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ORIGINAL RESEARCH ARTICLE

# Prevalence of 25-Hydroxyvitamin D Deficiency in the Outpatient Rehabilitation Population

## ABSTRACT

Pellicane AJ, Wysocki NM, Schnitzer TJ: Prevalence of 25-hydroxyvitamin D deficiency in the outpatient rehabilitation population. Am J Phys Med Rehabil 2010;89:899–904.

**Objective:** To assess the prevalence of 25-hydroxyvitamin D insufficiency and deficiency in the outpatient rehabilitation setting and to identify patient characteristics associated with low serum 25-hydroxyvitamin D levels.

**Design:** 25-Hydroxyvitamin D levels from 136 rehabilitation outpatients at an academic rehabilitation facility obtained from April 2007 to December 2008 for patient care purposes were captured via retrospective electronic medical record review.

**Results:** Considering only those subjects not receiving 25-hydroxyvitamin D supplementation at time of evaluation, 33.0% were 25-hydroxyvitamin D Sufficient while 53.2% were Insufficient and 13.8% Deficient. Those outpatient subjects receiving supplementation at time of evaluation had significantly higher 25-hydroxyvitamin D levels compared with those not receiving supplementation (34.1 $\pm$ 14.2 ng/ml *vs.* 25.9 $\pm$ 15.2 ng/ml; $P = 0.005$). Blacks had significantly lower 25-hydroxyvitamin D levels compared with whites (18.0 $\pm$ 10.6 ng/ml vs. 31.3 $\pm$ 14.3 ng/ml; $P < 0.001$). Subjects not on vitamin D supplementation assigned to diagnostic groups, Spinal Cord Injury, Brain Injury, and Hereditary Musculoskeletal, all had average 25-hydroxyvitamin D levels well below the lower limit of Sufficiency.

**Conclusions:** Sixty-seven percent of rehabilitation outpatients are 25-hydroxyvitamin D Insufficient or Deficient. Supplementation significantly affects 25-hydroxyvitamin D levels in the outpatient rehabilitation population. Non-white race and history of Spinal Cord Injury, Brain Injury, or Hereditary Musculoskeletal diagnosis seem to be associated with lower 25-hydroxyvitamin D levels.

**Key Words:** Vitamin D, Rehabilitation, Prevalence

Serum 25-hydroxyvitamin D [25(OH)D] deficiency is a risk factor for osteopenia, osteoporosis, and bone fractures[1–3] and may cause muscle weakness, musculoskeletal pain, impaired physical function,[3–5] progression of osteoarthritis,[6] or generalized osteomalacia due to secondary hyperparathyroidism.[7] More specifically, it should be noted that 25(OH)D levels <20 ng/ml have been associated with decreases in bone density, decreases in intestinal calcium absorption, and decrements in lower limb function.[8] Clearly, all of the aforementioned impairments may lead to or exacerbate functional limitations.

Numerous studies have demonstrated 25(OH)D insufficiency or deficiency in noninstitutionalized populations. Note that these studies use different criteria to define 25(OH)D sufficiency, insufficiency, and deficiency, making comparison difficult at times. During 1988–1994 and 2000–2004, 25(OH)D levels in a noninstitutionalized civilian United States population were obtained as part of the National Health and Nutrition Examination Surveys.[9] This study showed that all age groups ranging from age 6 yrs and older possessed mean 25(OH)D levels corresponding to 25(OH)D insufficiency (10.0–29.9 ng/ml). In addition, in a healthy United States population (average male age, 57.3 yrs; average female age, 53.7 yrs), Sherman et al.[10] reported 2.5% of those studied to have 25(OH)D levels <14 ng/ml. In other populations, the degree and prevalence of 25(OH)D insufficiency and deficiency was found to be even higher. Two hundred sixty-eight healthy, noninstitutionalized elderly (mean age, 72 yrs) were shown to have a mean 25(OH)D level of 15.5 ng/ml (significantly lower than younger controls with a mean age of 32 yrs, whose average level was 29.1 ng/ml).[11] In addition, a study of 116 homebound elderly (mean age, 81 yrs) revealed 48% to have 25(OH)D levels <10 ng/ml (which corresponds to 25(OH)D deficiency).[12]

