Vitamin D Status Across Age Groups in Turkey: Results of 108742 Samples from a Private Laboratory

Short title: Vitamin D Status in Turkey

Gül Yeşiltepe-Mutlu¹, Ekin Deniz Aksu¹, Abdullah Bereket² and Şükrü Hatun¹

¹Koç Üniversitesi Tıp Fakültesi, ²Marmara Üniversitesi Tıp Fakültesi

What is known

- Recently, extra-skeletal effects of vitamin D have caused an increase of interest in vitamin D. This interest has led the physicians to check serum 25OHD levels more oftenly.
- Furthermore, high dose vitamin D treatment have been prescribed by physicians even in cases with normal 25OHD levels in order to achieve extra-skeletal effects of vitamin D.

What is new

- This study, which has a very large sample size, aimed to assess vitamin D status in Turkey. Despite the previous trials demonstrating a high prevalence of vitamin D deficiency our data do not justify the presence of a vitamin D deficiency pandemic in Turkey.
- With successful implementation of the vitamin D supplementation program, Turkey seems to have overcome vitamin D deficiency for those under 1-year of age.

Abstract

Objective: This population-based study aimed to determine the vitamin D status in Turkey between 2011 and 2016, evaluate the effectiveness of the national vitamin D supplementation program.

Methods: Data on serum 25-hydroxyvitamin D (25-OHD) measurements were retrieved from an internationally accredited laboratory operating nationwide. A total of 108,742 measurements of 25-OHD were analyzed using the cut-off values of 0-11 ng/ml, 12-19 ng/ml, 20-49 ng/ml, 50-70 ng/ml and >70 ng/ml.

Results: Overall, the mean 25-OHD level was 21.6 ± 13.3 ng/ml. The mean 25-OHD levels according to age brackets were as follows: 37.3 ng/ml for <1 year of age, 30.1 ng/ml for 1-10 years of age, 23.7 ng/ml for 11-18 years of age. The mean 25-OHD levels among children <1 year and 1-3 years of age were significantly higher compared with those found for the other age groups. The prevalence of vitamin D deficiency (<12 ng/ml) was lowest in children at 1-3 years of age (5%).

Conclusion: With successful implementation of the vitamin D supplementation program, Turkey seems to have overcome vitamin D deficiency for those under 1-years of age. However, the positive impact of the program does not continue over 1 year of age, indicating that vitamin D supplementation may be required in the older children and adults. On the other hand, increased awareness about vitamin D should be continued to prevent unnecessary and excessive use of vitamin D supplements.

Keywords: Vitamin D, deficiency, National Prophylaxis Program, 1 year of age

Corresponding author: Gül Yeşiltepe-Mutlu, Koç Üniversitesi Hastanesi, Çocuk Endokrinoloji ve Diyabet Bölümü Maltepe Mh. Davutpaşa Cd.No:4 Topkapı 34010 İstanbul /Türkiye

+905057235725

gulyesiltepe@gmail.com

Submitted: 26-Sep-2019

Accept: 24-Dec-2019

Introduction

In the past 10 years, there has been growing interest in vitamin D deficiency, especially concerning its extra-skeletal effects. Serum 25-hydroxyvitamin D (25-OHD) measurements have become a part of routine health evaluations in both pediatric and adult populations, and more importantly, claims on a “vitamin D deficiency pandemic” have generated considerable debate associated with diverse definitions of deficiency [1]. According to a recently published study evaluating data from 711,718 children from Britain, the incidence of vitamin D deficiency increased from 3.14/100,000 in 2000 to 261/100,000 in 2014, amounting to a 15-fold increase after adjusting for population increases [2].

In Turkey, data are lacking on annual changes in the incidence of vitamin D deficiency. According to the “Intercontinental Marketing Services Health” (IMS Health) database, in 2012, a total of 2,280,626 ampoules of vitamin D (containing 300,000 international units per ampoule) were sold in Turkey, with a remarkable increase to 8,376,319 ampoules in the first 8 months of 2016. On the other hand, a nationwide vitamin-D-prophylaxis program including free provision of vitamin D drops (400 international units daily) to infants has been successfully in operation since 2005 [3].

This population-based study aimed to determine the vitamin D status in Turkey between 2011 and 2016, evaluate the effectiveness of the vitamin D supplementation program which started in 2005, analyze the relationships among

simultaneous serum measurements of the 25-hydroxyvitamin D (25-OHD), parathyroid hormone (PTH) and alkaline phosphatase (ALP), and determine the prevalence of vitamin D deficiency by age, gender, year, region and season.

