# Serum 25-Hydroxyvitamin D is an Independent Predictor of High Density Lipoprotein Cholesterol and Metabolic Syndrome in Men and Women

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## Background

- Observational studies have shown inverse relationships between vitamin D status, as assessed by the circulating concentration of 25-Hydroxyvitamin D [25(OH)D], and the incidence of several chronic diseases, especially cardiovascular disease (Dobnig 2008).
- Vitamin D insufficiency is common in the United States, with population studies suggesting that approximately 30% to 50% of the general population has circulating 25(OH)D levels < 30 ng/dL (≥ 30 ng/mL is considered sufficient, < 30 ng/mL is considered insufficient and < 20 ng/mL reflects vitamin D deficiency) (Holick 2008) .

## Objective

- The objective of this cross-sectional study was to assess the relationships between serum 25(OH)D and selected markers for cardiovascular disease risk, including the metabolic syndrome and its components, in men and women.

## Subjects

- Men and women, ≥18 years of age (n = 257).
- Most participants were attending an annual meeting for a dietary supplement manufacturer and distributor (n = 211) (Shaklee Corporation, Pleasanton, CA). Results from a previous study of attendees of this annual meeting suggested a high average level of 25(OH)D in this group. Additional participants were recruited through advertising in Bloomington, IN and Addison, IL.
- Female subjects who were pregnant or lactating and subjects with a history of cancer (other than non-melanoma skin cancer) in the prior two years were excluded.

## Methods

- Fasting lipids, glucose, serum levels of 25(OH)D, anthropometric measurements and blood pressure were assessed.
- Dietary intake and physical activity were assessed with the Harvard Food Frequency Questionnaire, the Stanford 7-day Physical Activity Recall Questionnaire, and questionnaires designed to assess dietary supplement use and sun exposure.
- Data were collected over a 7-week period in August and September 2008.

## Results

### Table 1. Subject characteristics at baseline.

| | Serum 25-hydroxyvitamin D | | | |
|---|---|---|---|---|
| | Tertile 1 ≤ 34 ng/mL (n = 80) | Tertile 2 35-45 ng/mL (n = 90) | Tertile 3 ≥ 46 ng/mL (n = 87) | P for Trend |
| Participants[1], *n* (%) | 80 (31.1) | 90 (35.1) | 87 (33.9) | – |
| Women, *n* (%) | 55 (68.8) | 65 (72.2) | 66 (75.9) | 0.305 |
| Non-Hispanic white, *n* (%) | 71 (88.8) | 84 (93.3) | 85 (97.5) | 0.026 |
| Current smoker, *n* (%) | 3 (3.8) | 2 (2.2) | 1 (1.1) | 0.280 |
| Current metabolic syndrome[2], *n* (%) | 25 (31.3) | 13 (14.4) | 9 (10.3) | < 0.001 |
| | Mean ± SEM | | | |
| Serum 25(OH)D, *ng/mL* | 29.7 ± 0.4 | 39.8 ± 0.3 | 52.1 ± 0.8 | < 0.001 |
| Age, *y* | 48.3 ± 1.6 | 53.1 ± 1.6 | 53.0 ± 1.6 | 0.039 |
| Waist circumference, *cm* | 94.5 ± 2.0 | 89.9 ± 1.5 | 85.6 ± 1.2 | < 0.001 |
| Body mass index, *kg/m²* | 29.1 ± 0.8 | 26.8 ± 0.6 | 25.3 ± 0.5 | < 0.001 |
| Alcohol intake, *drinks/wk* | 2.9 ± 0.4 | 3.2 ± 0.6 | 3.3 ± 0.4 | 0.588 |
| Vitamin D intake, *IU/d* | | | | |
| From food | 275.9 ± 19.4 | 327.3 ± 24.1 | 307.1 ± 18.4 | 0.324 |
| From supplements | 632.3 ± 60.9 | 799.3 ± 67.5 | 1019.4 ± 77.1 | < 0.001 |
| From food + supplements | 887.5 ± 44.4 | 1104.7 ± 74.9 | 1315.9 ± 79.9 | < 0.001 |
| Physical activity score, *MET-hr/wk* | 278.6 ± 5.6 | 284.8 ± 5.8 | 290.8 ± 5.8 | 0.139 |
| Systolic blood pressure, *mm Hg* | 119.5 ± 1.4 | 119.0 ± 1.5 | 118.3 ± 1.5 | 0.583 |
| Diastolic blood pressure, *mm Hg* | 74.3 ± 1.3 | 72.5 ± 0.9 | 73.2 ± 1.0 | 0.508 |
| Glucose, *mg/dL* | 94.8 ± 2.7 | 91.4 ± 1.3 | 89.8 ± 1.2 | 0.059 |
| Total cholesterol, *mg/dL* | 191.5 ± 4.2 | 194.2 ± 3.8 | 201.2 ± 3.9 | 0.085 |
| Non-HDL cholesterol, *mg/dL* | 143.1 ± 4.0 | 139.9 ± 3.8 | 138.9 ± 3.6 | 0.457 |
| LDL cholesterol, *mg/dL* | 121.0 ± 3.6 | 121.2 ± 3.5 | 122.0 ± 3.2 | 0.838 |
| HDL cholesterol, *mg/dL* | 48.4 ± 1.8 | 54.3 ± 1.9 | 62.3 ± 2.1 | < 0.001 |
| Triglycerides, *mg/dL* | 113.1 ± 9.3 | 93.6 ± 7.1 | 84.5 ± 5.8 | 0.008 |

