# Serum 25-Hydroxyvitamin D Levels and Insulin Sensitivity Across Pubertal Stages in Obese Children

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## Background

Decreased serum 25-hydroxyvitamin D (25-OHD) level has frequently been reported in obesity, a condition which is associated with insulin resistance. Insulin resistance was negatively associated with serum 25-OHD. Puberty is the period with altered insulin sensitivity. Previous studies showed conflicting results of the variation of serum 25-OHD levels across pubertal stages. However, data on serum 25-OHD levels across pubertal stages in obese children are limited.

## Objective

To determine serum 25-OHD levels and insulin sensitivity across pubertal stages in obese children

## Methods

There were 230 obese children, aged 11.4 (2.5) years, enrolled. All children underwent an oral glucose tolerance test (OGTT) and had serum 25-OHD, calcium, phosphate and intact parathyroid hormone (iPTH) level measurements. All children were classified into 3 groups of puberty; Tanner I (N = 62), Tanner II & III (N = 88) and Tanner IV & V (N = 80). Insulin sensitivity indices [whole body insulin sensitivity index (WBISI) and homeostatic model assessment of insulin resistance (HOMA-IR)] and β-cell function indices [homeostatic model assessment of β–cell function (HOMA-β) and insulinogenic index (IGI)] were calculated from serum glucose and insulin levels derived during the OGTT.

## Results

There were 119 girls (52%) and 111 boys (48%) included. Median (IQR) BMI SDS was 2.5 (2.1, 3.0). Their mean (SD) 25-OHD level was 26 (7) ng/mL. Despite being less obese with advanced stages of puberty [BMI SDS for Tanner I, II & III and IV & V: 2.9 (2.4, 3.7), 2.4 (2.1, 3.0) and 2.2 (1.8, 2.5), respectively, $p$ <0.001], serum 25-OHD were progressively decreased [30 (6), 26 (7) and 23 (6) ng/mL, $p$ <0.001] (Table 1). Changes of insulin sensitivity did not follow the same pattern as that of serum 25-OHD with maximum insulin resistance observed during Tanner stages II & III. There were no associations between 25-OHD and indices of insulin sensitivity and β-cell function. However, Tanner stages, iPTH and calcium levels showed significant associations with 25-OHD level after adjusting for age, sex and BMI SDS (Table 2). Multivariate analysis showed that Tanner stages, iPTH and calcium were independently associated with 25-OHD (Tanner II & III: β = -3.574, $p$ = 0.001; Tanner IV & V: β = -5.501, $p$ <0.001; iPTH: β = -0.074, $p$ = 0.020; calcium: β = 3.027, $p$ = 0.006).