Methods

Data on serum 25-OHD measurements between January 2011 and December 2016 were retrieved from an internationally accredited private laboratory operating nationwide.

As it is a retrospective study based on recorded data we were not able to have a consent form however we obtained approval from owners of data. Serum 25-OHD levels were measured with the LC-MS/MS method, Quattro Premier QE (Waters, MA, USA), as the sum of D2 and D3 levels. Serum PTH levels were measured by an electrochemiluminescence immunoassay (ECLIA) and serum ALP levels were measured by a colorimetric assay using the Roche Cobas e601 and Cobas c501 modules (Roche Diagnostics, Mannheim, Germany), respectively, in accordance with the International Federation of Clinical Chemistry (IFCC) standardization.

A total of random 108,742 measurements of 25-OHD (of which 17% (n:18,613) belonged to those younger than 18 years of age) were analyzed according to age, gender, region, season and year, using the cut-off values of 0-11 ng/ml, 12-19 ng/ml, 20-49 ng/ml, 50-70 ng/ml and >70 ng/ml from the 2001-2006 data of the National Health and Nutrition Examination Survey (NHANES) [4]. The repeated measurements obtained from the same individuals at different times excluded from the study. According to the Global Consensus Recommendations, a serum 25-OHD level of less than 12 ng/ml was considered to be diagnostic for vitamin D deficiency, while levels between 12-20 ng/ml were considered vitamin D insufficiency, and levels above 20 ng/ml but less than 50 ng/ml were considered normal [5]. In addition, 25-OHD levels greater than 50 ng/ml were defined as 'possibly dangerous' according to the recommendations of the Centers for Disease Control and Prevention (CDC) [4].

The data were compared with those of the NHANES 2001-2006 reports. Moreover, correlations between 25-OHD and ALP or PTH were assessed when simultaneous ALP (n=10,139) or PTH (n=4,916) measurements were available.

Statistical analysis

Outliers were discarded using the Tukey's method with boundaries 2.5 times the interquartile range (IQR). The Wilcoxon test was used for between-group comparisons of 25-OHD. The Kruskal-Wallis test followed by the Conover post hoc test was used for multiple comparisons. The Spearman's correlation coefficient was used for bivariate correlations, and multiple comparisons were corrected using Bonferroni's method.

Results

The number of 25-OHD measurements was similar across years, with an overall female predominance (72.9%). Overall, the mean 25-OHD level was 21.6 ± 13.3 ng/ml, being lower in women (21 ± 13.5 ng/ml) than in men (23.2 ± 12.5 ng/ml) ($p < 0.001$). The mean 25-OHD levels according to age brackets were as follows: 37.2 ng/ml for <1 year of age, 27.1 ng/ml for 1-10 years of age, 19.2 ng/ml for 11-18 years of age, 18.25 ng/ml for 19-30 years of age, 20.1 ng/ml for 31-50 years of age, 21.9 ng/ml for 51-70 years of age, and 21.1 ng/ml for >70 years of age. The mean 25-OHD levels among children <1 year of age and 1-10 years of age were significantly higher compared with those found for the other age groups ($p < 0.001$). According to seasonal distribution, 25-OHD levels were higher in summer (23.8 ng/ml) and fall (24.5 ng/ml) than those measured in winter (19.1 ng/ml) and spring (19.6 ng/ml) ($p < 0.001$). Serum 25-OHD levels according to years, seasons, geographic regions, age groups, and gender are shown in Table 1 and Figure 1.

The prevalence of vitamin D deficiency (<12 ng/ml) was lowest in children under 1 year of age (7%) and 1-10 years of age (8%), while the highest rates of prevalence were noted in women (30%), in those 19-30 years of age (36%), in the Black Sea region (42%), and in winter (36%). The prevalence rates of vitamin D deficiency and insufficiency according to age groups and seasonal distribution are shown in Figure 2.

For the youngest age group (<1 year), the prevalence of vitamin D deficiency was highest in the Mediterranean (15%), Black Sea (14%) and South-east (15%) regions (figure 3). For the youngest age groups (<1 year), the rates of deficiency and insufficiency showed decreases over the years and were around 3-4% in 2015 and 2016 (figure 4). When 25-OHD levels were classified according to Endocrine Society's guideline (6) recommending cut-off levels of <20, 20-30 and 30-100 ng/ml for deficiency, insufficiency and sufficiency, respectively, the rate of sufficiency was still highest in the youngest age group (table 2).