[1]Due to a large number of tied values, the number of participants in each tertile is not equal.

[2]Metabolic syndrome defined according to Grundy (2004).

**Abbreviations:**
HDL = high density lipoprotein; LDL = low density lipoprotein; 25(OH)D = 25-Hydroxyvitamin D; MET = metabolic equivalent score

### Table 2. Multivariate linear and logistic regression analyses for the relationships between serum 25-hydroxyvitamin D (ng/mL) and selected cardiovascular risk markers (dependent variables).

| | ß | SE (ß) | P-value |
|---|---|---|---|
| HDL cholesterol, *mg/dL* | | | |
| Model 1[1] | 0.52 | 0.09 | < 0.001 |
| Model 2[2] | 0.42 | 0.10 | < 0.001 |
| Triglycerides, *mg/dL* | | | |
| Model 1[1] | –0.59 | 0.40 | 0.146 |
| Waist circumference, *cm* | | | |
| Model 1[1] | –0.31 | 0.08 | < 0.001 |
| Model 2[3] | –0.38 | 0.09 | < 0.001 |
| Metabolic syndrome (0 = no, 1 = yes, logistic regression)[4] | | | |
| Model 1[1] | –0.05 | 0.02 | 0.006 |
| Model 2[3] | –0.07 | 0.02 | 0.003 |

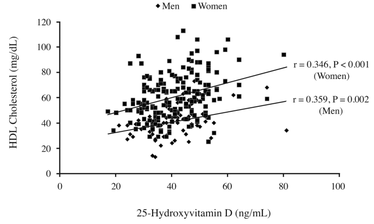
[1]Adjusted for age and sex.

[2]Adjusted for age, sex, body mass index, waist circumference, physical activity score, alcohol consumption, smoking status, and vitamin D supplement use.

[3]Adjusted for age, sex, physical activity score, alcohol consumption, smoking status, and vitamin D supplement use.

[4]The relationship between an increase of 1 ng/mL in 25(OH)D and relative odds for metabolic syndrome may be calculated from $e^{ß}$. For example, for ß = –0.05 as in Model 1, $e^{-0.05} = 0.95$, indicating a 5% reduction in the relative odds for metabolic syndrome for each 1 ng/mL increment in 25(OH)D.

### Figure 1. Relationship between serum 25-hydroxyvitamin D and high-density lipoprotein (HDL) cholesterol concentrations in men and women.




## Conclusions

- HDL cholesterol concentration increased in a graded fashion from the lowest to the highest 25(OH)D tertile.
- After adjustment for established determinants of the HDL cholesterol concentration, each 10 ng/mL increase in 25(OH)D was associated with a 4.2 mg/dL increase in HDL cholesterol concentration.
- Each 1 ng/mL increment in 25(OH)D was associated with a 5% reduction in the prevalence of metabolic syndrome, which appeared to be driven primarily by HDL cholesterol concentration and waist circumference.
- Since vitamin D is fat soluble, a greater storage capacity for vitamin D in overweight and obese individuals may result in a decreased circulating concentration of 25(OH)D from both exogenous and endogenous sources, resulting in the observed inverse association between 25(OH)D and indicators of adiposity (waist and body mass index).
- These findings suggest a lower serum 25(OH)D level is associated with the metabolic syndrome and less favorable values for some metabolic syndrome risk factors, particularly the HDL cholesterol concentration.
- Research is warranted to assess whether increasing vitamin D intake will improve the metabolic cardiovascular risk factor profile.

## References

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