International Journal of Cardiology xxx (2013) xxx–xxx

Contents lists available at SciVerse ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Letter to the Editor

Low vitamin D levels in adults with longer time to fall asleep: US NHANES, 2005–2006

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ARTICLE INFO

Article history:
Received 10 July 2013
Accepted 20 July 2013
Available online xxxx

Keywords:
Etiology
Risk factor
Vitamin D
Sleep
Population health

A new hypothesis on the link between vitamin D deficiency and sleep disorders has arisen very recently [1]. It was based on the observation of sleep improvement after administering vitamin D supplementation during a 2-year uncontrolled trial in 1500 patients with neurological complaints [1]. Epidemiological studies showed that the prevalence of sleep disturbances lies between 20% and 30% and increases with age, particularly in female [2]. If vitamin D plays an important role in the brainstem control of sleep, the interactions among vitamin D, sleep, and human disease such as neurological disease, hypertension, diabetes, cardiovascular disease, depression, and so forth should be given more attention both at intervention and prevention phases. In this context, it was aimed to determine the relationship of vitamin D levels and sleep conditions among the general population in a national, population-based setting.

As described elsewhere [3], United States National Health and Nutrition Examination Surveys (NHANES) was a national, population-based, multi-year, cross-sectional study. Information on demographics, lifestyle factors, and health and medical conditions was obtained at household interviews using questionnaires. Written informed consent was obtained for all subjects. In the 2005–2006 cohort, serum 25(OH)D concentrations were measured using a radioimmunoassay procedure. Sleep conditions in the current analysis included sleeping hours, minutes to fall asleep, ever reported sleep problems (sleep complaints), and ever told sleep disorders by a doctor among people aged 20 and above.

Effect of serum 25(OH)D concentrations on sleep conditions was examined by generalized linear model and logistic regression model, producing coefficients (beta) and odds ratios (OR) with $P < 0.05$ considered statistically significant. Covariates, including age, sex, ethnicity, body mass index, high blood pressure (≥140 mm Hg for systolic blood pressure and ≥90 mm Hg for diastolic blood pressure), active smoking (≥3 mg/mL cotinine), and depressive symptom (a proxy of mental health), were adjusted and final models were weighted for the survey design. Statistical software STATA version 12.0 (STATA, College Station, Texas, USA) was used to perform all the analyses. Since this study is a secondary data analysis by extracting data from the NHANES website which is free to the public, no further ethics approval is required.

Table 1 presents the characteristics of included participants (aged 16 and above, n = 6139) and mean volume of serum 25(OH)D concentrations (mean ± SD: 21.2 ± 9.3 ng/mL). The study sample on average

Table 1
Characteristics of participants aged 20 and above.

	n (%) or mean (SD)
Sex	
Male	2966 (48.3%)
Female	3173 (51.7%)
Age	41.7 (20.1)
Vitamin D (ng/mL)	21.2 (9.3)
Insufficiency (<30 ng/mL)	4584 (83.1%)
High blood pressure	1436 (26.1%)
Cotinine (ng/mL)	52.8 (117.9)
Active smoking (≥3 ng/mL)	1485 (27.0%)
Body mass index	28.1 (6.1)
Sleeping hours	7.1 (4.1)
Time to sleep (min)	22.4 (20.2)
Frequency of snoring	
Never	2014 (37.8%)
1–2 nights per week	1017 (19.1%)
3–4 nights per week	803 (15.1%)
5–7 nights per week	1495 (28.1%)
Frequency of stop breathing	
Never	4655 (82.6%)
1–2 nights per week	437 (7.8%)
3–4 nights per week	274 (4.9%)
5–7 nights per week	268 (4.8%)
Ever reported sleep problem	1184 (19.4%)
Ever told sleep disorder	370 (6.1%)
Sleep apnea	201/370 (54.3%)
Insomnia	78/370 (21.1%)
Restless legs	25/370 (6.8%)
Other	62/370 (16.8%)
Depression scores (range: 1–30)	4.6 (4.7)
Depression (≥10)	389/3180 (12.0%)

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http://dx.doi.org/10.1016/j.ijcard.2013.07.195

Table 2
Associations of serum 25(OH)D concentrations and sleep characteristics.

