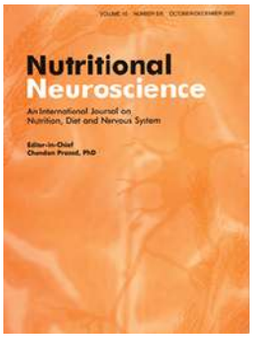

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The effect of vitamin D supplement on the score and quality of sleep in 20–50 year-old people with sleep disorders compared with control group

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Objectives: Sleep quality may be directly related with vitamin D serum level. Some studies found that people with lower vitamin D serum level experienced a lower sleep quality. Consequently, this study aimed at determining the effect of vitamin D supplements on sleep score and quality in 20–50 year-old people with sleep disorders.

Methods: This double blind, clinical trial was performed in November 2015–February 2016 on 89 people with sleep disorders based on Petersburg's Sleep Index. Patient samples were divided randomly into two groups: intervention and placebo. At the end of the study, the data on 89 subjects (44 in intervention group and 45 people in placebo group) were examined. Intervention group received a 50 000-unit vitamin D supplement, one in a fortnight for 8 weeks. Meanwhile, placebo group received placebo. Before and after intervention, Petersburg's Sleep Quality Questionnaire, International Physical Activity Questionnaire, general information questionnaire, sun exposure, vitamin D serum level and 3-day food record questionnaire were assessed and recorded for all participants. To analyze data, *t*-test, chi square, ANCOVA, U-Mann–Whitney and Wilcoxon statistical tests were used.

Findings: Based on the results of the present study, at the end of the study sleep score (PSQI) reduced significantly in vitamin recipients as compared with placebo recipients ($P < 0.05$). This difference was significant even after modifying confounding variables ($P < 0.05$).

Conclusion: This study shows that the use of vitamin D supplement improves sleep quality, reduces sleep latency, raises sleep duration and improves subjective sleep quality in people of 20–50 year-old with sleep disorder.

Keywords: Vitamin D supplement, Serum vitamin D, Sleep disorders

Introduction

Sleep is a state of unconsciousness, convertible to awareness by adequate sensory stimulation.[1] Sleep is an active process requiring different parts of the brain to participate. The daily cycle of sleeping and waking is controlled by different hormones produced by hypothalamus, different light stimulations, biological clock and voluntary behavior.[2,3] In sleep disorders, a person may not enjoy full and satisfactory sleep. He/she may have problems in going to sleep, wake much sooner than expected, or experience a non-integrated sleep during the night.[4] Sleeplessness (insomnia) has been associated with other physical problems including diabetes, coronary heart disease, obstructive sleep apnea (OSA), arthritis, pain in muscles (myalgia) as well as other chronic diseases.[5] Previous studies have shown that sleep restriction is associated with a dysregulation of some hormones including Ghrelin, leptin, insulin, cortisol and growth hormone. Such hormone changes cause disorder in energy regulation which, in turn, causes gaining weight and obesity.[6] Vitamin D includes a set of fat-soluble cycosteroid hormones[7,8] which can be supplied in two different ways: through internal source, that is, dermatic synthesis of the vitamin by

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sunlight (UV ray) and through external source (exogene), that is, by eating food containing vitamin D.[9] Some studies show relationship between sleep period and vitamin D serum level in Korean elderly people, in such a way that insufficient sleep period may be related to low vitamin D serum level.[10] In a study, McCarthy[11] applied vitamin D supplements to cure a 28-year-old woman suffering sleep disorders. This study showed that sleeplessness could be successfully cured by vitamin D. Bozkurt *et al.*[12] observed in their study that severe obstructive apnea was significantly related to low serum levels of 25(OH) D. In another study, Grandner *et al.*[13] found a significant relationship between sleep daily rhythm and vitamin D reception in such a way that in this study, delay in sleep phase was accompanied by the lack of dietary vitamin D. In a study by Gominak *et al.*,[14] it was observed that vitamin D supplement in the group with sleep disorders normalized their sleep for several months after maintenance and normalization of 25(OH)D (60–80 ng/ml). The present study determines the impact of vitamin D supplement on sleep score and quality in 20–50 year-old subjects suffering sleep disorders by considering potential confounding variables and controlling vitamin D serum level at the beginning and the end of the study.

