamin D concentrations of young American black and white women[1–4]

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**See corresponding editorial on page 1108.**

**ABSTRACT** Seasonal changes in 25-hydroxyvitamin D concentrations were studied in 51 black and 39 white women aged 20–40 y from Boston. Individual measurements were made in February or March (February-March), June or July (June-July), October or November (October-November), and the following February or March (February-March). Samples from the four visits were analyzed in batches at the end of the study. Plasma 25-hydroxyvitamin D was substantially lower in black than in white women at all the time points, including February-March when values were lowest (30.2 ± 19.7 nmol/L in black and 60.0 ± 21.4 nmol/L in white women) and June-July when they were highest (41.0 ± 16.4 nmol/L in black and 85.4 ± 33.0 nmol/L in white women). Although both groups showed seasonal variation in 25-hydroxyvitamin D concentrations, the mean increase between February-March and June-July was smaller in black women (10.8 ± 14.0 nmol/L compared with 25.4 ± 29.8 nmol/L in white women, $P = 0.006$) and their overall amplitude of seasonal change was lower ($P = 0.001$). Concentrations of serum parathyroid hormone in February-March were significantly higher ($P < 0.005$) in black women (5.29 ± 2.32 pmol/L) than in white women (4.08 ± 1.41 pmol/L) and were significantly inversely correlated with 25-hydroxyvitamin D in blacks ($r = -0.42$, $P = 0.002$) but not in whites ($r = -0.19$, $P = 0.246$). Although it is well established that blacks have denser bones and lower fracture rates than whites, elevated parathyroid hormone concentrations resulting from low 25-hydroxyvitamin D concentrations may have negative skeletal consequences within black populations. *Am J Clin Nutr* 1998;67:1232–6.

**KEY WORDS** 25-Hydroxyvitamin D, vitamin D, seasonal changes, race, parathyroid hormone, cholecalciferol, humans, women

## INTRODUCTION

Numerous cross-sectional (1–5) and longitudinal (6–9) studies of white adults living in northern Europe and the northern United States have shown higher blood concentrations of 25-hydroxyvitamin D, the best clinical indicator of vitamin D status, in summertime than in wintertime (10). These seasonal differences occur, at least in part, because wintertime sunlight exposure in northern regions does not promote skin conversion of precursors to (6*Z*)-tacalciol (previtamin D) (11). The same conversion is partially inhibited by dark skin pigmentation (12), and most studies of 25-hydroxyvitamin D concentrations in black adults have shown that concentrations are lower in blacks than in comparable whites (13–18). However, there is only limited information about seasonal changes in 25-hydroxyvitamin D concentrations in blacks. Of two cross-sectional studies conducted, one found no seasonal differences in 25-hydroxyvitamin D among young black women living in New York (17), and the other found higher concentrations in summer than in winter in black men living in northern California (2).

We measured 25-hydroxyvitamin D concentrations four times over a 1-y period in 90 young female residents of the Boston area, 51 blacks and 39 whites, to describe and compare patterns of seasonal change in the two groups. We also examined associations between 25-hydroxyvitamin D and blood concentrations of 1,25-dihydroxyvitamin D and parathyroid hormone (PTH). Together, 1,25-dihydroxyvitamin D and PTH influence calcium absorption and calcium excretion, maintain normal plasma calcium concentrations, and influence skeletal calcium reserves.

## SUBJECTS AND METHODS

### Subjects

The 90 subjects in this analysis were drawn from 138 women between the ages of 20 and 40 y who were recruited from the

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Boston area (latitude: 42 °N). We excluded 12 women who did not complete the study, 1 woman who refused to have her blood drawn, and 35 women who used oral contraceptives. Eligibility requirements were reported in full previously (19). Briefly, potential subjects had to have three of four grandparents of the same race (black or white), have no plans to move away or become pregnant during the next year, weigh < 113 kg, have not used drugs that affect bone metabolism in the previous year, and have no current medical conditions that affect bone metabolism. The protocol was approved by the Human Investigations Review Committee at Tufts University, and written informed consent was obtained from each participant.