ALP was simultaneously measured in 9.3%, and PTH was measured in 4.5% of the subjects undergoing serum 25-OHD measurements making correlation analyses possible. In correlation analysis, 25-OHD showed an inverse correlation with PTH in those under 1 year of age ($r = -0.28$, $p < 0.001$), and those between 11 and 18 years of age ($r = -0.38$, $p < 0.001$). It was shown that elevated PTH was consistently lowered to a plateau when serum 25-OHD is at 20 ng/ml or higher overall (figure 5). Correlation of serum 25-OHD concentrations with ALP was significant only in adult population (>18 years) ($r = -0.095538$, $p = 0.014667$). The mean PTH level was significantly high in the group with a 25OHD level of 0-20 ng/ml ($p < 0.0001$). However, the mean ALP level was similar in the different vitamin D status groups ($p > 0.05$). Serum levels of ALP and PTH according to vitamin D status were given in the table 4.

Discussion

Notwithstanding the fact that the present data are from subjects whose clinical features are unknown, 25-OHD measurements indicate the expected differences between genders and seasons, and more importantly show the beneficial effects of the vitamin D supplementation program (0-1 years) in Turkey (serum 25-OHD levels being highest in the youngest age group), making these data reliable for evaluation. Furthermore, a high data count of 108,742 strengthens the statistical power of the study.

Our findings demonstrate a relatively stable number of Vitamin D test requests from the physicians between 2011 to 2016. We also noted that physicians usually ordered 25-OHD tests without simultaneous ALP or PTH measurements. The growing interest in measuring and use of vitamin D supplementation mainly stems from concerns for the extra-skeletal effects of vitamin D and controversies on the thresholds of serum 25-OHD [7,8]. Because of this interest, physicians often order a 25-OHD test as part of the routine health assessment (especially in women), although a vitamin D deficiency-related clinical problem does not exist. This is true not only for adults but for children as well. In order to prevent unnecessary vitamin D

testing in primary care, the Turkish Ministry of Health Vitamin D Scientific Board published a guideline about the indications of vitamin D testing [9]. In the UK, a 17-fold increase in vitamin D testing and prescription costs, from 1,647 pounds in 2008 to 28,913 pounds in 2014 per 100,000 patient-years [10], perhaps increased testing leads a dramatic increase in the diagnosis of vitamin D deficiency as well. The overvaluing of 25-OHD measurements without accompanying ALP or PTH measurements [11] and diagnosing 'vitamin D deficiency' based on diverse thresholds have resulted in an increased use of high-dose vitamin D [12]. However, the Institute of Medicine (IOM) emphasizes the fact that studies about vitamin D and extra-skeletal problems such as cancer, cardiovascular diseases, diabetes and autoimmune diseases do not provide consistent evidence and that there is no need to determine varying vitamin D thresholds for these diseases, and thus to prescribe more vitamin D [7,8,13].

In the present study, the mean 25-OHD levels found for diverse age groups correspond to those reported in the NHANES 2001-2006 (table 3) [4]. This similarity may be related to the fact that the samples were obtained from a private laboratory serving people with relatively high socio-economic status. Nevertheless, when the same thresholds are used, a notably higher prevalence of vitamin D deficiency in Turkey becomes apparent (27% vs. 8%) mostly owing to adults with Vitamin D deficiency which might be related to lesser exposure to sunshine due to clothing styles and lesser intake of dairy products in Turkey. Moreover, vitamin D insufficiency has still appeared as a health issue particularly among the adults. The prevalence rates of vitamin D deficiency and insufficiency were found to be 27% and 24%, respectively, with increasing rates in the less economically developed regions such as Eastern Anatolia (39%) and Southeastern Anatolia (36%), and in the Black Sea region (42%) where the number of sunny days is fewer is supporting that conclusion. However, a very recent, retrospective study (14) from the western part of Turkey showed the prevalence of vitamin D insufficiency and deficiency among children to be %21.3 and %44.8, respectively. Although these ratios are higher than those in our study, the highest ratio of having normal vitamin D status was present in the 0-1 years of age group, similar to our results.

Another interesting finding was that a 25-OHD level of greater than 50 ng/ml, which the CDC defines as "possibly harmful", was found to be in 4% of subjects compared with 1% in the United States. Although we do not have definitive data to account for its cause, this might be related to the recently increased use of vitamin D ampoules (containing 300.000U of Vitamin D per ampoule) instead of lower strength Vitamin D preparations -such as drops- in Turkey for the purpose of correcting Vitamin D deficiency more rapidly. Recently, a regulation was implemented by health authorities that selling of ampoule forms of Vitamin D requires prescription from the doctor, which might decrease hypervitaminosis D cases.