Methods

Participants

This double-blinded, clinical trial was performed during November 2015–February 2016 on 89 people aged 20–50 years with sleep disorders based on Pittsburg Sleep Quality Index (PSQI) referring to Golestan hospital Ahvaz. Among them all, participants of the study were selected based on inclusion and exclusion criteria. Participants took part in the study by full satisfaction. Diagnosis criteria of sleep disorder was completing PSQI and scoring 5/more on this questionnaire and examining and confirming non-existence of sleep disorders by team doctor. The scientific validity of Petersburg questionnaire in Iran was measured in different studies by content reliability.[15] They were included in the study if they had scoring 5/more of PSQI, age range of 20–50 years, consent to take part in the study, not smoking, not using sleep medications (narcotics, non-prescription narcotics, benzodiazepine, barbiturates, antidepressant, antihistamines, antipsychotics, sedatives), not taking high doses of vitamin D supplement (50 000 IU, 300 000 IU) in the previous three months. Exclusion criteria were pregnancy, suffering problems causing sleep disorder such as hypertension, heart disease, using alcohol, suffering depression, anxiety or intense stress, un-consent to take part in the study and smoking.

Consent

All details of the present research were given to participants including the title of the study, as well as its purposes, method, benefits and its final findings. Informed consent form was completed and verified by participants through interview. Personal information of participants was confidentially recorded and preserved. In case of any outbreak, the participants can leave the study after diagnosis by doctor. All ethic principles in medical study were observed throughout this research.

Randomization

This was a double-blinded clinical trial randomized by a statistician. Samples were selected according to convenient sampling. Participants of the study, project executives and clinic's personnel were completely unaware of (blinded) control and intervention groups.

Analysis plan

Convenient sampling was applied to this study. All referents suffering sleep disorder were first diagnosed by the doctor according to PSQI and entered the study on the conditions of possessing all inclusion criteria and listening to all explanations on vitamin D supplement and the purpose of the study. Subjects entered the study after completing written agreement form. Patients under study were divided into two groups of vitamin D supplement and placebo recipients by random allocation. Totally 93 people agreed to take part in the study, 47 people of which were placed in placebo recipient group and 46 people were placed in vitamin D recipient group (Fig. 1). Participants in intervention group received four edible pearls, each 50 000 IU vitamin D (produced by Dana Pharmaceutic Company) one in a fortnight. To placebo group, a placebo capsule (edible paraffin) was given one in a fortnight. At the entrance to study, general instructions were given to all participants not to change their diet by deleting dietary sources of vitamin D, changing physical activity pattern nor losing weight. At the beginning and the end of the study, a 3-day food record was taken (two consecutive days and a holiday).

Measures

Measurement tool for sleep disorder was PSQI. This questionnaire investigates sleep disorder during the previous month and is composed of nine main questions. Generally, this questionnaire includes seven scopes: subjective sleep quality, sleep duration, sleep latency, sleep efficiency-which equals real sleep duration from the whole time passed in bed, sleep disturbances, use of sleep medications and daytime dysfunction, which means experiencing problems resulted by sleeplessness. Total score varies from 0 to

