Overview of Vitamin D status in India with special reference to children & adolescents

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Introduction

• Vitamin D is a hormone which is primarily formed in the skin by exposure to sunlight
• Responsible for bone formation and maintenance by absorbing calcium from the intestine
• Vitamin D status has profound effect on growth and development of children and implication for adult bone health
• The most commonly used and sensitive index in assessing vitamin D status of an individual is 25(OH)D

_Hollis BW Calcif Tissue Int; 1996; 58; 4-5._

• Age, sex, pubertal status, latitude, season, race and ethnicity influence the serum concentration of 25(OH)D.
Introduction

• Approximately 40-50% of total skeletal mass at maturity is accumulated during childhood and adolescence.  
  
  *(Mora et al, 1999; Cadogan et al, 1998)*

• During growth periods of childhood, puberty and early adulthood, bone formation exceeds bone resorption  
  
  *(Anderson 2000)*

• 30% of peak bone mass is accrued in the three years surrounding puberty  
  
  *(Bailey et al 1996)*

• Life style determinants - exercise, body composition, nutrition and calcium intake affect bone development.
Functions of vitamin D

**Calciotropic**
- Restores PTH levels to non-stimulating levels
- Optimizes calcium absorption
- ↓ bone turnover and maintains muscle strength
- Maintains normal serum calcium and phosphate levels
- Prevents developments of rickets, osteomalacia and fractures

**Non calciotropic**
- Immunomodulatory function
- Decreases cell proliferation
- Metabolic functions
- Prevention of diabetes, prostrate and colon cancer
Normal levels of circulating 25(OH)D

- Exact cut-offs for “deficiency” and “insufficiency” remain controversial
- Several classifications exist e.g. Lips P:-
  - <5 ng/mL - severe hypovitaminosis D
  - 5-10 ng/mL - moderate hypovitaminosis D
  - 10-20 ng/mL - mild hypovitaminosis D
- Functional indicators like PTH, ca absorption and BMD for defining 25(OH)D adequacy, have shown 80 nmol/L (32ng/ml) as the “cut-off”.
Prevalence of vitamin D insufficiency

- Wide spread in North America, Europe
- India is endemic for clinical and biochemical vitamin D deficiency.
- Community-based studies - the prevalence of clinical rickets in preschool children in India -1.5% to 11.4% - 1970's; 2% to 9.4% - 1990's
- Hospital based studies - a prevalence of 0.2% to 5.3%.
- In Indian migrants in the United Kingdom - prevalence in children and adolescents - 5% to 30%.

Prevalence of vitamin D insufficiency

- Immigrant studies using biochemical and radiological parameters - 12.5% to 66%.
  

- In children of Indian origin residing in South Africa, the prevalence of knock knees and bow legs - 6.1 - 19.4%.
  
  *Richardson BD et al 1975*

- Incidence of rickets had come down in the immigrant population.
  
  *Goel et al. Lancet 1981; 2: 405-6*

- No evidence of reduction in rickets reported from India.

- Atmospheric pollution - contributing factor.

  *Puliyel JM. J Bone Min Res 2000; 15 (Suppl):S356*
Vitamin D and Bone Mineral Density status of healthy school children in northern India


• **Objectives:** To study the prevalence of clinical and biochemical vitamin D deficiency in healthy children & adolescents, aged 10-18 years during their period of most rapid growth.

• To assess the calcium-vitamin D-PTH axis in two different socioeconomic backgrounds.

• To study the effect of hypovitaminosis D on BMD.
Design: Clinical evaluation for evidence of vitamin D deficiency - 5137 school children, belonging to lower (LSES-3089, B-1079 & G-2010) and upper socioeconomic status (USES-2048, B-968, G-1080) schools.

- Serum calcium, inorganic phosphorus, alkaline phosphatase, 25-hydroxyvitamin D [25(OH)D] and (iPTH) measured randomly in 760 subjects (LSES- 430, USES- 330).

- Dietary assessment total energy, calcium and phytate in 349 (LSES- 171, USES-178) subjects by a 24- h recall of food intake.