The most important finding of the present study is that in Turkey, 25-OHD levels are higher in the first year of life with significantly lower rates of vitamin D deficiency and insufficiency compared with the other age groups. This favors the vitamin D supplementation program, launched in 2005, on provision of free vitamin D supplementation to all newborn infants until 1 year of age at a daily dose of 400U. This program has been closely supervised by the Ministry of Health, and according to the most recent data, 96.6% of all newborn babies were given vitamin D drops. However, apart from the high success rate of this program, the prevalence rates of vitamin D deficiency for those younger than 1 year of age still remain above 10% in the Eastern, Southeastern, Black Sea and Mediterranean regions, suggesting that more emphasis be placed on regional differences.

Several recommendations have been made for successful implementation of vitamin D supplementation programs, which include informing families starting at birth, providing vitamin D support to all infants, providing vitamin D free of charge, and utilizing the family physician system to monitor usage of vitamin D [15]. Turkey is among the European countries with at least 80% compliance with vitamin D supplementation and supervision program and compared with practices in the UK, the active role of the Ministry of Health is of particular importance for the continuation of the program [15, 16]. However, despite the high success rate of the program, some problems still remain. As high as 47% of pediatricians recommend or prescribe vitamin D at the end of the second week, and 19.9% discontinue vitamin D due to reasons such as the presence of a small fontanelle [17]. According to the Global Consensus recommendations, efforts should be continued to provide 400 international units of vitamin D to all newborns starting the first day of life, regardless of nutritional status [5, 18].

As expected, 25-OH-D levels showed inverse correlation with PTH and alkaline phosphatase levels but this was most prominent after 14-19 years of age. Alkaline phosphatase levels were not correlated with 25-OH-D levels in the pediatric age group, possibly owing to a wide reference range and dynamic temporal changes in alkaline phosphatase levels that occur with age during infancy and childhood [19].

Study limitations

Undoubtedly, the data presented in this study were from a private laboratory, which may be a somewhat less appropriate sample to represent a nationwide study. The other limitations were the lacking data regarding the time of day the samples were taken, clinical status, lifestyle and vitamin D intake. The low rate of concurrent PTH and ALP measurement caused difficulties in interpreting the severity of vitamin D deficiency. Despite these limitations, due to the high number of measurements, presence of samples from all regions of the country, and the fact that results show expected differences between genders, seasons and age groups, the authors feel that the present study provides important information on and relevant insight into the vitamin D status in Turkey.

In conclusion, with the successful implementation of the vitamin D supplementation program, Turkey seems to have overcome vitamin D deficiency for those under 1 year of age. However, the positive impact of the program does not continue over 1 year of age, indicating that vitamin D supplementation may be required in the older children and adults. On the other hand, increased awareness about vitamin D should be continued to prevent unnecessary and excessive use of vitamin D supplements.

Acknowledgment

The authors would like to thank Professor Yahya Laleli, Deniz İlhan Topçu MD, Murat Öktem MD for sharing the data.

Compliance with ethical standards

Conflict of Interest: The authors declare that they have no competing interest.

Funding: There are no financial disclosures or disclaimers related to this manuscript.

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Ethics

Ethics Committee Approval: Nonavailable

Informed Consent: Nonavailable

(as this is a retrospective study and it is based on recorded data)

