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Vitamin D Deficiency is Related to Worse Emotional State

Research Article

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Abstract: **The aim** was to evaluate vitamin D levels in young healthy Lithuanian males in winter and to find possible associations of vitamin D concentration to body composition, cognitive functioning, emotional state.

Subjects and Methods. A total of 130 healthy males (age range, 18-26 years) were divided into the subgroups according to vitamin D concentration. The Profile of Mood States (POMS) questionnaire and Hospital Anxiety and Depression Scale were employed in the assessment of emotional state. Cognitive functioning was assessed by the Trail Making Test and the Digit Symbol Test of the Wechsler Adult Intelligence Scale.

Results. The mean concentration of vitamin D for the entire sample was 13.0±5.3 ng/ml. Only 2 persons (1.6%) had the recommended vitamin D level. Nearly half (45.4%) of study participants had vitamin D deficiency. Lower concentrations were associated with a significantly higher score on the POMS confusion-bewilderment scale. A tendency toward a lower mean depression-dejection score in the participants with a sufficient vitamin D level was observed. Vitamin D concentration correlated positively with body mass index (BMI) and inversely with the confusion-bewilderment score.

In conclusion, almost half of the young healthy males participating in the study were detected to have vitamin D deficiency in winter. Low vitamin D concentrations are associated with a worse emotional state.

Keywords: *Vitamin D • Healthy young males • Body composition • Cognitive functioning • Emotional state*

1. Introduction

The term "vitamin D" refers to either vitamin D_2 (ergocalciferol) or D_3 (cholecalciferol). The level of 25-hydroxyvitamin D (25-[OH]D), a metabolite of vitamin D, shows the actual vitamin D concentration and usually is measured in blood. The major sources of vitamin D are food (such as milk, some cereals, and fatty fish such as salmon, sardines) and the action of UV radiation from the sun in the skin [1].

Hypovitaminosis D is a predisposing condition for various chronic diseases. In addition to skeletal disorders, vitamin D deficiency increases the risk of cancer, particularly of the colon, breast, and prostate gland, chronic inflammatory and autoimmune diseases (type 1 diabetes mellitus, inflammatory bowel disease, and multiple sclerosis) as well as metabolic disorders (metabolic syndrome and hypertension) [2].

The findings of population studies confirmed a significant inverse correlation between vitamin D levels and body mass index (BMI), waist circumference, fasting plasma glucose, and insulin levels [3]. In extremely obese patients, vitamin D levels decrease with the

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increasing BMI and fat mass, and they are not affected by the degree of obesity [4].

Functions of vitamin D extend well beyond its role in the somatic health state. Convincing evidence links vitamin D deficiency to adverse cognitive and behavioral effects [1]. It is associated with low mood, depression, and cognitive performance, especially in elderly adults [5,6,7]. Vitamin D insufficiency affects physical, social, and mental functions and impairs quality of life of osteoporotic patients [8]. However, the study by McGrath et al. did not confirm any association of lower vitamin D levels with impaired psychometric or cognitive performance in adolescent, adult, or elderly groups [9].

Results of population-based studies confirm an association of depression status and severity with decreased vitamin D levels and increased parathyroid hormone levels in elderly adults [10], and vitamin D supplementation significantly reduced anxiety and depression, especially during the winter months [11]. Patients with vitamin D deficiency have higher anxiety and depression levels than patients with normal vitamin D concentrations [12].

Therefore, there is a large amount of data on the importance of vitamin D in physical and psychological health and well-being that is controversial.

Vitamin D levels are influenced by several modifiable and nonmodifiable factors such as diet, latitude, season, time outdoors, skin pigmentation, clothing, and tanning habits [13,14]. The question is how much solar UV exposure is adequate to maintain the balance between its benefit and the risk of cancer [15]. In the study by Hintzpeter et al., multiple linear regression analysis showed that independent determinants of serum vitamin D levels included season, vitamin D intake from diet or supplements, and physical activity; in addition, age and BMI contributed to multiple linear regression models [16]. Even air pollution may be a neglected risk factor for hypovitaminosis D [17].

Although there is no consensus on optimal vitamin D levels, a level of greater than 30 ng/ml is recommended as optimal by some experts (to convert to nanomoles per liter, multiply by 2.496) [18,19]. Most experts agree that minimum levels should be at least 20 ng/ml. Vitamin D deficiency is defined as less than 11-12 ng/ml and vitamin D insufficiency as a serum vitamin D level between 11-12 ng/ml and 20 ng/ml [20].