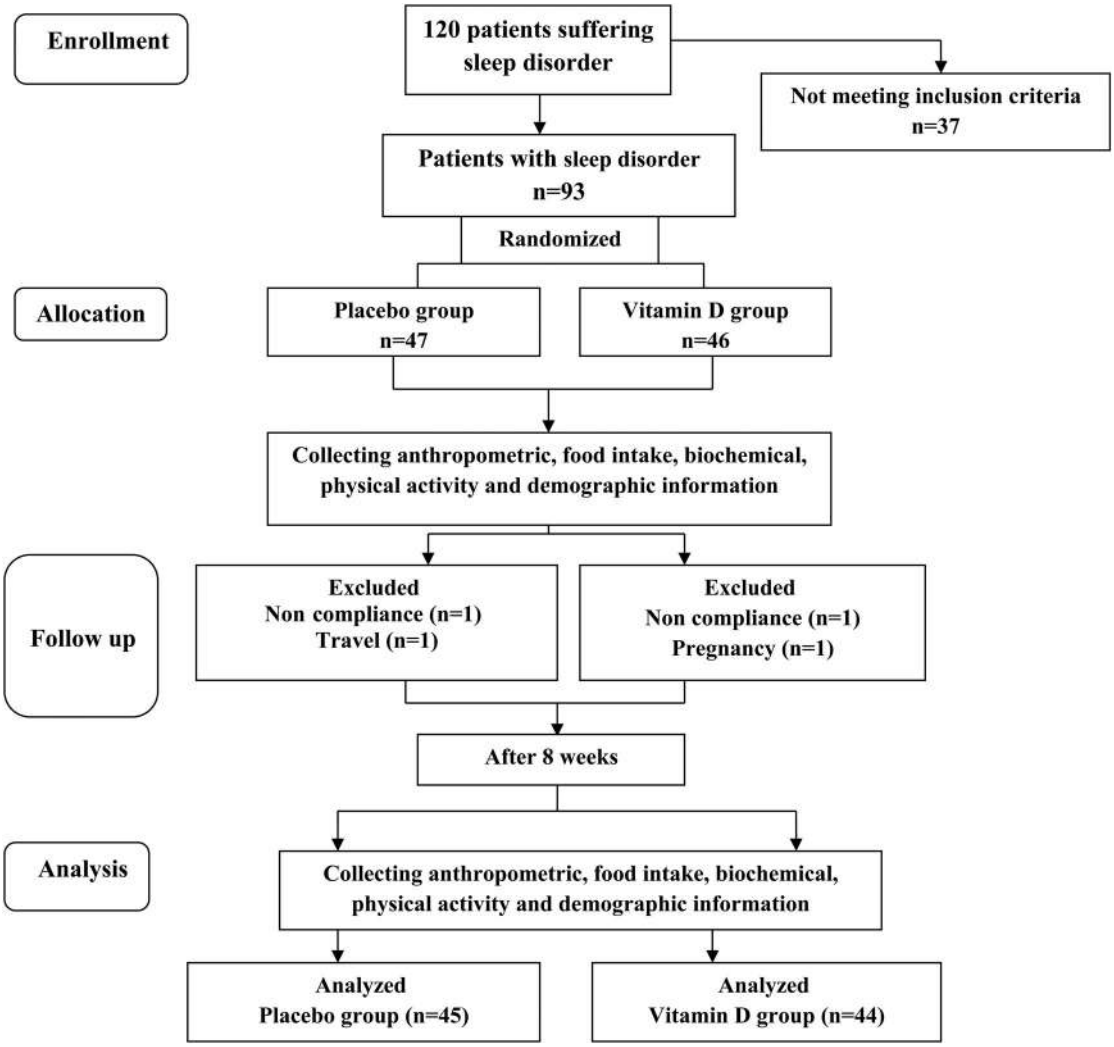

Figure 1 Flowchart of study.

21. After final scoring, acquiring 5/more shows sleep disorder. Through face to face interview and questioning patients, personal information was gathered and recorded including age, occupation, education, sex, marital status, diabetes, depression, smoking, dietary/supplementary vitamin use, sensitivity to vitamin or dietary supplements, prescription drugs and going on a special diet. Food data were presented according to 3-day food record of received amount of energy, carbohydrate, protein, fat, saturated fatty acids, mono unsaturated fatty acids, poly unsaturated fatty acids (PUFA), cholesterol, vitamin B6, vitamin B12,vitamin D, calcium, zinc, iron, selenium, vitamin A, tocopherol and food fiber. For food analysis, Nutritionist IV software (First Databank, San Bruno, CA, USA) modified for Iranian foods was used. At the beginning of the study and at the end of the eighth week, height (cm), weight (kg), waist circumference (cm), hip circumference (cm), BMI (kg/m^2) and waist to hip ratio were measured by an experienced nutritionist and related information was gathered. Using Seca scale, subjects were weighed two times with light clothes and without shoes with a 0.1 kg error; then; the mean for two times was recorded. The heights of participants were measured while standing and shoeless, using a non-elastic meter for two times with a 0.2 cm error. The mean of two times was then recorded. Their body mass index (BMI) was calculated by dividing weight (kg) by height squared (m). Their waist circumferences (WC) were measured in their mid-body under the lowest rib of the chest with a maximum error of 0.5 cm by a non-elastic tape meter. As well, their hip circumferences (HC) were measured in their largest hip periphery using a non-elastic tape meter with a maximum error of 0.5 cm. To calculate waist to hip ratio (WHR), WC/HC formula was used. Subjects' physical activity was examined in the last 7 days at the beginning and the end of the study by International physical activity questionnaire (IPAQ) on a Mets/minute/week basis and considering intense/medium physical activity, walking and the period of time one spent sitting during the last 7 days. At the beginning and the end of the study Sun exposure (minute/day) was assessed by asking about the duration and part of the body that was exposed

Table 1 Demographic characteristics of the study population

Variable		Placebo group ($n = 45$)	Vitamin D group ($n = 44$)	*P*
Age (year)		35.5 ± 10.00	37.9 ± 9.50	0.110[#]
Education	Diploma and less than diploma	28 (63.64)	34 (75.55)	0.441[*]
	Associate degree and bachelor	14 (31.82)	9 (20.00)	
	Msc, MD, PhD	2 (4.54)	2 (4.45)	
Sex	Male	10 (22.22)	11 (25.00)	0.763[*]
	Female	35 (77.78)	33 (75.00)	
Occupation	Employee/student	7 (15.55)	19 (43.18)	0.021*
	Jobless/housewife	32 (71.12)	19 (43.18)	
	Self employed	6 (13.33)	6 (13.64)	
Marital status	Single/widow/divorced	22 (48.89)	19 (43.20)	0.591[*]
	Married	23 (51.11)	25 (56.80)	

P: Comparison between two groups of vitamin D recipients and placebo recipients (*Chi test, [#]*t*-test).

to the sun. Using of sunscreen cream was asked and daily nap (minute/day) was calculated. At the beginning and end of 8 weeks intervention, blood samples (5 cc) were collected. Serum samples were separated by centrifugation and stored at −80°C for analysis. To determine 25(OH) D, IDS kit (Padtan Danesh Co., Iran) was used.