There are fewer data with regard to hypovitaminosis D in the various rehabilitation settings. In the subacute rehabilitation setting, Shinchuk et al.[13] found a 49.1% prevalence of 25(OH)D levels <20 ng/ml, and Goldray et al.[14] found a 21.9% prevalence of 25(OH)D levels between 5 and 9 ng/ml. In the acute rehabilitation setting, Kiebzak et al.[15] found 94% of patients with 25(OH)D levels <32 ng/ml and determined a significant difference in Functional Independence Measure (FIM) efficiency, comparing patients above and below the median 25(OH)D level of 16.55 ng/ml. Tsarouhas[16] found that 94.3% of traumatic and nontraumatic orthopedic patients admitted to acute inpatient rehabilitation had 25(OH)D levels <30 ng/ml and found blacks and women to have a significantly lower mean 25(OH)D compared with whites and men, respectively. All of these studies focused on inpatient rehabilitation populations. To our knowledge, no study has attempted to characterize the prevalence of 25(OH)D insufficiency and deficiency in the outpatient rehabilitation population.

Studies have shown that treatment and improvement of 25(OH)D insufficiency and deficiency can improve muscle power and strength,[17–20] improve musculoskeletal pain,[21] decrease fall[22] and fracture rates,[23,24] and improve overall function.[25,26] Given the prevalence of low 25(OH)D levels in the both the noninstitutionalized and inpatient rehabilitation settings, its relationship to functional impairments, and evidence suggesting improvement in impairments with its correction, the study of hypovitaminosis D in the outpatient rehabilitation population is warranted. This study used data obtained for patient care purposes in the outpatient rehabilitation setting in an attempt to characterize the prevalence of hypovitaminosis D and to identify patient characteristics associated with low 25(OH)D levels.

## METHODS

This study was approved by the Northwestern University Institutional Review Board in Evanston, Illinois. Any outpatient who presented to the Rehabilitation Institute of Chicago and had a serum 25(OH)D level drawn (regardless of reason) between April 1, 2007, and December 1, 2008, was studied retrospectively. Only initial 25(OH)D levels were studied, and any repeat 25(OH)D levels on subjects were carefully identified and eliminated from inclusion. One hundred thirty-six outpatient subjects were identified using these criteria. No formal consent was obtained, as the data collected represented direct patient care. Demographic data (age, sex, and race), primary diagnosis, treatment at time of evaluation, as well as the 25(OH)D level for each subject were collected. 25(OH)D measurements were performed at Northwestern Memorial Hospital by using an enzyme-linked immunosorbent assay kit (International Diagnostic Systems Corp, St. Joseph, MI). 25(OH)D levels were characterized per guidelines set forth by International Diagnostic Systems Corp (Table 1). These levels corresponded to published levels, defining sufficiency, insufficiency, and deficiency.[27–29] In addition, all subjects not on supplementation at time of 25(OH)D draw were assigned to a general diagnostic group on the basis of the subject's primary

**TABLE 1** Interpretation of 25(OH)D level (ng/ml)

| | |
|---|---|
| Toxicity | ≥100.0 |
| Sufficiency | 30.0–99.9 |
| Insufficiency | 10.0–29.9 |
| Deficiency | <10.0 |

25(OH)D, 25-hydroxyvitamin D.

diagnosis. The general diagnostic groups included Spinal Cord Injury, Brain Injury, Cerebral Palsy, Hereditary Neurologic, Miscellaneous Neurologic, Hereditary Musculoskeletal, Musculoskeletal Pain, Osteoporosis, Rheumatologic, and Cancer. Statistical analysis was not performed based on diagnostic group, given the low numbers of subjects in each group.