Authorship Contributions

Surgical and Medical Practices: none

Concept: Şükrü Hatun

Design: Şükrü Hatun

Data Collection or Processing: Ekin Deniz Aksu

Analysis or Interpretation: Ekin Deniz Aksu

Literature Search: Şükrü Hatun, Gül Yeşiltepe Mutlu

Writing: Şükrü Hatun, Gül Yeşiltepe Mutlu, Abdullah Bereket

Conflict of Interest: No conflict of interest

Financial Disclosure: No financial disclosure

References

1. Manson JE, Brannon PM, Rosen CJ, Taylor CL. Vitamin D Deficiency - Is There Really a Pandemic? *N Engl J Med*. 2016 Nov 10;375(19):1817-1820.
2. Basatemur E, Horsfall L, Marston L, Rait G, Sutcliffe A. Trends in the Diagnosis of Vitamin D Deficiency. *Pediatrics*. 2017 Mar;139(3).
3. Hatun Ş, Ozkan B, Bereket A. Vitamin D deficiency and prevention: Turkish experience. *Acta Paediatr*. 2011 Sep;100(9):1195-1199.
4. Looker AC, Johnson CL, Lacher DA, Pfeiffer CM, Schleicher RL, Sempos CT. Vitamin D status: United States, 2001-2006. *NCHS Data Brief*. 2011 Mar;(59):1-8.
5. Munns CF, Shaw N, Kiely M, Specker BL, et al. Global Consensus Recommendations on Prevention and Management of Nutritional Rickets. *J Clin Endocrinol Metab*. 2016;101(2):394-415.
6. Holick MF, Binkley NC, Bischoff-Ferrari HA et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. *J Clin Endocrinol Metab*. 2011 Jul;96(7):1911-30.
7. Ross AC, Manson JE, Abrams SA, Aloia JF, et al. The 2011 report on dietary reference intakes for calcium and vitamin D from the Institute of Medicine: what clinicians need to know. *J Clin Endocrinol Metab*. 2011 Jan;96(1):53-58.
8. Rosen CJ, Abrams SA, Aloia JF, Brannon PM, et al. IOM committee members respond to Endocrine Society vitamin D guideline. *J Clin Endocrinol Metab*. 2012 Apr;97(4):1146-1152.
9. The Turkish Ministry of Health Vitamin D Scientific Board Resolutions 2019, e-belge.saglik.gov.tr
10. Basatemur E, Hunter R, Horsfall L, Sutcliffe A, Rait G. Costs of vitamin D testing and prescribing among children in primary care. *Eur J Pediatr*. 2017;176(10):1405-1409.
11. Ferrari R, Prosser C. Testing vitamin D levels and choosing wisely. *JAMA Intern Med* 176(7):1019-1020.
12. Souberbielle JC, Benhamou CL, Cortet B, Rousière M, et al. French law: what about a reasoned reimbursement of serum vitamin D assays? *Geriatr Psychol Neuropsychiatr Vieil*. 2016;14:377-382.
13. Shaw NJ, Mughal MZ. Vitamin D and child health: part 2 (extra-skeletal and other aspects). *Arch Dis Child* 98(5):368-372. doi:10.1136/archdischild-2012-302585.
14. Arslan G, Acar S, Nalbantoğlu Ö et al. Son Beş Yılda Pediatri Polikliniklerine Başvuran Çocuklarda Serum D Vitamini Düzeylerinin Geriye Dönük Olarak Değerlendirilmesi. *Journal of Dr. Behçet Uz Children's Hospital*, 2019 (9) supp, p5.
15. Uday S, Kongjonaj A, Aguiar M, Tulchinsky T, Högl W. Variations in infant and childhood vitamin D supplementation programmes across Europe and factors influencing adherence. *Endocr Connect*. 2017 Nov;6(8):667-675.
16. Uday S, Högl W. Prevention of rickets and osteomalacia in the UK: political action overdue. *Arch Dis Child*. 2018 Apr 16. pii: archdischild-2018-314826.
17. Seymen Karabulut G, Hatun Ş, Bideci A, Hasanoğlu E. Attitudes of Pediatricians Regarding Prevention and Treatment of Vitamin D Deficiency. *J Clin Res Pediatr Endocrinol*. 2016 Sep 1;8(3):368-71.
18. Yeşiltepe Mutlu G, Hatun Ş. Use of Vitamin D in Children and Adults: Frequently Asked Questions. *J Clin Res Pediatr Endocrinol*. 2018 Apr 27. doi: 10.4274/jcrpe.0012
19. Turan S, Topcu B, Gökçe I, Güran T, Atay Z, Omar A, Akçay T, Bereket A. Serum Alkaline Phosphatase Levels in Healthy Children and Evaluation of Alkaline Phosphatase z-scores in Different Types of Rickets. *J Clin Res Pediatr Endocrinol*. 2011 Mar;3(1):7-11.

Figure 1. Distribution of serum 25-OHD levels according to years, age groups, gender and seasons (ng/ml)

Figure 2. The prevalence rates of vitamin D deficiency and insufficiency according to age groups and seasonal distribution (%)

Figure 3. Regional distribution of the mean 25-OHD levels (ng/ml) and the frequencies of vitamin D deficiency (overall and for <1 year of age) (%).

Figure 4. The prevalence rates of vitamin D deficiency and insufficiency for the youngest age group (<1 yr) according to years.