Statistical analyses

The data analysis was performed by SPSS statistic software (version 21 IBM Corp., Armonk, NY, USA). Descriptive statistics for quantitative variables were expressed using mean and standard deviation. Normal distribution of all variables was examined using Kolmogorov–Smirnov statistical method. To compare quantitative variables, Chi square test was used. To compare quantitative data mean between two groups, independent sample *t*-test was used. In case of intervening variables in demographic variables, covariance analysis (ANCOVA) was used. Also, paired sample *t*-test was used to compare previous and next amounts in a group. For variables whose distribution was not normal, non-parametric equal tests were used (Wilcoxon and Mann–Whitney statistical test). The significance level was determined at $P < 0.05$. For food analysis, Nutritionist IV software (First Databank, San Bruno, CA, USA) modified for Iranian foods was used.

Results

Demographic information of subjects is presented in Table 1. The mean age for each group included 35.5 ± 10 years in vitamin D group, 37.9 ± 9.5 years in placebo group and As it shows, there is no significant, statistical difference between two groups ($P = 0.110$). Also, in terms of sex, education and marital status, there was no significant, statistical difference between two groups ($P > 0.05$). However, the comparison of job position between two groups revealed a significant, statistical difference between them ($P = 0.021$). Table 2 shows the anthropometric indexes of participants at the beginning and the end of the study. The

Table 2 Mean and standard deviation of anthropometric indexes in study groups at baseline and the end of the study and intergroup comparison

Variable		Vitamin D group ($n = 44$)	Placebo group ($n = 45$)	P1	P2
Weight (kg)	Baseline	71.27 ± 17.91	68.01 ± 13.01	0.240	0.321
	The end of the study	71.18 ± 17.26	67.93 ± 13.34	0.114	0.643
	P3	0.823	0.771		
Body mass index	Baseline	26.30 ± 6.50	25.76 ± 4.85	0.463	0.660
	The end of the study	26.13 ± 5.85	25.64 ± 4.61	0.540	0.731
	P3	0.822	0.775		
Waist (centimeter)	Baseline	88.87 ± 13.87	89.36 ± 11.45	0.941	0.833
	The end of the study	90.00 ± 12.68	89.32 ± 11.20	0.613	0.801
	P3	0.090	0.881		
Hip circumference (centimeter)	Baseline	101.94 ± 12.60	101.73 ± 8.94	0.803	0.931
	The end of the study	102.95 ± 12.34	99.07 ± 16.31	0.332	0.804
	P3	0.251	0.220		
Waist/hip	Baseline	0.869 ± 0.078	0.881 ± 0.075	0.850	0.661
	The end of the study	0.876 ± 0.071	0.879 ± 0.08	0.883	0.650
	P3	0.233	0.151		

Numbers have been reported as percentage or mean ± SD.
P1: comparison of mean and SD of anthropometric indexes between two groups of vitamin D recipients and placebo recipients (independent sample *t*-test for hip circumference and weight variables and Mann–Whitney U statistical test for other variables).
P2: comparison of mean and SD of anthropometric indexes between two groups of vitamin D recipients and placebo recipients after modifying job effect (ANCONA statistical test).
P3: comparison of mean and SD of anthropometric indices in each group at the beginning and at the end of the study (paired sample *t*-test for weight, BMI and pelvic circumference variables and Wilcoxon statistical test for other variables).