### Timing of study visits

The study included four measurement periods of ≈2 mo each, during which the 90 women had blood drawn for assessment of plasma vitamin D. These visits took place in February through March (February-March), June through July (June-July), October through November (October-November), and the following February through March. Individual follow-up visits took place an average (± SD) of 4.1 ± 0.2, 8.3 ± 0.3, and 12.1 ± 0.4 mo after the baseline visits.

### Measurements

Plasma 25-hydroxyvitamin D samples from all four study visits were analyzed in batches at the end of the study by the method of Preece et al (20), with intra- and interassay CVs of 5.0% and 7.3%, respectively. Plasma 1,25-dihydroxyvitamin D was measured in samples from the baseline visit (February-March) by the competitive protein-binding method of Reinhardt et al (21), with intra- and interassay CVs of 4.9% and 7.7%, respectively. Serum intact PTH was measured at baseline (February-March) and 4 mo later (June-July) with Allegro intact radioimmunoassay kits from Nichols Institute (San Juan Capistrano, CA), with intra- and interassay CVs of 5.6% and 6.6%, respectively.

Body weight was measured with a conventional scale, and height was measured with a wall-mounted stadiometer. Dietary vitamin D and calcium intakes since the previous study visit were estimated at each of the follow-up study visits with a food-frequency questionnaire designed to estimate calcium and vitamin D intakes from natural and fortified foods (22). Use of vitamin D supplements, calcium supplements, and oral contraceptives was recorded at the baseline and final visits. Average total intakes of calcium and vitamin D were computed as the sums of average dietary and supplemental intakes. Information about time spent outside over the previous 3 mo was obtained by questionnaire at every visit.

**TABLE 1**
Characteristics of the black and white women[1]

| | Black women ($n$ = 51) | White women ($n$ = 39) |
|---|---|---|
| Age (y) | 30.6 ± 5.9 | 31.7 ± 6.1 |
| Height (cm) | 164.6 ± 7.5 | 166.2 ± 6.0 |
| Weight (kg) | 71.5 ± 14.8 | 63.0 ± 8.5[2] |
| Calcium intake (mg/d) | 638.1 ± 388.5 | 758.1 ± 317.3 |
| Vitamin D intake (IU/d) | 206.6 ± 162.4 | 231.8 ± 155.2 |
| Source of vitamin D (IU/d) | | |
| Milk as a beverage | 9.4 ± 15.0 | 50.0 ± 66.9[2] |
| Other milk and dairy | 57.1 ± 50.1 | 57.8 ± 31.2 |
| Other foods[3] | 38.4 ± 32.9 | 19.0 ± 13.0[2] |
| Supplements | 100.7 ± 135.8 | 106.4 ± 142.6 |

[1] $\bar{x}$ ± SD.
[2] Significantly different from black women, $P \leq 0.001$.
[3] Includes fish, eggs, and fortified nondairy foods.

**TABLE 2**
Laboratory values according to race[1]

| | Black women ($n$ = 51) | White women ($n$ = 39) |
|---|---|---|
| February-March | | |
| Plasma 25-hydroxyvitamin D (nmol/L) | 30.2 ± 19.7 | 60.0 ± 21.4[2] |
| Plasma 1,25-dihydroxyvitamin D (pmol/L) | 93.3 ± 19.6 | 87.6 ± 22.0 |
| Serum parathyroid hormone (pmol/L) | 5.29 ± 2.32 | 4.08 ± 1.41[2] |
| June-July | | |
| Plasma 25-hydroxyvitamin D (nmol/L) | 41.0 ± 16.4 | 85.4 ± 33.0[2] |
| Serum parathyroid hormone (pmol/L) | 4.69 ± 1.96 | 4.03 ± 1.63 |

[1] $\bar{x}$ ± SD.
[2] Significantly different from black women, $P < 0.005$.

### Statistical analysis

Two sample $t$ tests were used to compare characteristics and laboratory values of the black and white women. Within-race changes in 25-hydroxyvitamin D from February-March to June-July were evaluated with one-sample $t$ tests. Adjusted means and repeated-measures analyses of variance were conducted with the SAS general linear models procedure (SAS Institute, Cary, NC). Pearson correlation coefficients were used to describe linear relations among variables. $P$ values were derived from two-tailed tests conducted at the 0.05 level.