The results of studies show that vitamin D deficiency or insufficiency is very common and widespread, regardless of geographical location. In a study of German adults, regardless of season, 15.6% of men and 17.0% of women had severe-to-moderate vitamin D deficiency [16]. In the southeastern United States, hypovitaminosis D prevalence is 45% among African-Americans and 11% among whites [21].

Vitamin D deficiency exists despite abundant sun exposure. In the Kashmir valley of India, 83% of healthy natives have vitamin D deficiency [22]. The study by Pèrez-Llamasinvestigating elderly people of the Mediterranean area showed that vitamin D deficiency was more common in women (40.3%) than in men (20.7%) and serum vitamin D concentration varied considerably with the season in which the samples were taken [23].

As Lithuania is a northern country, where sun exposure is relatively low and recommendations of vitamin D dietary intake are not met, we hypothesized that vitamin D levels in young healthy Lithuanian residents, especially in winter, are too low and would therefore be related to a worse emotional state and decreased cognitive functions. The focus of the study was on detection of vitamin D levels in winter, which is almost half a year long in the northern latitudes, because it is important to know the lowest possible levels in healthy young people under conditions not favorable for its production.

The aim of the study was to evaluate vitamin D levels in healthy young Lithuanian males (military conscripts and medical students) in winter and to find possible associations between vitamin D concentration and body composition, cognitive functioning, and emotional state.

2. Methods and materials

2.1. Participants and protocol

A total of 130 healthy young males (age range, 18-26 years) were recruited for a pilot study. The participants were 71 military conscripts and 59 medical students who were included randomly.

Written informed consent was obtained from all the participants, and the study was approved by the Bioethics Committee of Medical Academy, Lithuanian University of Health Sciences.

Fasting overnight blood samples were obtained in winter (January and the beginning of February). All the samples were taken between 8 AM and noon. Serum was separated and stored at –20ºC until analysis. The 25(OH)D level was measured by an immunoenzyme assay (Cobas, Roche).

The participants were divided into three groups according to vitamin D concentration: 1) vitamin D deficient (<12 ng/ml); 2) vitamin D insufficient (12-20 ng/ml); and 3) vitamin D sufficient (>20 ng/ml).

Height, weight, and body composition were estimated using a Jawon Medical body composition analyzer by bioimpedance.

2.2. Psychological Assessment

The Profile of Mood States (POMS) questionnaire [24] and Hospital Anxiety and Depression Scale [25] were employed in the assessment of emotional state. The POMS questionnaire is a sensitive measure of mood. It measures the POMS global score and several subscales: tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, and confusion-bewilderment. A higher score represents a higher level of certain mood aspect.

Assessment of cognitive functioning was performed with the Trail Making Test [26] and Digit Symbol Test (DST) of the Wechsler Adult Intelligence Scale [27]. The Trail Making Test is a timed test, which requires the subject to connect an alternating sequence of numbers (Trail making A) or numbers and letters (Trail making B) in ascending order. The score on the test, which is based on the time required to complete the sequence, is a measure of executive function, attention, and visual scanning abilities. The DST requires the subject to repeat sequences of numbers in a given order to show attention ability and psychomotor speed.

2.3. Statistical Analyses

Descriptive values were given as mean ± standard deviation. The differences between the groups were compared using the Mann-Whitney and Kruskal-Wallis tests. Univariate associations between vitamin D concentration and anthropometric, body composition, and psychological data were determined by Pearson correlation coefficients. We determined that a sample size of 130 would have sufficient power ($\beta = 0.76$, $\alpha = 0.05$) to detect a partial correlation coefficient of greater or equal to 0.22. *P* values of <0.05 were considered to indicate statistical significance. All statistical tests were two-sided with an alpha of <0.05 and all analyses were performed using STATISTICA software.

3. Results

Characteristics of the study participants are summarized in Table 1. All the participants were mobile, had no chronic diseases, and were white by race.

The mean concentration of vitamin D for the entire sample was 13.0±5.3 ng/ml; in the group of military conscripts it was 13.5±4.8 ng/ml (range, 5.2-30.9 ng/ml), and in the group of medical students 12.4±5.8 ng/ml (range, 4.0-30.0 ng/ml). Only 2 persons (1.6%) in the study cohort had the recommended level of vitamin D (>30 ng/ml). Figure 1 shows the distribution of vitamin D concentration for all the participants, and Table 2 displays the distribution of military conscripts, medical students, and all participants by vitamin D status.