### Data Analysis

Analysis was performed by using Stata software (version 11; StataCorp LP, College Station, TX). Forward exact test was used to describe the distribution of subjects based on supplementation status and 25(OH)D status. Two-sample *t* test with equal variances was used to assess treatment status and gender's relationship to 25(OH)D level. Analysis of variance was used to compare 25(OH)D levels among different racial groups. Pearson's correlation coefficient was used to evaluate the relationship between 25(OH)D level and age.

## RESULTS

Subjects' average age was 54.1 ± 19.4 yrs (range, 20–91 yrs). Of the 136 subjects studied, 31.6% were men ($n = 43$) and 68.4% were women ($n = 93$); 51.5% were white ($n = 70$), 23.5% were black ($n = 32$), 8.8% were other ($n = 12$), and 16.2% had no racial designation ($n = 22$; Table 2).

Considering all subjects ($n = 136$), 41.9% ($n = 57$) were 25(OH)D Sufficient while 46.3% ($n = 63$) were Insufficient, and 11.8% ($n = 16$) were Deficient. Considering only those subjects not receiving 25(OH)D supplementation at time of evaluation ($n = 94$), 33.0% ($n = 31$) were 25(OH)D Sufficient while 53.2% ($n = 50$) were Insufficient, and 13.8% ($n = 13$) were Deficient. Finally, considering only those subjects receiving 25(OH)D supplementation at time of evaluation ($n = 39$), 61.5% ($n = 24$) were 25(OH)D Sufficient while 33.3% ($n = 13$) were Insufficient, and 5.1% ($n = 2$) were Deficient (Table 3). The percentage of subjects receiving supplementation and deemed 25(OH)D Sufficient was significantly higher than expected given the distribution, and the percentage of subjects not receiving supplementation and deemed 25(OH)D Insufficient or Deficient was significantly higher than expected given the distribution (Fisher's exact test, $P = 0.009$). Those outpatient subjects receiving supplementation at time of evaluation had significantly higher 25(OH)D levels compared with those not receiving supplementation (34.1 ± 14.2 ng/ml *vs.* 25.9 ± 15.2 ng/ml; $P = 0.005$).

Considering all subjects, blacks (19.5 ± 12.8 ng/ml; $P < 0.001$) and non-blacks/non-whites (22.2 ± 9.1 ng/ml; $P = 0.031$) had significantly lower 25(OH)D levels compared with whites (33.1 ± 14.2 ng/ml). When considering only those subjects not receiving supplementation at time of evaluation, blacks (18.0 ± 10.2 ng/ml; $P < 0.001$) continued to have significantly lower 25(OH)D levels while non-blacks/non-whites (20.3 ± 9.7 ng/ml; $P = 0.081$) did not continue to have significantly lower 25(OH)D levels compared with whites (31.3 ± 14.3 ng/ml).

Men possessed significantly lower 25(OH)D levels compared with women when considering all subjects (24.2 ± 12.4 ng/ml *vs.* 30.2 ± 16.3 ng/ml; $P = 0.033$). This significant difference, however, did not persist when considering only those subjects not receiving supplementation at time of evaluation (men, 23.9 ± 12.7 ng/ml *vs.* women, 27.0 ± 16.4 ng/ml; $P = 0.360$). In addition, there was no significant relationship between 25(OH)D level and age when considering all subjects or when considering only those subjects not receiving supplementation at time of evaluation.

