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Association between Serum Vitamin D and Bone Mineral Density in US Population

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Abstract

Osteoporosis is a condition where the bones become weak that affects 12.6% of the United States (US) population over 50 years of age. Vitamin D helps to improve bone health as it functions in helping reabsorb calcium from the intestines. Several studies have been conducted on the effects of vitamin D on Bone Mineral Density (BMD), where it has shown that insufficient vitamin D is associated with a reduction in BMD. The purpose is to determine the relationship between serum vitamin D and BMD of the femoral neck in the US population in National Health and Nutrition Examination Survey (NHANES) 2013-2014.

Multivariable linear regression analyses were performed to describe independent associations between serum vitamin D and BMD after controlling for covariates (age, sex, ethnicity, income, BMI). The mean BMD was 0.78 g/cm^2 and the mean serum vitamin D was 70.41 nmol/L, serum vitamin D was not statistically significantly associated with BMD (p = 0.416).

Serum vitamin D does not statistically significantly associate with BMD. Further studies can be done in larger samples to explore this association.

Keywords: Osteoporosis, NHANES, BMD

Association between Serum Vitamin D and Bone Mineral Density in US Population

Osteoporosis is a condition where the bones become weak and brittle that affects 12.6% of the United States (US) population over 50 years of age ((Sarafrazi et al., 2021). There are no known causes for osteoporosis, rather, there are certain risk factors that are associated with osteoporosis. Some of these risk factors are old age, being a female, of White or Asian race, and having a smaller frame. A bone mineral density test (BMD) (gm/cm^2) can be done to assess the relative strength of the bones in the body to determine if one has or is at risk for osteoporosis.

Some ways to increase bone health are physical exercise, intake of calcium, and vitamin D. Vitamin D helps to improve bone health as it helps reabsorb calcium from the intestine and in bone mineralization. Several studies have been conducted to explore the association between serum vitamin D and BMD. Vitamin D plays a role in BMD levels as vitamin D deficiency is linked to a reduction in BMD and a higher risk of developing osteoporosis (Ardawi et al., 2012). Another study mentioned how low vitamin D status contributes to severe osteoporosis (Kota et al., 2013).

The purpose of this analysis is to determine if there is a relationship between vitamin D in the body and BMD of the femoral neck in the US population, and if this association differs by gender.

Methods

Study Sample

A cross-sectional study, using existing data from National Health and Nutrition Examination Survey (NHANES) 2013-2014, US healthy adults ($N = 2748$, 18 years and older, 49.2% male) to evaluate the association between serum vitamin D and femoral neck BMD.

Data Collection

Questionnaires were utilized to collect demographic and personal information (age, sex, race/ethnicity, income). Serum vitamin D was measured by using a high-performance liquid chromatography-tandem mass spectrometry. BMD was measured with a Hologic fan beam x-ray bone densitometer, which uses two different energy levels produced by an energy tube. Race was recoded from five race categories to three categories for this analysis. Annual household income in thousands of dollars, was recoded from 15 strata to three strata (< $25,000, $25,000-$55,000 and $55,000+). Physical exam included measurement of weight (scale) and height (stadiometer) to derive body mass index (BMI).

Statistical Procedures

The statistical analysis was conducted overall, and by gender. Descriptive statistics for continuous variables included measures of centrality (mean) and dispersion (standard deviation). Bar charts were created to display the distribution of serum vitamin D and BMD. Statistical significance was determined across gender using two-sample t-test (continuous) or chi-square test (categorical). Multivariable linear regression analyses were performed to describe independent associations between serum vitamin D and BMD after controlling for covariates (age, sex, ethnicity, income, BMI). All tests were two-sided and conducted at the $\alpha = 0.05$ level of significance.

Analyses were performed using Statistical Package for the Social Sciences (SPSS) IBM Corp. Released 2021. IBM SPSS Statistics for Windows, Version 28.0. Armonk, NY: IBM Corp.

Results

The average age for the sample was 58.57 years (Table 1). Non-Hispanic Whites (46.3%) represented the majority of the sample. The mean BMD was 0.78 (gm/cm^2).

Table 1

Characteristics of NHANES 2013-2014 Participants, Overall, and by Gender

Characteristic	Overall *N* = 2748	Male *n* = 1352 (49.2%)	Female *n* = 1396 (50.8%)	*p*-value*
BMD (gm/cm^2), *mean ± sd*	0.78 ± 0.15	0.82 ± 0.14	0.74 ± 0.14	<.001
Serum Vitamin D (nmol/L), *mean ± sd*	70.41 ± 29.51	66.45 ± 25.73	74.25 ± 32.31	<.001
Race, *n (%)*				.060
Non-Hispanic White	1271 (46.3)	609 (45.0)	662 (47.4)	
Non-Hispanic Black	537 (19.5)	281 (20.8)	256 (18.4)	
Other Race	940 (34.2)	462 (34.2)	478 (34.2)	
Age (years), *mean ± sd*	58.57 ± 12.01	58.78 ± 12.00	58.36 ±12.02	.355
BMI (kg/m^2), *mean ± sd*	28.73 ± 6.19	28.41 ± 5.38	29.04 ± 6.87	.008
Annual Household Income, *n (%)*				.002
< $25,000	794 (28.9)	364 (26.9)	430 (30.8)	
$25,000 - $55,000	796 (29.0)	373 (27.6)	423 (30.3)	
$55,000 +	1158 (42.1)	615 (45.5)	543 (38.9)	

*p-values for difference between male and female used t-test (continuous) or chi-square test (categorical)

Based on the unadjusted univariate analysis, all variables except income were significantly associated with BMD (Table 2).