Table 1 Main characteristics of the study participants

Characteristic	Military conscripts (n=71)	Medical students (n=59)	P (Mann-Whitney test)
Age, years	20.9±1.6	21.2±1.5	NS
Height, cm	181.8±7.1	182.1±7.5	NS
Weight, kg	76.5±16.5	78.7±10.5	NS
Body mass index, kg/m^2	23.0±3.8	23.7±2.7	NS
Vitamin D concentration, ng/ml	13.5±4.8	12.4±5.8	NS
POMS global score	21.9±25.8	27.2±26.1	NS
Stressful life events during last year, n	12.7±8.3	8.2±4.7	.001

Values are given as mean ± standard deviation.
POMS, Profile of Mood States; NS, not significant.

Only 10.6% (n=14) of all the participants had sufficient vitamin D concentration, and vitamin D deficiency was documented in 45.4% (n=59) of the study population.

After the participants were classified into subgroups by vitamin D concentration, differences in body composition and psychological state were established.

Comparison of the characteristics of body composition among the subgroups by different vitamin D levels is shown in Table 3. Only BMI was significantly higher in the participants with the highest vitamin D

Figure 1 Distribution of vitamin D concentration in all the participants of the study

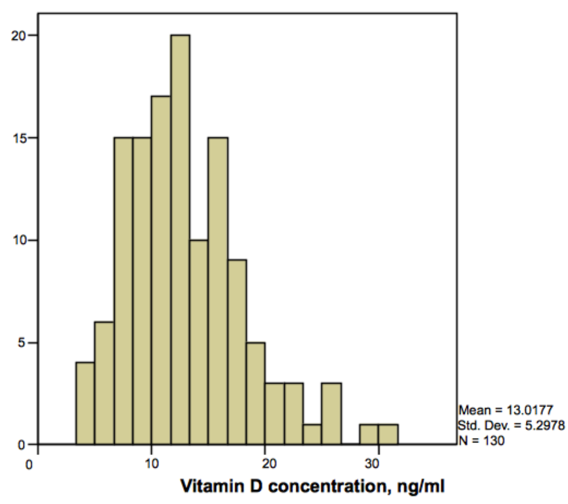

Table 2 Distribution of military conscripts, medical students, and all participants by vitamin D status

Group	Vitamin D status	Number of participants	Percentage of participants
Military conscripts (n=71)	Deficiency	30	42.3
	Insufficiency	35	49.3
	Sufficient concentration	6	8.4
Medical students (n=59)	Deficiency	29	49.1
	Insufficiency	22	37.3
	Sufficient concentration	8	13.6
All participants (n=130)	Deficiency	59	45.4
	Insufficiency	57	44.0
	Sufficient concentration	14	10.6

levels. Table 4 shows differences in psychological state (cognitive functioning and emotional state) when the groups with different vitamin D status are compared. The participants with sufficient vitamin D levels scored more favorably on the confusion-bewilderment scale of the POMS than those with vitamin D deficiency or insufficiency; a trend toward a significant difference was observed for the depression-dejection score, being lower in the subgroup with sufficient vitamin D levels.

Comparison of the characteristics of body composition and psychological state among different subgroups by vitamin D level in military conscripts and medical students separately revealed similar patterns of difference. No significant differences in the characteristics of body composition among the subgroups of medical students with different vitamin D levels were found (Table 5). The evaluation of cognitive function and emotional state in medical students

Table 3 Body composition in different subgroups by vitamin D concentration in all participants

Parameter	Vitamin D deficiency (<12 ng/ml) n=59	Vitamin D insufficiency (12-20 ng/ml) n=57	Sufficient vitamin D (>20 ng/ml) n=14	P (Kruskal-Wallis test)
Body mass index, kg/m^2	22.8±3.3	23.4±3.2	25.6±3.7	.045
Fat body mass, kg	17.6±6.4	17.5±5.6	19.5±4.2	NS
Lean body mass, kg	62.4±8.6	63.9±8.4	66.9±14.1	NS
Water body mass, kg	44.7±6.3	45.8±6.0	48.1±10.1	NS

Values are given as mean ± standard deviation. NS, not significant.