comparison of groups showed that at the beginning of the study there was no significant statistical difference in any anthropometric indexes ($P > 0.05$). These results remained non-significant after modifying the confounding variable (job position) ($P > 0.05$). Intergroup comparison of the variables showed that in vitamin D recipients and placebo groups, there was no significant difference at the end of the study in terms of anthropometric features as compared to the amounts at the beginning of the study ($P > 0.05$). Food reception of the participants was assessed at the beginning and at the end of the study. The results of this assessment have been reported in Table 3. The intergroup comparison showed that at the beginning of the study, there was no significant, statistical difference in food receptions of patients suffering sleep disorders ($P > 0.05$). At the end of the study, after confounding variable (job) was modified, no significant, statistical difference was found in food reception of patients with sleep disorders, except in saturated fatty acids and mono unsaturated fatty acids ($P = 0.004$, $P = 0.011$, respectively). The intergroup comparison of the variables showed that in both groups, no parameters showed significant difference at the end of the study, as compared to the beginning of the study ($P > 0.05$). Table 4 indicates serum vitamin D level, sun exposure, physical activity measure and daily napping of participants at the beginning and at the end of the study. The results of statistical analysis showed that the amount of physical activity in both vitamin D recipients and placebo group was not significantly different at the beginning and the end of the study ($P > 0.05$). As well, there was no significant statistical difference in terms of the level of physical activity between both groups of vitamin D recipients and placebo group at the beginning and the end of the study ($P > 0.05$). These results showed no significant statistical difference after modifying confounding variable (job position) at the beginning and the end of the study ($P > 0.05$). The intergroup comparison showed that there was no significant difference in any parameters of vitamin D serum level, the time exposed to sunlight and daily nap ($P > 0.05$). intergroup comparison showed that at the end of the study, there was no significant statistical difference between two groups in terms of daily nap and the time exposed to sunlight ($P > 0.05$), but at the end of intervention, there was a significant difference between the two groups in terms of vitamin D levels ($P < 0.05$). The intergroup comparison of the variables showed significant differences in vitamin D level in vitamin D recipient group at the end of the study, as compared to the beginning of the study ($P < 0.05$). In vitamin D group, a significant difference was observed regarding the time exposed to sunlight ($P = 0.011$).

In intergroup comparison, there was no significant statistical difference in placebo group at the end of the study in terms of the time exposed to sunlight, vitamin D serum level, and daily nap ($P > 0.05$). As well, intergroup comparison showed that at the end of the study there was no significant difference between vitamin D and placebo recipients in terms of daily nap time, as compared to the beginning of the study ($P > 0.05$). Table 5 shows the comparison of the mean and standard deviation of sleep components and sleep subgroup before and after intervention into two intervention and control groups. Intergroup comparison showed that at the beginning of the study, no significant statistical difference ($P > 0.05$) was observed in subgroups of sleep and sleep score, except for daytime dysfunction score ($P = 0.002$). After modification of confounding variables (job, saturated fatty acids, mono unsaturated fatty acids, time exposed to sunlight) at the beginning of the study, solely sleep time period showed significant difference in both groups ($P < 0.05$). As well, at the end of the intervention, there was a significant difference between two groups in terms of sleep score (PSQI), sleep latency, sleep duration, sleep efficiency, sleep disturbances (score) and the subjective sleep quality (score) ($P < 0.001$, $P = 0.001$, $P < 0.001$, $P = 0.001$, $P = 0.024$, $P = 0.019$, respectively). These results remained significant even after modifying confounding variables (job, saturated fatty acid, mono unsaturated fatty acid, time exposed to sunlight) for PSQI, sleep latency, sleep duration and subjective sleep quality (score) ($P < 0.001$, $P = 0.002$, $P < 0.001$ and $P = 0.039$, respectively). Intergroup comparison of the variables showed that no significant difference was found in placebo group in terms of sleep score and the score of sleep subgroup at the end of the study, as compared to the beginning of the study ($P < 0.05$).

Discussion

As far as the researchers are aware, this is the first double-blinded clinical trial which the effect of 50 000 unit of vitamin D supplement on sleep score and quality by controlling vitamin D level before and after intervention in 20–50 year-old patients with sleep disorder who had no sleep-disrupting diseases and took no medications. In this study, taking one 50000 unit vitamin D supplement in a fortnight for 8 weeks can significantly improve (decrease) sleep score (PSQI), sleep latency and the score of subjective sleep quality in vitamin D recipients as compared with placebo recipients. At the end of the study, a significant increase was observed in vitamin D recipients as compared with placebo recipient group in terms of sleep duration. In this study, levels above 30 ng/ml of 25(OH) D serum has been considered as normal

Table 3 Mean and standard deviation of food intake in the study groups at the baseline and intergroup comparison