Table 2

Unadjusted Univariate Regression Showing Association between Bone Mineral Density and Serum Vitamin D Concentration, NHANES 2013-2014

Variable	Coefficient (95% CI)	*p*-value
Serum Vitamin D (nmol/L)	-0.001 (-0.001, -0.001)	<.001
Age (years)	-0.004 (-0.005, -0.004)	<.001
Sex (female vs. male)	-0.073 (-0.084, -0.063)	<.001
BMI (kg/m^2)	0.008 (0.008, 0.009)	<.001
Race		<.001
Non-Hispanic White (ref)		
Non-Hispanic Black	0.104 (0.090, 0.117)	<0.01
Other Race	-0.034 (-0.050, -0.018)	<.001
Annual Household Income		<.001
< $25,000 (ref)		
$25,000 - $55,000	0.004 (-0.008, 0.016)	.554
$55,000 +	0.029 (0.018, 0.040)	<.001

In the multivariable regression analysis (Table 3) after adjusting for all other variables, serum vitamin D was not statistically significantly associated with BMD ($p = .416$). There was also no association between serum vitamin D and BMD in the gender stratified analysis.

Table 3

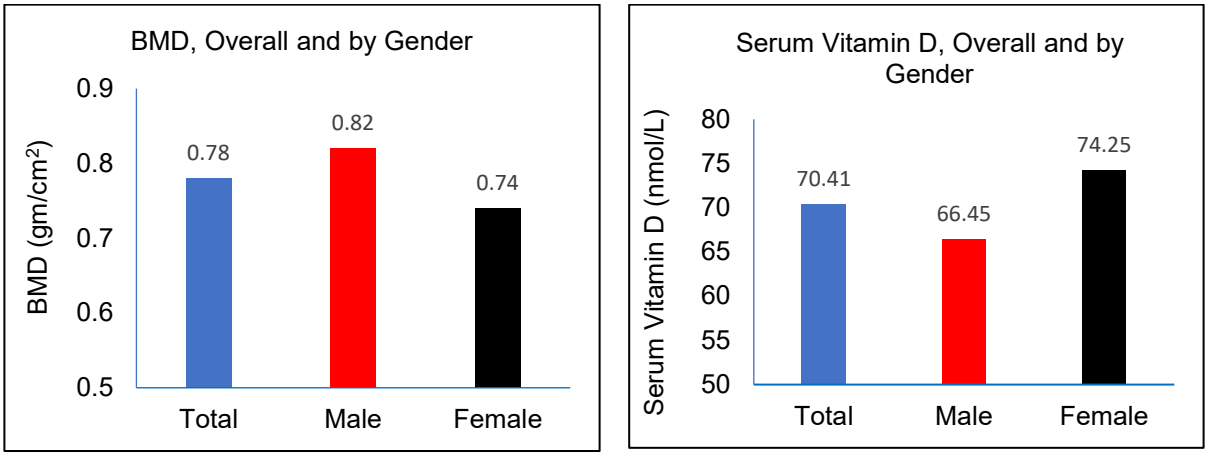
Adjusted Multivariable Regression Showing Association between Bone Mineral Density and Serum Vitamin D Concentration, NHANES 2013-2014

Variable	Coefficient (95% CI)	*p*-value
Serum Vitamin D (nmol/L)	0.000 (0.000, 0.000)	.416
Age (years)	-0.004 (-0.004, -0.004)	<.001
Sex (female vs. male)	-0.077 (-0.086, -0.068)	<.001
BMI (kg/m^2)	0.008 (0.007, 0.008)	<.001
Race		<.001
Non-Hispanic White (ref)		
Non-Hispanic Black	0.088 (0.076, 0.099)	<0.01
Other Race	-0.004 (-0.017, 0.009)	.548
Annual Household Income		<.001
< $25,000 (ref)		
$25,000 - $55,000	0.019 (0.008, 0.031)	0.001
$55,000 +	0.028 (0.018, 0.039)	<.001

The mean BMD for the overall sample was 0.78 gm/cm^2, (Figure 1). Figure 1 also shows the mean serum vitamin D overall and by gender.

Figure 1

Mean BMD and Serum Vitamin D, Overall and by Gender



Discussion

The result of the study shows that serum vitamin D was not associated with BMD in US general population. Existing research reports contradictory evidence between serum vitamin D level and BMD. A cross sectional study published in 2011 from Saudi Arabia showed that lower serum vitamin D was associated with low BMD in both men and women (Sadat-Ali et al., 2011). Similar to our research, a 2017 publication cited cross sectional research finding from Saudi Arabia showing no relationship between serum vitamin D level and BMD (Alkhenizan et al., 2017).

The current study was internally valid as a nationally representative data was used. NHANES uses very vigorous protocols to prevent information/selection biases. We adjusted for confounders in the regression model. The results are externally valid and generalizable for the US population as both genders, various races and socio-economic strata were analyzed. A strength of this analysis is that we used a large sample.

Conclusion

We did not observe any significant association between serum vitamin D levels and BMD of the femoral neck. Further studies can be carried out in larger samples to explore this association.

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