The relationship between diagnostic group and 25(OH)D level was not evaluated statistically because of the low number of subjects in each diagnostic group. Diagnostic group data were, however, displayed on a box-and-whisker plot for general comparison (Fig. 1). Note that a horizontal line corresponding to 25(OH)D level of 30.0 ng/ml was included in the figure, as this corresponds to the threshold value delineating 25(OH)D Sufficiency from 25(OH)D Insufficiency. It should be noted that subjects not on vitamin D supplementation assigned to diagnostic groups, Spinal Cord Injury, Brain Injury, and Hereditary Musculoskeletal, all

**TABLE 2** Patient demographics and diagnoses ($n = 136$)

| | |
|---|---|
| Age (mean ± SD), yrs | 54.1 ± 19.4 |
| Age range, yrs | 20–91 |
| Sex, *n* (%) | |
| Male | 43 (31.6) |
| Female | 93 (68.4) |
| Race, *n* (%) | |
| White | 70 (51.5) |
| Black | 32 (23.5) |
| Other | 12 (8.8) |
| No racial designation | 22 (16.2) |
| Diagnoses | |
| Cerebral palsy | $n = 27$ |
| Musculoskeletal pain | $n = 20$ |
| Miscellaneous neurologic | $n = 19$ |
| Osteoporosis | $n = 17$ |
| Spinal cord injury | $n = 16$ |
| Hereditary neurologic | $n = 10$ |
| Hereditary musculoskeletal | $n = 8$ |
| Rheumatologic | $n = 8$ |
| Brain injury | $n = 7$ |
| General medical | $n = 4$ |

**TABLE 3** Outpatient 25(OH)D status and mean 25(OH)D level by treatment

| 25(OH)D Status | All Subjects ($n$ = 136) | Subjects Without 25(OH)D Supplementation ($n$ = 94) | Subjects with 25(OH)D Supplementation ($n$ = 39) | |
|---|---|---|---|---|
| Sufficiency, $n$ (%) | 57 (41.9) | 31 (33.0) | 24 (61.5) | |
| Insufficiency, $n$ (%) | 63 (46.3) | 50 (53.2) | 13 (33.3) | |
| Deficiency, $n$ (%) | 16 (11.8) | 13 (13.8) | 2 (5.1) | |
| Mean 25(OH)D (ng/ml) | | 25.9 ± 15.2 | 34.1 ± 14.2 | $P$ = 0.005 |

25(OH)D, 25-hydroxyvitamin D.

had average 25(OH)D levels well below 30.0 ng/ml (18.7, 16.5, and 16.0 ng/ml, respectively).

## DISCUSSION

To our knowledge, there are no existing data on the prevalence of hypovitaminosis D in the outpatient rehabilitation population. Some review articles reference original research in their discussion of hypovitaminosis D in the outpatient rehabilitation population; however, these articles actually describe patient populations from other specialties or focus exclusively on musculoskeletal pain and its relationship to hypovitaminosis D (while ignoring all other outpatient rehabilitation diagnoses).[30,31] One study by Greenberg et al.[32] did study outpatient rehabilitation stroke survivors and their frequency of use of medications to maintain bone health; however, the study did not describe hypovitaminosis D prevalence in their sample. For comparison, note that the National Health and Nutritional Examination Survey described a mean 25(OH)D level of 23.7 ± 0.4 ng/ml in patients aged 50–69 yrs in a noninstitutionalized United States population.[9] The average age of the outpatient subjects studied here was 54.10 ± 19.44 yrs and revealed a mean 25(OH)D level of 28.3 ± 15.4 ng/ml.

Given that 67.0% of the outpatients not receiving 25(OH)D supplementation studied here were deemed 25(OH)D Insufficient or Deficient, future research on hypovitaminosis D and its impact on the outpatient rehabilitation population should occur. In addition, because 38.4% of the outpatients receiving 25(OH)D supplementation studied here were deemed 25(OH)D Insufficient or Deficient, education focused on effective hypovitaminosis D treatment in this population is warranted, as well. Finally, given that this study demonstrated particularly low vitamin D levels in those outpatients assigned to diagnostic groups, Spinal Cord Injury, Brain Injury, and Hereditary Musculoskeletal (18.72, 16.53, and 16.01 ng/ml, respectively), it