Variable		Vitamin D group ($n = 44$)	Placebo group ($n = 45$)	P1	P2
Energy (kcal/day)	Baseline	2014.00 ± 605.90	2026.55 ± 749.90	0.861	0.775
	The end of the study	2011.20 ± 715.80	2104.56 ± 619.37	0.528	0.391
	P3	0.933	0.561		
Carbohydrates (g)	Baseline	257.53 ± 87.81	272.19 ± 103.11	0.471	0.663
	The end of the study	271.73 ± 99.79	280.19 ± 99.80	0.673	0.892
	P3	0.47	0.632		
Lipid (g)	Baseline	75.23 ± 31.15	77.13 ± 42.28	0.811	0.503
	The end of the study	66.39 ± 26.05	80.07 ± 41.09	0.813	0.6
	P3	0.081	0.58		
Proteins (g)	Baseline	73.73 ± 33.88	72.31 ± 28.89	0.84	0.982
	The End of the study	75.42 ± 33.60	77.10 ± 25.97	0.343	0.291
	P3	0.221	0.642		
Carbohydrates (%)	Baseline	51.79 ± 11.90	54.75 ± 12.44	0.212	0.31
	The end of the study	54.17 ± 13.83	49.92 ± 13.05	0.103	0.071
	P3	0.333	0.081		
Lipid (%)	Baseline	34.37 ± 10.65	32.74 ± 12.75	0.342	0.234
	The end of the study	32.44 ± 12.64	34.56 ± 17.25	0.682	0.551
	P3	0.281	0.76		
Proteins (%)	Baseline	14.54 ± 4.75	14.98 ± 4.22	0.362	0.721
	The end of the study	15.46 ± 5.75	15.67 ± 6.09	0.744	0.845
	P3	0.213	0.462		
SFA (saturated fatty acid) (g)	Baseline	20.98 ± 13.14	22.98 ± 13.55	0.432	0.49
	The end of the study	17.83 ± 10.04	24.71 ± 14.97	0.021	0.011
	P3	0.233	0.51		
MUFA (mono unsaturated fatty acid) (g)	Baseline	19.98 ± 9.60	21.97 ± 13.01	0.412	0.301
	The end of the study	17.40 ± 8.70	24.27 ± 16.25	0.074	0.004
	P3	0.022	0.593		
PUFA (poly unsaturated fatty acid (g)	Baseline	25.10 ± 15.87	24.02 ± 17.30	0.763	0.931
	The end of the study	23.05 ± 13.47	24.95 ± 15.39	0.542	0.473
	P3	0.501	0.78		
Cholesterol (mg)	Baseline	316.60 ± 240.50	261.71 ± 211.10	0.881	0.352
	The end of the study	242.96 ± 214.76	298.72 ± 209.66	0.533	0.183
	P3	0.101	0.504		
Fiber (g)	Baseline	12.79 ± 2.04	11.04 ± 4.74	0.484	0.563
	The end of the study	12.80 ± 6.97	11.84 ± 4.82	0.551	0.492
	P3	0.39	0.205		
Vitamin E (mg)	Baseline	1.66 ± 1.220	2.60 ± 1.321	0.44	0.294
	The end of the study	2.07 ± .923	2.82 ± 1.782	0.383	0.914
	P3	0.243	0.66		
Vitamin B6 (mg)	Baseline	1.37 ± 0.73	1.38 ± 0.59	0.634	0.93
	The end of the study	1.91 ± 0.22	1.76 ± 1.00	0.182	0.991
	P3	0.39	0.074		
Vitamin B12 (μmg)	Baseline	3.24 ± 2.88	3.34 ± 2.29	0.37	0.954
	The end of the study	3.34 ± 2.94	3.92 ± 3.20	0.152	0.941
	P3	0.991	0.503		
Vitamin A (RE)	Baseline	642.70 ± 277.06	521.5 ± 234.70	0.23	0.221
	The end of the study	585.49 ± 301.20	439.40 ± 291.85	0.224	0.281
	P3	0.23	0.474		
Vitamin D (mg)	Baseline	2.21 ± 0.92	2.38 ± 1.06	0.414	0.682
	The end of the study	2.1 ± 1.02	2.54 ± 0.98	0.039	0.729
	P3	0.47	0.393		
Iron (Fe) (mg)	Baseline	11.83 ± 2.16	12.50 ± 2.74	0.479	0.376
	The end of the study	14.56 ± 2.68	12.66 ± 2.26	0.401	0.539
	P3	0.198	0.768		
Selenium (mg)	Baseline	0.06 ± 0.04	0.06 ± 0.05	0.669	0.949
	The end of the study	0.06 ± 0.05	0.05 ± 0.04	0.329	0.179
	P3	0.789	0.117		
Zinc (mg)	Baseline	8.27 ± 2.22	8.82 ± 2.35	0.269	0.661
	The end of the study	8.65 ± 3.33	8.79 ± 2.35	0.414	0.667
	P3	0.719	0.888		
Calcium (mg)	Baseline	541.48 ± 295.83	461.78 ± 224.76	0.451	0.301
	The end of the study	482.07 ± 220.32	439.87 ± 298.52	0.421	0.449
		0.667	0.881		

P1: Comparison of mean and SD of dietary intakes between two groups of vitamin D recipients and placebo recipients (Independent sample *t*-test for energy, carbohydrate, fat, iron, monounsaturated fatty acids and polyunsaturated fatty acids and Mann–Whitney U statistical test for other variables).
P2: Comparison of mean and SD of dietary intakes between two groups of vitamin D received and placebo received after adjusting job effect (ANCOVA statistical test).
P3: Comparison of mean and SD of dietary intakes in each groups at the beginning and the end of the study (Paired sample *t*-test for variable energy, carbohydrates, monounsaturated fatty acids, polyunsaturated fatty acids, iron, zinc, vitamin D group and energy, carbohydrates, fat, protein, proteins energy in the placebo group and Wilcoxon statistical test for other variables).