- Distal forearm and calcaneal BMD assessed in 555 children by a portable pDXA machine ( LSES- 321, USES- 234).
Results:

- Clinical evidence of vitamin D deficiency noted in 556/5137 (10.82%) subjects.
  - Boys - 10.4%,
  - Girls – 11.1%, p=0.46

- G. Valgum - 3.3% (B-2.4%, G-3.9%, P<0.01).
  - G. Varum - 7.5% (B-8%, G-7.2%, p=0.39).

- No sig. difference was noted in clinical Hypovitaminosis D among LSES & USES (11.6% vs 9.7%, p=0.07).
Contd..

- LSES group had significantly lower 25(OH)D concentration (10.8 ± 6.0 ng/mL) than USES group (13.3 ± 8.3 ng/mL, \( P < 0.001 \)).

- 25(OH)D levels below 9 ng/ml seen in 35.66% of subjects (42.32% in LSES; 26.97% in USES; \( P < 0.001 \)).

- Hypovitaminosis D according to Lips criteria was seen in 92% of LSES and 84% of USES.

- In both the groups boys had a higher 25(OH)D concentration than girls (\( P = 0.030 \) in LSES; \( P = 0.015 \) in USES).
A significant negative correlation between the mean serum iPTH and 25(OH) D concentrations ($r = -0.202; \ P < 0.001$).

Significant positive correlation was seen between serum ALP & iPTH ($p<0.01$).

Mean forearm bone mineral density was significantly higher in USES group than in LSES group ($P <0.001$).
TABLE 2
Comparison of unadjusted means of bone mineral density (BMD) in the 2 socioeconomic groups

<table>
<thead>
<tr>
<th>Variable and age category</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LSES group</td>
<td>USES group</td>
</tr>
<tr>
<td>Forearm BMD (g/cm²)²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10–12 y</td>
<td>0.313 ± 0.044 [27]</td>
<td>0.387 ± 0.146 [24]</td>
</tr>
<tr>
<td>13–15 y</td>
<td>0.359 ± 0.067 [57]</td>
<td>0.397 ± 0.064 [56]</td>
</tr>
<tr>
<td>16–18 y</td>
<td>0.414 ± 0.059 [31]</td>
<td>0.408 ± 0.049 [30]</td>
</tr>
<tr>
<td>Calcaneum BMD (g/cm²)³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10–12 y</td>
<td>0.424 ± 0.088 [27]</td>
<td>0.501 ± 0.073 [24]</td>
</tr>
<tr>
<td>13–15 y</td>
<td>0.464 ± 0.074 [57]</td>
<td>0.557 ± 0.095 [56]</td>
</tr>
<tr>
<td>16–18 y</td>
<td>0.505 ± 0.073 [31]</td>
<td>0.592 ± 0.089 [30]</td>
</tr>
</tbody>
</table>

² All values are \( \bar{x} \pm SD \); \( n \) in brackets. LSES, lower socioeconomic status; USES, upper socioeconomic status. The means reported in the table are adjusted for height and weight.

³ Three-factor interaction was not significant. The main effect of age was significant, \( P < 0.01 \) (ANOVA).
<table>
<thead>
<tr>
<th>Variable and age category</th>
<th>LSES group</th>
<th>USES group</th>
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<th>USES group</th>
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<tbody>
<tr>
<td></td>
<td>Males</td>
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<td>Females</td>
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<tr>
<td>Calcium (mg/dL)²</td>
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<tr>
<td>10–12 y</td>
<td>9.3 ± 1.3 [42]</td>
<td>9.7 ± 1.2 [33]</td>
<td>9.5 ± 0.6 [78]</td>
<td>9.3 ± 1.1 [47]</td>
</tr>
<tr>
<td>13–15 y</td>
<td>9.5 ± 0.8 [85]</td>
<td>9.5 ± 1.2 [70]</td>
<td>9.4 ± 0.7 [123]</td>
<td>9.6 ± 1.9 [62]</td>
</tr>
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<td>16–18 y</td>
<td>9.3 ± 0.6 [40]</td>
<td>9.6 ± 0.7 [55]</td>
<td>9.2 ± 0.7 [62]</td>
<td>9.2 ± 0.6 [63]</td>
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<tr>
<td>Phosphorus (mg/dL)³</td>
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<tr>
<td>10–12 y</td>
<td>4.0 ± 0.5 [42]</td>
<td>4.7 ± 1.0 [33]</td>
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<tr>
<td>Alkaline phosphatase (IU/L)⁴</td>
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<tr>
<td>PTH (pg/mL)⁵</td>
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<tr>
<td>10–12 y</td>
<td>35.4 ± 19.8 [42]</td>
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</tr>
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<td>46.7 ± 51.8 [123]</td>
<td>26.2 ± 18.4 [62]</td>
</tr>
<tr>
<td>16–18 y</td>
<td>37.9 ± 35.8 [40]</td>
<td>24.2 ± 14.4 [55]</td>
<td>32.1 ± 23.6 [62]</td>
<td>22.2 ± 10.4 [63]</td>
</tr>
<tr>
<td>25(OH)D (ng/mL)⁶</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10–12 y</td>
<td>12.4 ± 5.5 [42]</td>
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</tr>
</tbody>
</table>
Conclusion:

- A high prevalence of clinical and biochemical hypovitaminosis D exists in apparently healthy school children in North India.
- Children from LSES having higher prevalence of Vit D deficiency and low BMD suggests that nutrition may play an important role in causation of Hypovitaminosis D and low bone mass.
Peripheral bone mineral density and its predictors in healthy school girls from two different socio-economic groups in Delhi


664 girls between 7 & 17 yrs were analyzed for Peripheral BMD, Biochemistry, 25 (OH)D and PTH. (LSES = 369 & USES = 295)

Salient Observations:

- Height, weight and BMI in USES girls were sig. higher than LSES subjects. (BMI kg/m² 19.4±4.0 vs 16.9±3.1).
- Overall mean bone mineral density at distal forearm (BMIdf) (0.366±0.075 vs 0.337±0.070) and BMDca (0.407±0.073 vs 0.464±0.093) values were sig. higher in USES than in LSES subjects.
Contd..

- Afgahani et al, 2003 evaluating bone mass in Chinese adolescent girls 12-16 yrs, showed that BMDdf was lower when compared LSES & USES girls from India.
- Similarly BMDca in these girls were lower than USES girls but higher than LSES subjects.
- Comparison of BMDca with data from healthy caucasian children in UK with same model of pDXA showed that LSES subjects had lower and USES had higher BMD values.
BMD distal forearms (BMDdf.)

- In both groups, BMDdf increased with age with tendency to plateau at 16 yrs, particularly in the LSES group. Similar results have been reported from several workers.


  The mean ↑ in BMDdf across all ages had a smoother curve than that of LSES group.

- BMDdf in all ages was higher in USES than for corresponding ages in the LSES group and this difference attained statistical significance from 10yrs of age onwards.

- % difference in BMDdf between 7 & 17yrs was 49% in LSES and 60% in USES.
BMD Calcaneum (BMDca)

- BMDca showed an increase in both groups till the age of 12yrs after which there is a tendency towards a plateau especially in the LSES group.
- Contrary to our observation, Chinn DJ et al. 2003, showed an increase through all ages by p DXA.
- Ikeda et al. 2004 & Volta C et al. 2004 using US densitometer showed plateauing at 12 and 16 yrs respectively.
- BMDca values in all ages were higher in USES than in LSES groups this difference statically sig. from 11yrs onwards.
- The % difference between 7yrs and 17yrs was 51% in LSES and 56% in USES.
Association of BMD with other Parameters Correlations:

- Significant associations of age, body wt and ALP with BMDdf was noted on multiple regression analysis and model incorporating age, height & weight explains approx 50% of the variance at site.

- Both height and weight were sig. predictors of BMDca for USES. Only wt was found to be a sig. factor in the LSES group.

- A multivariate regression model using age, ht & wt alone explained overall BMDdf & BMDca variability in 50% & 49% respectively.
Contd..