**Table 1. Clinical characteristics of all children according to Tanner stages**

| Parameters | All children (N = 230) | Tanner stages | | | *P* |
|---|---|---|---|---|---|
| | | I (N = 62) | II & III (N = 88) | IV & V (N = 80) | |
| Age (y) | 11.4 (2.5) | 9.2 (2.0) | 11.5 (1.7) | 13.1 (2.4) | <0.001 |
| Male/female, N (%) | 111/119 (48/52) | 40/22 (65/35) | 58/30 (66/34) | 13/67 (16/84) | <0.001 |
| Weight SDS* | 4.6 (3.4, 6.1) | 4.6 (3.1, 6.2) | 4.4 (3.4, 6.1) | 4.7 (3.4, 6.1) | 0.754 |
| BMI SDS* | 2.5 (2.1, 3.0) | 2.9 (2.4, 3.7) | 2.4 (2.1, 3.0) | 2.2 (1.8, 2.5) | <0.001 |
| Waist circumference percentile* | 106 (94, 122) | 110 (100, 140) | 108 (97, 127) | 101 (91, 114) | 0.010 |
| 25-OHD (ng/mL) | 26 (7) | 30 (6) | 26 (7) | 23 (6) | <0.001 |
| iPTH* (pg/mL) | 35 (29, 46) | 31 (25, 38) | 35 (29, 46) | 40 (32, 53) | <0.001 |
| Calcium* (mg/dL) | 9.5 (9.2, 9.7) | 9.6 (9.4, 9.8) | 9.6 (9.2, 9.8) | 9.3 (9.0, 9.6) | 0.002 |
| Phosphate* (mg/dL) | 5.0 (4.5, 5.4) | 5.0 (4.7, 5.3) | 5.1 (4.8, 5.6) | 4.5 (4.2, 5.1) | <0.001 |
| Glucose metabolism status, N (%)<br>• Normal glucose tolerance<br>• Hyperinsulinemia<br>• Abnormal glucose tolerance | <br>49 (21)<br>124 (54)<br>57 (25) | <br>20 (32)<br>29 (47)<br>13 (21) | <br>11 (13)<br>52 (59)<br>25 (28) | <br>18 (22)<br>43 (54)<br>19 (24) | 0.071 |
| HbA1c (%) | 5.8 (0.5) | 6.0 (0.4) | 6.0 (0.4) | 5.6 (0.5) | 0.012 |
| WBISI* | 2.8 (1.8, 3.9) | 3.0 (1.9, 4.8) | 2.1 (1.6, 3.3) | 3.3 (2.0, 4.3) | <0.001 |
| HOMA-IR* | 2.9 (1.9, 4.1) | 2.5 (1.5, 3.9) | 3.1 (2.1, 4.5) | 2.6 (1.8, 3.8) | 0.021 |
| IGI* | 1.7 (1.1, 2.5) | 1.5 (0.9, 2.5) | 2.0 (1.3, 3.1) | 1.5 (0.9, 2.3) | 0.005 |
| HOMA-β* | 248 (164, 387) | 207 (112, 393) | 273 (164, 456) | 248 (191, 338) | 0.098 |
| Total cholesterol (mg/dL) | 181 (33) | 183 (36) | 180 (30) | 181 (34) | 0.785 |
| Triglyceride* (mg/dL) | 92 (65, 121) | 86 (58, 122) | 92 (65, 113) | 93 (68, 126) | 0.377 |
| HDL-C* (mg/dL) | 42 (36, 48) | 42 (37, 50) | 41 (37, 49) | 40 (36, 47) | 0.463 |
| LDL-C (mg/dL) | 116 (30) | 120 (33) | 114 (28) | 115 (29) | 0.489 |

Data are presented as mean (SD) or *median (IQR)

*P* value, comparing among 3 Tanner stage groups (Kruskal-Wallis test for non-normally distributed data, one-way ANOVA for normally distributed data and Chi-square test for categorical data)

**Table 2. Univariate analysis of 25-hydroxyvitamin D (25-OHD) and other parameters in all patients**

*Adjusted for age, sex and BMI SDS

| Parameters | 25-OHD | | | |
|---|---|---|---|---|
| | Unadjusted | | Adjusted* | |
| | β | *P* | β | *P* |
| Tanner stages<br>• II & III<br>• IV & V | <br>-4.144<br>-7.026 | <br><0.001<br><0.001 | <br>-2.840<br>-4.142 | <br>0.018<br>0.013 |
| iPTH | -0.143 | <0.001 | -0.113 | <0.001 |
| Calcium | 4.886 | <0.001 | 3.550 | 0.001 |
| Phosphate | 0.620 | 0.410 | - | - |
| HbA1c | 2.284 | 0.118 | - | - |
| WBISI | 0.106 | 0.613 | - | - |
| HOMA-IR | 0.039 | 0.843 | - | - |
| IGI | -0.580 | 0.065 | - | - |
| HOMA-β | -0.001 | 0.599 | - | - |

## Conclusions

Progressive decrease in serum 25-OHD level was observed with more advanced stage of puberty in obese children and did not follow the same pattern as that of insulin sensitivity. Therefore, the changes of serum 25-OHD were unlikely related to insulin sensitivity.