Table 4 Mean and standard deviation of serum vitamin D level, sun exposure, physical activity measure and daily nap in the study groups at the beginning and the end of the study and intergroup comparison

Variable		Vitamin D group ($n = 44$)	Placebo group ($n = 45$)	P1	P2
Serum 25 (OH)D level (ng/ml)	Baseline	25.00 ± 8.95	27.60 ± 8.30	0.131	0.158
	The end of the study	37.69 ± 12.25	27.97 ± 7. 46	<0.001	<0.001
	P3	<0.001	0.781		
Sun exposure (minute)	Baseline	21.13 ± 15.87	21.88 ± 20.84	0.329	0.381
	The end of the study	17.04 ± 8.17	20.66 ± 16.60	0.881	0.737
	P3	0.011	0.219		
Daily nap (minute)	Baseline	37.50 ± 35.98	25.77 ± 23.30	0.171	0.072
	The end of the study	31.59 ± 30.32	29.66 ± 16.60	0.778	0.901
	P3	0.170	0.209		
Physical activity (Met-minute/week)	Baseline	1901.40 ± 1603.00	1570.09 ± 1517.09	0.449	0.568
	The end of the study	1717.50 ± 1627.6	1805.68 ± 1589.51	0.580	0.628
	P3	0.428	0.248		

P1: Comparison mean and SD of serum vitamin D level, sun exposure, physical activity and daily nap between two groups of vitamin D recipients and placebo recipients (Mann–Whitney U statistical test for variables).
P2: Comparison mean and SD serum vitamin D level, sun exposure, physical activity and daily nap between two groups of vitamin D recipients and placebo recipients after modifying job effect (ANCONA statistical test)
P3: Comparison mean and SD of serum vitamin D level, sun exposure, physical activity and daily nap in each groups at the beginning and the end of the study (Wilcoxon statistical test).
25(OH)D: 25-Hydroxy vitamin D. METs: metabolic equivalent.

levels of vitamin D, and level of 20–29 ng/ml of 25 (OH) D serum is considered as insufficient and levels less than 20 ng/ml as vitamin D deficiency.[8] Huang *et al.*,[16] found in their intervention study that vitamin D supplement significantly reduced sleep latency and increased sleep period. In a study by Darling *et al.*,[17] it was found that sleep period was significantly related to vitamin D serum levels in all participants. Also, a relationship was found between sleep efficiency with vitamin D serum level in women before menopause. Another study shows that supplementation with vitamin D improves respiration-related sleep disorder.[18] Despite few studies on vitamin D and sleep, the findings of those studies

Table 5 Mean and standard deviation of sleep score and sleep subgroups score in the study groups at the beginning and the end of the study and intergroup comparison

Variable		Vitamin D group ($n = 44$)	Placebo group ($n = 45$)	P1	P2
PSQI (score)	Baseline	9.45 ± 2.44	10.51 ± 3.14	0.289	0.138
	The end of the study	6.75 ± 2.97	9.73 ± 3.04	<0.001	<0.001
	P3	<0.001	0.181		
Sleep duration (hour)	Baseline	5.83 ± 1.15	5.22 ± 1.54	0.108	0.036
	The end of the study	6.50 ± 1.49	5.21 ± 1.44	<0.001	<0.001
	P3	0.002	0.719		
Sleep latency (minute)	Baseline	49.88 ± 38.99	65.00 ± 47.54	0.060	0.091
	The end of the study	33.18 ± 27.91	58.57 ± 36.81	0.001	0.002
	P3	0.002	0.588		
Sleep efficiency (%)	Baseline	82.58 ± 9.93	78.20 ± 12.90	0.082	0.110
	The end of the study	86.97 ± 11.39	80.89 ± 11.46	0.001	0.082
	P3	0.021	0.278		
Sleep disturbances (score)	Baseline	1.23 ± 0.47	1.40 ± 0.78	0.301	0.218
	The end of the study	1.14 ± 0.46	1.41 ± 0.65	0.024	0.070
	P3	0.252	0.639		
Use of sleep medications (time per week)	Baseline	2.07 ± 1.92	0.77 ± 1.02	0.188	0.318
	The end of the study	0.70 ± 0.96	0.75 ± 0.98	0.901	0.989
	P3	0.038	0.629		
Day time dysfunction (score)	Baseline	1.57 ± 0.99	1.17 ± 0.93	0.041	0.079
	The end of the study	1.07 ± 0.94	1.20 ± 0.99	0.570	0.49
	P3	0.002	0.949		
Subjective sleep quality (score)	Baseline	1.68 ± 0.77	1.57 ± 0.62	0.628	0.519
	The end of the study	1.18 ± 0.62	1.46 ± 0.58	0.019	0.039
	P3	<0.001	0.251		