- Pettifor et al, 1997 showed combined effect of age, ht & wt to be 57% on BMDdf.
- Models incorporating age, ht, wt & sexual maturation explained 46-79% variability in BMDdf.
- Similarly, taking into account age, ht & wt explained BMDca variability in 39% of LSES, 49% of USES and 49% overall. No other study has provided this information.
- Model incorporating biochemical parameters alone explained BMDdf variability in 25% of LSES & 42% of USES and 32% overall.
Similarly, biochemical parameters explained BMDca variability in 15% LSES, 21% USES and 18% overall.

25 (OH)D alone contributed to 1% variability in both BMDdf and BMDca.

No sig. association of either Vit D or PTH was found with either site as shown by Quitila TA et al Marwaha RK et al 2005

Serum ALP had sig. negative association with BMDdf as was also shown by PettiforM et al, 1997.
Conclusion

- Age, ht & wt remain the best predictors of BMD at distal forearm and Calcaneum.
- The only bone mineral parameter which had sig. influence on BMDdf was Alkaline Phosphates.
- Nutrition plays a significant role in attaining optimal bone density.
- There is need for interventional studies, evaluating the role of nutrition in improving BMD and peak bone mass in our population.
### Base line characteristics, biochemical and bone mineral density parameters of the cohort

<table>
<thead>
<tr>
<th>Variable</th>
<th>LSES (n = 369)</th>
<th>USES (n = 295)</th>
<th>Overall (n = 664)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>12.8 ± 2.7</td>
<td>12.7 ± 2.6</td>
<td>12.8 ± 2.7</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>144.4 ± 11.9</td>
<td>149.7 ± 12.3^a</td>
<td>146.8 ± 12.3</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>35.9 ± 10.0</td>
<td>44.3 ± 12.9^a</td>
<td>39.7 ± 12.1</td>
</tr>
<tr>
<td>BMI (kg/m^2)</td>
<td>16.9 ± 3.1</td>
<td>19.4 ± 4.0^a</td>
<td>18.0 ± 3.7</td>
</tr>
<tr>
<td>Calcium (mg/dL)</td>
<td>9.2 ± 0.8</td>
<td>9.3 ± 0.7^b</td>
<td>9.3 ± 0.8</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>4.2 ± 0.8</td>
<td>4.2 ± 0.8</td>
<td>4.2 ± 0.8</td>
</tr>
<tr>
<td>ALP (IU/L)</td>
<td>423 ± 228</td>
<td>316 ± 166^a</td>
<td>375 ± 210</td>
</tr>
<tr>
<td>PTH (pg/mL)</td>
<td>45.7 ± 64.6</td>
<td>29.9 ± 18.4^a</td>
<td>38.7 ± 50.2</td>
</tr>
<tr>
<td>25-OHD (ng/mL)</td>
<td>11.1 ± 5.2</td>
<td>11.8 ± 6.4</td>
<td>11.4 ± 5.8</td>
</tr>
<tr>
<td>BMDdf (g/cm^2)</td>
<td>0.337 ± 0.070</td>
<td>0.366 ± 0.075^a</td>
<td>0.350 ± 0.074</td>
</tr>
<tr>
<td>BMDca (g/cm^2)</td>
<td>0.407 ± 0.073</td>
<td>0.464 ± 0.093^a</td>
<td>0.433 ± 0.087</td>
</tr>
</tbody>
</table>
Pearson’s correlations of BMD at distal forearm and calcaneum in both the groups

<table>
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<th>USES (n = 295)</th>
<th>Overall (n = 664)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BMDdf</td>
<td>BMDca</td>
<td>BMDdf</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>0.66&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.50&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.69&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>0.54&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.63&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>0.64&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.60&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.72&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Calcium (mg/dL)</td>
<td>-0.03</td>
<td>-0.11&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-0.03</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>-0.24&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.25&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.36&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>ALP (IU/L)</td>
<td>-0.48&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.62&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>PTH (pg/mL)</td>
<td>-0.10&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-0.06</td>
<td>-0.14&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>25-OHD (ng/mL)</td>
<td>-0.08</td>
<td>-0.12&lt;sup&gt;c&lt;/sup&gt;</td>
<td>-0.09</td>
</tr>
<tr>
<td>BMDdf (g/cm&lt;sup&gt;2&lt;/sup&gt;)</td>
<td>1</td>
<td>0.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
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</table>
Vitamin D Nutrition status of exclusively breast fed infants and their mothers

**Material & Methods:**

- A prospective, hospital based, cross sectional study where 180 healthy, exclusively breast fed infants, aged 2.24 wks. and their mothers were evaluated clinically and biochemically for asymptomatic Vitamin D deficiency.