Crude model			
	Beta	95% CI	P value
Sleeping hours	0.09	−0.14 to 0.32	0.45
Minutes to fall asleep	−3.29	−4.38 to −2.19	<0.001
Snoring[a]	−0.10	−0.17 to −0.03	0.01
Stop breathing[a]	−0.07	−0.11 to −0.03	0.002
	Odds ratio	95% CI	P value
Sleep complaints	1.24	1.07 to 1.42	0.003
Ever told sleep disorders	0.87	0.69 to 1.09	0.23
Adjusted model			
	Beta	95% CI	P value
Sleeping hours	0.28	−0.10 to 0.67	0.14
Minutes to fall asleep	−2.15	−3.81 to −0.50	0.01
Snoring[a]	−0.12	−0.22 to −0.02	0.02
Stop breathing[a]	−0.01	−0.08 to 0.06	0.81
	Odds ratio	95% CI	P value
Sleep complaints	1.68	1.37 to 2.07	<0.001
Ever told sleep disorders	1.20	0.85 to 1.68	0.30
Weighted model			
	Beta	95% CI	P value
Sleeping hours	0.19	−0.40 to 0.77	0.51
Minutes to fall asleep	−3.13	−5.62 to −0.64	0.02
Snoring[a]	−0.12	−0.25 to 0.005	0.06
Stop breathing[a]	−0.03	−0.14 to 0.08	0.62
	Odds ratio	95% CI	P value
Sleep complaints	1.60	1.20 to 2.14	0.004
Ever told sleep disorders	1.17	0.83 to 1.65	0.34

Note: Adjusted model: adjusting for age, sex, ethnicity, body mass index, high blood pressure, active smoking, and depressive symptoms; weighted model: adjusting for age, sex, ethnicity, body mass index, high blood pressure, active smoking, depressive symptoms, and survey weighting.

[a] From never to 1–2 nights per week, 3–4 nights per week, and 5–7 nights per week.

was vitamin D insufficient and no one exceeded the toxicity level. The average sleeping hour was 7.1 h and the average time to fall asleep was 22.4 min. 1184 (19.4%) people have told doctor about their sleep problems while 370 (6.1%) people were diagnosed with sleep disorders.

Table 2 shows associations of serum 25(OH)D concentrations and sleep characteristics. After adjusting for age, sex, ethnicity, high blood pressure, body mass index, active smoking, depressive symptoms, and survey weighting, no association between serum 25(OH)D concentrations and sleeping hours was observed (beta 0.19, 95% CI −0.40 to 0.77, P = 0.51) while a significant inverse association was found between serum 25(OH)D concentrations and minutes to fall asleep (beta −3.13, 95% CI −5.62 to −0.64, P = 0.02). Moreover, people with higher vitamin D levels could be more likely to complain sleep problems (OR 1.60, 95% CI 1.20 to 2.14, P = 0.004).

In the present national, population-based, cross-sectional study, with the relative objective measuring method for both exposures and outcomes, the effect of serum 25(OH)D concentrations on the sleep conditions in the general population was examined for the first time. It was observed that serum 25(OH)D concentrations were significantly associated with minutes to fall asleep, indicating that people with lower vitamin D levels tended to have longer time to fall asleep. On the other hand, it was also observed that people with higher vitamin D levels had more sleep complaints, although the reason is unclear. One hypothesis could be that people with higher vitamin D concentrations are more aware of their health status. Since in the current study it is only cross-sectional, it is not possible to confirm the causation pathway and will reply on future longitudinal cohort studies to provide hard evidence.

A recent study has found a significant association between circadian phase of sleep and dietary vitamin D intake, meaning that later sleep acrophase, an indicator of sleep timing, was associated with more dietary vitamin D [4]. The most well-known role of vitamin D is the regulation of calcium absorption and bone metabolism; however, there is also growing evidence about its possible role in the pathogenesis of inflammation, insulin resistance, and diabetes [1,5,6]. Furthermore, vitamin D target neurons (those with nuclear concentrations of the hormone) have been discovered in specific brain and spinal cord locations in multiple animals, [7–10] and were found to influence the activity of certain endocrine–autonomic, sensory and motor systems. The current analysis thus provides evidence in supporting the hypothesis on the potential anatomic link between vitamin D and sleep not only suggesting a new treatment for increasing sleep quality in patients but a need for wider investigation of careful management of vitamin D levels to prevent or improve several medical conditions in the general population as well [1].

In conclusion, this is the first national, population-based study showing that higher serum 25(OH)D concentrations were significantly associated with shorter time to fall in the general adult population. Although vitamin D levels were also initially associated with other sleep characteristics, such as snoring and breathing, the significance disappeared after full adjustments. If the link between vitamin D and sleep conditions can be confirmed in clinical trials, prescription of vitamin D consumption, either from sun or foods, might need to be considered.

Acknowledgment

None.

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Please cite this article as: Shiue I, Low vitamin D levels in adults with longer time to fall asleep: US NHANES, 2005–2006, Int J Cardiol (2013), http://dx.doi.org/10.1016/j.ijcard.2013.07.195