P1: Comparison mean and SD of sleep score and sleep subgroups score between two group vitamin D recipients and placebo recipients (Mann–Whitney U statistical test for variables).
P2: Comparison mean and SD of sleep score and sleep subgroups score between two group of vitamin D recipients and placebo recipients after adjusting for jobs, saturated fatty acids, monounsaturated fatty acids and sun exposure time (ANCONA statistical test)
P3: Comparison mean and SD sleep score and sleep subgroups score in each groups at the beginning and the end of the study (Wilcoxon statistical test for variable).
PSQI: Pittsburgh Sleep Quality Index.

verify our study. Although real mechanisms and causative relation between sleep period and vitamin D serum level is not yet understood, several mechanisms have been suggested for it. As follows: Autoradiographic study with ^{3}H-1,25$(OH)_2$ vitamin D3 in neurons of brain and spinal cord of rats and mice shows that there are several special selective bonding places along neurons in the central nervous for vitamin D which are symmetric with sleep induction places.[19] Vitamin D deficiency creates biologic potential (mechanically) for Obstructive Sleep Apnea (OSA) which can disturb sleep through myopathy, facilitating the development of chronic inflammation of nasal mucosa or hypertrophy of the tonsils.[20] Prostaglandin D2 is a central sleep regulator which causes sleeplessness symptoms obstructive sleep apnea.[21] In case of vitamin D deficiency prostaglandin D2 level increase and consequently the sleeplessness symptoms of obstructive apnea increases.[22] Low level of vitamin D creates and develops myopathic pain and myopathic pain can disrupt sleep.[23] The findings of the present study show that in vitamin D recipient group, weight mean, BMI, waist circumference, hip circumference, WHR did not change significantly at the end of the study after comparison with the beginning of the study. The study by Kim[10] showed an inverse relationship between BMI and vitamin D serum level. In a study by Faraji *et al*.,[24] a relationship was found between height, hip circumference, WHR and vitamin D serum level. In a study by Al-Mulhim,[25] it was found that vitamin D supplement affects anthropometric indices by reducing waist circumference in women while this supplement has no effect on other anthropometric indices. In a study by Jafari *et al*.[26] in which low-fat yogurt enriched by 2000 units of vitamin D in 100 g of yogurt during 12 weeks reduced waist circumference and WHR in women suffering type 2 diabetes. Studies that consider vitamin D as effective an anthropometric indices, justify that vitamin D deficiency can lead to secondary hyperparathyroidism. Consequently, intercellular free calcium increases in fat tissue.[27] And then lipogenes increase through disorder in inducing lipolysis catecholamine. This can lead to fat accumulation and obesity.[28] Also, vitamin D reduces the expression and activity of peroxisome proliferator-activated receptor gamma (PPAR-γ) tissue formation.[29] Although above-mentioned mechanism justifies the probable impact of vitamin D on anthropometric indices, no relationship was found in the present study between vitamin D intake and anthropometric indices. Perhaps, for the same reason, BMI and waist circumference of all participants in our intervention were not included among obese people. Another reason why vitamin D supplement does not affect anthropometric indices may be the short period for supplementation (8 weeks). As a result, it is necessary in next studies to examine the impact of vitamin D on overweight or obese people suffering sleep disorder in a longer period. The strength of this study is that was conducted on patients with no sleep-disorder problem nor sleep-disorder substance intake (alcohol, smoking) and by adjusting sleep-disorder or sleep-improving factors including daily sun exposure, physical activity, food intake before and after intervention, and by examining vitamin D serum level before and after intervention, thus, the direct impact of vitamin D intake on sleep has been presented more clearly. Limitations of this study include single-centre study, short time period, using questionnaire for evaluating sleep disorder which is not an accurate tool for sleep-disorder evaluation. It is suggested that further studies consider bigger sample volume, and conduct a longer intervention on people with vitamin D deficiency and use a more accurate tool to evaluate sleep quality.

Conclusion

The present study showed that in people without sleep disturbing problems, 50 000-unit vitamin D supplement, one in a fortnight for 8 weeks reduced sleep score (PSQI) or improved sleep score, reduced sleep latency, increased sleep duration and subjective sleep quality after modifying confounding variables. However, the present study found no significant change after modifying confounding variables in subgroups of daily dysfunction, sleep efficiency, sleep problems, use of sleep medications.

Disclaimer statements

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