## RESULTS

The 90 subjects were 20–40-y old. The black women were similar to the white women in mean age and height, but the black women were an average of 8.5 kg heavier (**Table 1**). Although the differences were not significant, the black women also had modestly lower mean intakes of calcium and vitamin D (Table 1). In addition, the black women obtained a smaller proportion of their vitamin D intake from milk consumed as a beverage and a greater proportion from nondairy sources than did whites.

Unadjusted plasma 25-hydroxyvitamin D concentrations were substantially lower in black than in white women at all time points, including February-March when values were lowest and June-July when they were highest (**Table 2**). Adjustment for body weight and vitamin D intake reduced the race difference in 25-hydroxyvitamin D concentrations by < 5 nmol/L (**Figure 1**). Although women of both races had significant increases in 25-hydroxyvitamin D between February-March and June-July ($P < 0.001$), the mean increase was smaller in the black women (10.8 ± 14.0 nmol/L compared with 25.4 ± 29.8 nmol/L in whites, $P = 0.006$). By the second February-March measurement period, the values in both groups had returned to near baseline values. There was a significant time-by-race interaction in

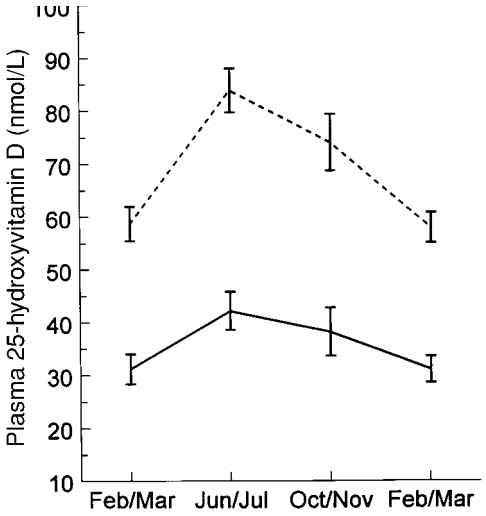


**FIGURE 1.** Mean (±SEM) seasonal change in 25-hydroxyvitamin D concentrations of 51 black (solid line) and 39 white (dashed line) women, adjusted for body weight and vitamin D intake.

25-hydroxyvitamin D values at the four time points ($P = 0.001$; repeated-measures analysis of variance), providing further statistical support of smaller seasonal changes in 25-hydroxyvitamin D in black than in white women.

Concentrations of 1,25-dihydroxyvitamin D in black women did not differ significantly from those in white women at the only time point they were measured (February-March; Table 2). Serum PTH concentrations in February-March were significantly higher in black than in white women (Table 2), and this difference was reduced by only 0.05 pmol/L with adjustment for racial differences in weight and calcium intake. Black women had a greater decrease in serum PTH between February-March and June-July ($-0.60 \pm 1.48$ pmol/L compared with $-0.05 \pm 1.06$ pmol/L in white women, $P = 0.043$), such that values of black and white women were more similar in June-July than in February-March (Table 2). As shown in **Figure 2**, the association of PTH with 25-hydroxyvitamin D was generally linear within race. In black women, 25-hydroxyvitamin D concentrations in February-March were inversely correlated with PTH concentrations ($r = -0.42$, $P = 0.002$), and changes in 25-hydroxyvitamin D from winter to summer were inversely correlated with changes in PTH concentrations ($r = -0.33$, $P = 0.019$). In white women, however, 25-hydroxyvitamin D was not significantly correlated with PTH in February-March ($r = -0.19$, $P = 0.246$), and changes in 25-hydroxyvitamin D from winter to summer were not significantly correlated with changes in PTH ($-0.24$, $P = 0.145$). Time per week spent outside did not differ significantly by race and was not correlated with 25-hydroxyvitamin D in either race at any time of the year.

## DISCUSSION

Concentrations of 25-hydroxyvitamin D in the young black women in this study were less than half those of the young white women at each of the four time points at which measurements were made. Although both groups showed seasonal variation in 25-hydroxyvitamin D concentrations, the amplitude of change, including summertime increases, was lower in black than in white women. It is unlikely that these findings resulted from any absolute racial limit in the production of 25-hydroxyvitamin D or its precursors because, when ultraviolet exposure is sufficient, black adult populations can achieve mean concentrations of both vitamin D and 25-hydroxyvitamin D that are similar to those of whites (12, 23–25). Rather, it would appear that the more pigmented skin of the black women allowed them to form substantially less previtamin D between April and November when ultraviolet exposure in New England is sufficient to induce synthesis (11). The persistence of a racial difference in 25-hydroxyvitamin D through February and March suggests that black women may also store less previtamin D, vitamin D, or vitamin D metabolites in body tissues for several months beyond the synthesis period (26, 27). This hypothesis, however, has not been tested by comparing the vitamin D tissue stores of blacks and whites.