**Inclusion & Exclusion Criteria:**

- Full term singleton deliveries.
- Age: 2-15 days – 6 months.
- Exclusively breast fed.
- No congenital malformations.

**Exclusions criteria for mothers:**

- Known hepatic, renal or bone disorders
- Malabsorptions states, H/O GI surgery.
- Drug intake
Clinical Assessment:
- Genu Varum
- Genu Valgum mothers
Wide anterior fontanelle
- Frontal bossing
- Widening of wrist

Laboratory Investigations:
Carried out in both mothers & baby

Serum Calcium
- Total
- Ionic
S. Inorganic Phosphorous
Alkaline Phosphates
PTH
25 (OH)D
Observations
Vitamin D status in infants

- Clinical features of hypovitaminosis D was noted in 7/180 (3.9%).
- Mean 25 (OH)D = 11.55±8.3 ng/ml.
  Median – 11 ng/ml (Range 1.0-70 ng/ml).
- 79/180 (43.2%) had vitamin D deficiency (<10 ng/ml). 38 (21.1%) had severe Vitamin D deficiency (<5 ng/ml) & 41 had mild to moderate deficiency (5-10 ng/ml).
- Dawodu et al, 2003- 82% exclusively breast fed infants from UAE had Hypovitaminosis D.
- Mean PTH = 57.62±61.70 pg/ml,
  Median PTH 35 pg/ml. (Range 10-450 pg/ml)
- Secondary Hyper parathyroidism was seen in 55/79 (69.6%) infants with Vitamin D < 10 ng/ml in contrast to 3/101 (3.1%) in infants with Vitamin D > 10 ng/ml.
Mean PTH was sig. higher in infants with Vitamin D deficiency when compared to those with Vitamin D sufficiency (94.2±78.3 vs 28.9±11.6).

Significant –ve correlation was noted between serum 25(OH)D and PTH (PC=-0.431, P=0.01).

Cut off value of 25 (OH)D below which PTH starts rising above normal was found to be 11.7 ng/ml.

Zeghoud et al found cut off to be 12 ng/ml

ALP was found elevated in 11/180 (6.1%).

Hypocalcaemia was seen in 8/180 (4.1%) infants.
Vitamin D Nutrition Status of mothers

- Clinical features of Vitamin D deficiency was noted in 41/180 (22.9%).
  
  Mean 25(OH)D = 10.87±5.82ng/ml
  
  Median = 10 ng/ml (Range 1-32 ng/ml)

- Hypovitaminosis D (<10 ng/ml) = 86/180 (47.8%)
  
  Severe = 13.9%
  
  Mild to moderate = 33.9%

- PTH

  Mean Serum PTH = 52.57±52.59
  
  Median PTH = 34 pg/ml (Range 10 - 410 pg/ml).
Contd..

- 51/86 (59.3%) mothers with hypovitaminosis D had secondary hyperparathyroidism PTH (>54 pg/ml) in contrast to 4.3% with Vitamin D >10 ng/ml.

- Significant correlation was noted between serum 25(OH)D and serum PTH (PC= -0.480, P=0.01).

- 72% of mothers had ↑ ALP levels indicating biochemical osteomalacia.