Figure 5. Relation between Serum 25-Hydroxyvitamin D Concentrations and Mean ($\pm$ SE) Serum Concentrations of Parathyroid Hormone

Table 1. The percentages of serum 25-OHD levels according to age groups, gender, geographic regions, seasons, and years

	25OHD level intervals (ng/ml)					25OHD (ng/ml) mean +-SD (min-max)	Measurements(n)
	0-11	12-19	20-49	50-70	>70		
Age groups (year)							
<1	7	6	66	19	1	^a 37.2[15.8 (2.5-74.3)]	2903
1-10	8	22	67	4	0	^a 27[11.7 (1-74.3)]	10331
11-18	26	32	41	1	0	19.1[10.4 (1-72.9)]	5379
19-30	36	28	34	2	0	18.2[11.8 (2-74.2)]	11831
31-50	30	26	41	3	0	20.1[12.5 (0.25-74.4)]	36946
51-70	26	23	46	4	0	21.9[13.4 (1.8-74.4)]	30675
>70	33	19	43	4	0	21.1[14.2 (1.8-74.5)]	10677
Overall	27	24	45	4	0	21.6[13.2 (0.25-74.5)]	108742
Female	30	23	43	4	0	^b 21[13.4 (0.25-74.5)]	79293
Male	18	27	50	4	0	23.2[12.5 (1-74.4)]	29449
Regional distribution							
Central Anatolia region	24	26	47	3	0	21.9[12.7]	51754
Aegean region	22	22	51	4	0	23.5[13.7]	14566
Marmara region	30	22	44	4	0	21.6[14]	10420
Mediterranean region	26	23	47	4	0	22.2[13.7]	14289
Eastern Anatolia region	39	20	37	4	0	19.5[13.9]	376
Black Sea region	42	24	31	3	0	17.6[12.7]	8488
Southeastern Anatolia region	36	23	38	3	0	19.4[13.4]	8849
Seasonal distribution							
Spring	34	26	36	4	0	19.6[13.3]	29108
Summer	17	23	55	4	0	^c 24.5[13.2]	24384
Autumn	18	23	55	4	0	^c 23.8[12.5]	26813
Winter	36	25	36	3	0	19.1[12.9]	28437
Years							
2011	25	27	47	4	0	22.3[13.4]	16884
2012	33	24	39	3	0	19.8[13.1]	15827
2013	29	24	44	3	0	20.9[13.1]	20130
2014	29	24	44	4	0	21.2[13.3]	21076
2015	25	24	47	4	0	22.5[13.4]	16897
2016	21	25	50	4	0	22.9[12.9]	17928

^aThe mean 25-OHD levels among children <1 year of age and 1-3 years of age were significantly higher compared with those found for the other age groups ($p<0.001$).

^bThe mean 25-OHD level was significantly lower in women than in men ($p<0.001$).

^c25-OHD levels were significantly higher in summer and fall than those measured in winter and spring ($p<0.001$).

Table 2. The percentages of vitamin D deficiency, insufficiency and sufficiency based on the Endocrine Society's recommendations in different age groups

25OHD level intervals (ng/ml)			
	0-20	21-29	30-100
Age groups (year)			
<1	14	16	70
1-10	29	35	36
11-18	58	30	12
19-30	63	23	14
31-50	56	26	18
51-70	50	27	23
>70	52	23	24

Table 3. Comparison of the mean serum 25-OHD levels in our study and the National Health and Nutrition Examination Surveys 2001-2006 (NHANES) according to age groups

Age groups	Mean 25-OHD level ng(ml) (Turkey)	National Health and Nutrition Examination Surveys (NHANES) 2001-2006 the 50 percentile of 25-OHD levels (ng/ml)
<1	37.26[15.82	Not available
1-3	30.12[11.95	27.8
4-8	23.70[10.49	26.9
9-13	21.07[9.86	24.8
14-18	18.75[10.68	23.2
19-30	18.25[11.83	22.2
31-50	20.17[12.57	22.9
51-70	21.99[13.47	23.2
>70	21.11[14.24	22.8

Table 4. the mean serum levels of ALP and PTH according to vitamin D status

25-OHD level (ng/ml)	ALP (IU/L)	PTH (pg/ml)
0-20	82 ±68	63.1±61^a
20-30	90.4±102	49.5±53
30-50	109.2±213	45±28
50-70	111±155	48.1±48
>70	89.2±62.4	44.7±31.7

(^a The mean PTH level was significantly high in the group with a 25OHD level of 0-20 ng/ml ($p<0.0001$)).