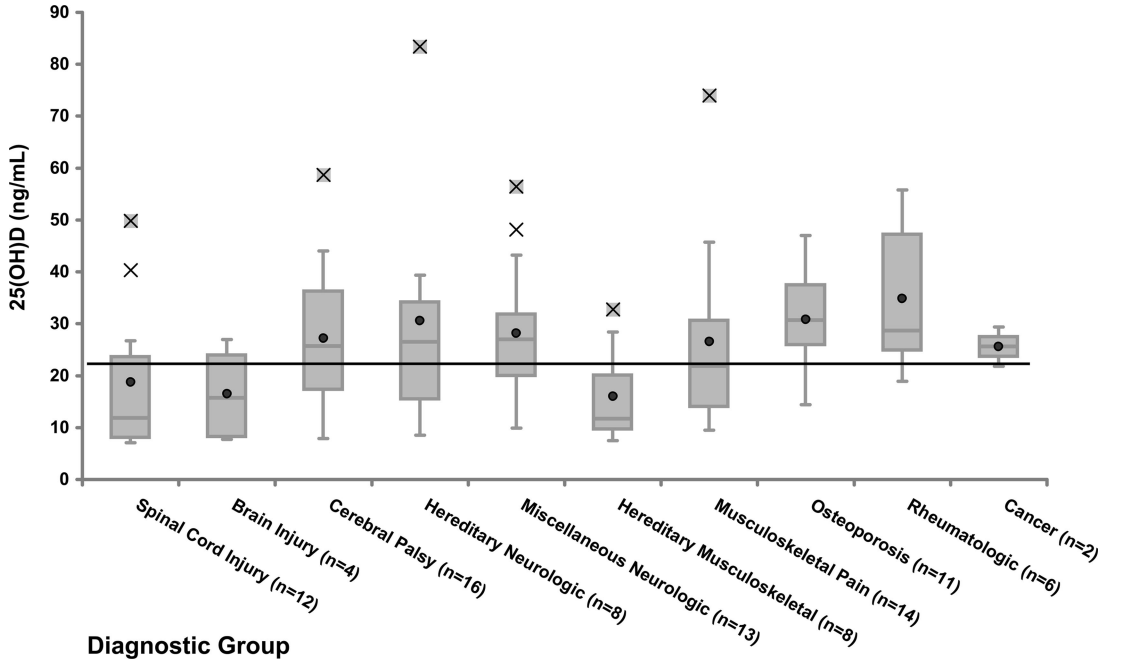


**FIGURE 1** *Outpatient 25-hydroxyvitamin D [25(OH)D] by diagnostic group.*

may be reasonable to suggest focusing work on these outpatient populations first. Minority race and male gender may also be considered potential risk factors for hypovitaminosis D in the outpatient rehabilitation population.

This study has several limitations. First, the mixed diagnostic population studied here is not ideal for attempting to describe prevalence. Second, information on subject living situation (home, skilled nursing etc.) was not assessed. Third, information on contraindications to hypovitaminosis D treatment protocols was not investigated in the nonsupplemented subjects. Fourth, the seasonal and geographic effects on 25(OH)D level were not considered during data analysis. It should be noted that serum 25(OH)D levels are higher in the summer and fall and lower in the winter and spring,[33] and 25(OH)D levels are maximal at 30–60 days after peak sunlight exposure in the summer months.[34] In addition, Chicago, Illinois, is located at 41° 51′ 0″ N latitude, and it has been reported that at latitudes above 37°N and below 37°S during winter months, sunlight is insufficient to induce cutaneous vitamin $D_3$ synthesis.[29] Fifth, assessment of individual subject sunlight exposure was not possible, given the retrospective nature of the study. Finally, the adequacy of supplementation from a supplement dose standpoint was not included in the data collection.

## CONCLUSIONS

Sixty-seven percent of rehabilitation outpatients are 25(OH)D Insufficient or Deficient. 25(OH)D supplementation significantly affects 25(OH)D levels in the outpatient rehabilitation population but does not assure 25(OH)D Sufficiency. Non-white race and history of Spinal Cord Injury, Brain Injury, or Hereditary Musculoskeletal diagnosis seem to be associated with lower 25(OH)D levels.

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