- Total / ionic Ca was ↓ in only 4 mothers.
## Table: Comparison between Vitamin D nutrition Status of mothers and babies

<table>
<thead>
<tr>
<th></th>
<th>Number of infants with 25 (OH) D &lt;10 ng/ml</th>
<th>Number of infants with 25 (OH) D &gt;10 ng/ml</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of mothers with 25(OH) D &lt;10 ng/ml (86)</strong></td>
<td>52</td>
<td>34</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>60.4%</td>
<td></td>
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<tr>
<td><strong>Number of mothers with 25(OH) D &gt;10 ng/ml (94)</strong></td>
<td>27</td>
<td>67</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>28.7%</td>
<td></td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td>79</td>
<td>101</td>
<td>180</td>
</tr>
</tbody>
</table>
Table: Comparison between biochemical parameters of mother and baby

<table>
<thead>
<tr>
<th>Serum levels</th>
<th>Mother Medians (mean S.D)</th>
<th>Infants Medians (mean S.D)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Ca</td>
<td>9.8 0.89 mg/dl</td>
<td>10.01 1.2 mg/dl</td>
<td>0.170</td>
</tr>
<tr>
<td>Ionic Ca</td>
<td>4.6 0.40 mg/dl</td>
<td>4.6 0.47 mg/dl</td>
<td>0.475</td>
</tr>
<tr>
<td>PTH</td>
<td>52.57 52.59 pg/ml</td>
<td>57 61 pg/ml</td>
<td>0.421</td>
</tr>
<tr>
<td>25 (OH)D</td>
<td>10.87 5.8 mg/dl</td>
<td>11.55 8.3 mg/dl</td>
<td>0.340</td>
</tr>
<tr>
<td>IP*</td>
<td>4.4 1.1 mg/dl</td>
<td>5.3 1.4 mg/dl</td>
<td></td>
</tr>
<tr>
<td>ALP*</td>
<td>337 172 IU/I 72.2%</td>
<td>655 311 IU/I 6.1% ↑ ALP</td>
<td></td>
</tr>
</tbody>
</table>
Correlation between Vitamin D status of mother & baby

- A strong +ve correlation was found between individual mother and baby serum 25 (OH) D (PC=0.324, P=0.000).
- 52 (60.4%) of infants born to mothers with hypovitaminosis D had low serum 25(OH)D in contrast to 28.7% born to mothers with normal 25(OH)D.
- Using logistic regressions, infants born to mother with hypovitaminosis D carry a 3.79 times more risk of developing hypovitaminosis D as compared to those born to mothers with normal 25(OH)D levels (P=0.000).
## Table: Comparison of studies on prevalence of Hypovitaminosis D in neonates & infants in various countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Author &amp; yr. of study</th>
<th>Study group</th>
<th>Mean 25(OH)D</th>
<th>% of hypovitaminosis D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leeds</td>
<td>Heckmatt JZ et al 1979</td>
<td>New born &amp; young infants</td>
<td>36% (&lt; 10 ng/ml)</td>
<td></td>
</tr>
<tr>
<td>U.A.E.</td>
<td>Dawodu A et al 2003</td>
<td>Infants</td>
<td>82% (&lt;10 ng/ml)</td>
<td></td>
</tr>
<tr>
<td>New Delhi, India</td>
<td>Goswami R et al 2000</td>
<td>Newborns</td>
<td>6.686±4.2ng/ml</td>
<td></td>
</tr>
<tr>
<td>Lucknow, Delhi</td>
<td>Bhatia VL et al 2005</td>
<td>Newborn Cord blood</td>
<td>8.4±5.7ng/ml</td>
<td>42.5% (&lt;10ng/ml)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Hoogenboezem et al 1989</td>
<td>Newborn Cord blood</td>
<td>22±1.8ng/ml</td>
<td></td>
</tr>
<tr>
<td>Pakistan (Study on hypocalcemic babies and their mothers)</td>
<td>Atiq M et al 1998</td>
<td>Infants</td>
<td>7.5±3.3ng/ml</td>
<td></td>
</tr>
<tr>
<td>New Delhi, India</td>
<td>Marwaha et al 2007</td>
<td>Infants</td>
<td>11.55±8.3ng/ml</td>
<td>43.9% (&lt;10ng/ml)</td>
</tr>
</tbody>
</table>
Conclusion

- High prevalence of physiologically significant hypovitaminosis D noted among lactating women (47.8%) and healthy exclusively breast fed infants (43.2%), warrants public health intervention.

- Infants born to mothers with hypovitaminosis D had 3.79 times more risk of developing vitamin D deficiency as compared to those born to mothers with normal vitamin D levels.