We are aware of only one previous report of prospectively measured seasonal changes in 25-hydroxyvitamin D concentrations in black adults (28). In that study, nine black men and women from South Carolina had increases in 25-hydroxyvitamin D concentrations between winter and summer that were half those of six whites. The racial difference we observed in the present study was modestly greater, perhaps because of the higher latitude in Boston than in South Carolina (42 °N compared with ≈33 °N) or because of the exclusion of men from our study. The seasonal changes we observed can also be compared with those reported by Scragg et al (29), who made serial measurements of cholecalciferol concentrations in 390 New Zealand adults (latitude: 40° S). In that study, values in a darker-skinned group (Pacific Islanders) were substantially lower than those of a lighter-skinned group (those of European or Asian ancestry) at every time of year. In that study, as in ours, changes from winter to summer were more than twice as great in the lighter- than in the darker-skinned groups.

The black women in the present study had low 25-hydroxyvitamin D concentrations relative to the white women, but they had similar 1,25-dihydroxyvitamin D concentrations. This finding is consistent with other reports in which blacks had lower 25-hydroxyvitamin D concentrations than whites but did not have lower 1,25-dihydroxyvitamin D concentrations (13–16). This finding, however, does not necessarily imply an intrinsically racial

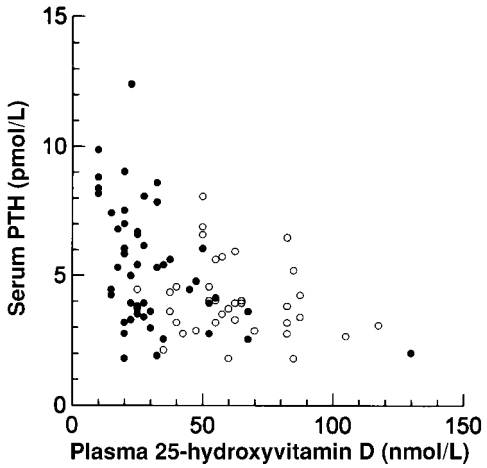


**FIGURE 2.** Association of parathyroid hormone (PTH) with 25-hydroxyvitamin D concentrations in 51 black (●) and 39 white (○) women. Measurements were made in February or March.

enhancement of 25-hydroxyvitamin D hydroxylation in blacks because white populations also tend to have normal to high 1,25-dihydroxyvitamin D concentrations when they have a mild 25-hydroxyvitamin D deficiency (30).

Wintertime serum PTH concentrations in black women were higher than those in white women and were more strongly inversely correlated with 25-hydroxyvitamin D concentrations. Plotted values of PTH by plasma 25-hydroxyvitamin D concentrations in black and white women are not inconsistent with a curvilinear association common to both races (Figure 2), but a larger sample size would be required to determine the shape of such a curve with confidence. Several other studies have also shown a pattern of lower 25-hydroxyvitamin D and higher PTH concentrations in black than in white adults (13, 15, 16, 18), whereas other studies in which 25-hydroxyvitamin D concentrations in the two groups were more similar did not (13, 17). The inverse association between seasonal changes in 25-hydroxyvitamin D and seasonal changes in PTH in the black women further suggests that their wintertime 25-hydroxyvitamin D concentrations may not be optimal. As reported previously, the black women in this study (19) and others (31, 32) have bone density that is substantially higher than that of whites, consistent with a relative skeletal resistance to PTH (33, 34). Nevertheless, a positive association between 25-hydroxyvitamin D and bone mineral density has been noted within a black population (18) and vitamin D deficiency should not be dismissed as a risk factor for osteoporosis in black adults.

In conclusion, the healthy young black women in this study had substantially lower plasma 25-hydroxyvitamin D concentrations than white women all year long, a smaller 25-hydroxyvitamin D increase between winter and summer, and higher PTH concentrations in winter.

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