Table 4 Cognitive functioning and emotional state in different subgroups by vitamin D concentration in all participants

	Vitamin D deficiency (<12 ng/ml) n=59	Vitamin D insufficiency (12-20 ng/ml) n=57	Sufficient vitamin D (>20 ng/ml) n=14	P (Kruskal-Wallis test)
Cognitive functioning:				
Trail making A*	27.2±8.7	28.6±9.3	27.3±6.7	NS
Trail making B*	61.1±19.3	60.6±19.9	65.4±27.7	NS
DST forwards**	7.2±2.0	6.7±2.1	7.1±2.3	NS
DST backwards**	5.8±1.4	5.5±1.7	5.8±1.8	NS
DST raw score**	12.9±3.0	12.3±3.1	12.9±3.8	NS
Emotional state:				
HAD depression#	3.8±2.3	4.0±2.7	2.5±1.8	NS
HAD anxiety#	5.9±3.1	6.2±3.1	4.3±2.6	NS
POMS global score#	25.2±24.2	25.5±27.4	8.9±21.7	NS
POMS tension-anxiety#	7.1±4.6	7.0±5.2	4.3±3.6	NS
POMS depression-dejection#	10.8±8.1	10.9±7.9	5.7±5.5	.052
POMS anger-hostility#	11.4±7.4	11.0±6.4	9.9±7.1	NS
POMS vigor-activity##	16.5±5.3	16.4±5.2	17.8±1.6	NS
POMS fatigue-inertia#	8.5±4.8	9.1±5.0	5.9±4.2	NS
POMS confusion-bewilderment#	3.9±3.2	3.9±7.4	0.9±3.5	.032

Values are given as mean ± standard deviation.
DST, Digital Symbol Test; HAD, Hospital and Anxiety; POMS, Profile of Mood States; NS, not significant.
**The higher score denotes worse functioning.*
***The higher score denotes better functioning.*
#The higher score denotes worse emotional state.
##The higher score denotes better emotional state.

Table 5 Body composition in different subgroups of medical students by vitamin D concentration

Parameter	Vitamin D deficiency (<12 ng/ml) n=29	Vitamin D insufficiency (12-20 ng/ml) n=22	Sufficient vitamin D (>20 ng/ml) n=8	P (Kruskal-Wallis test)
Body mass index, kg/m^2	23.3±2.9	24.1±2.7	24.3±1.9	NS
Fat body mass, kg	20.6±5.0	20.2±4.1	19.7±4.8	NS
Lean body mass, kg	62.2±6.6	62.8±6.4	61.6±10.0	NS
Water body mass, kg	44.8±4.7	45.3±4.6	44.3±7.1	NS

Values are given as mean ± standard deviation.

revealed a significant difference only in the mean score on the POMS confusion-bewilderment scale, indicating better emotional state in the subgroup with sufficient vitamin D level (Table 6). In military conscripts, analysis of the same features revealed a tendency toward a higher BMI and lower mean depression-dejection score for the subgroup with sufficient vitamin D level (Tables 7 and 8). Only the POMS confusion-bewilderment score showed a significant difference when the subgroups of military conscripts with different vitamin D levels were compared (Table 8).

Pearson correlation analysis demonstrated some significant correlations between vitamin D concentration and characteristics of body composition or psychological state (Table 9). Vitamin D concentration correlated positively with BMI in the entire sample of the study and in the group of military conscripts, and it correlated inversely with confusion-bewilderment, depression-dejection and anger-hostility scores in the group of medical students.

4. Discussion

The present study shows that the majority (89.4%) of the young healthy Lithuanian males participating in the study had vitamin D deficiency or insufficiency in winter. Only every tenth subject had sufficient vitamin D concentration. This confirms the findings of a number of studies carried out in other countries, especially in northern countries, during winter [16,28,29]; the exception is Norway and other Scandinavian countries, where a regular usage of cod-liver supplements and fish products in the diet is usual [30].

Table 6 Cognitive functioning and emotional state in different subgroups of medical students by vitamin D concentration

	Vitamin D deficiency (<12 ng/ml) n=29	Vitamin D insufficiency (12-20 ng/ml) n=22	Sufficient vitamin D (>20 ng/ml) n=8	P (Kruskal-Wallis test)
Cognitive functioning:				
Trail making A*	27.7±9.0	26.1±7.3	27.5±6.1	NS
Trail making B*	53.1±17.2	51.1±11.9	60.0±15.8	NS
DST forwards**	7.4±2.1	6.9±1.7	7.8±2.7	NS
DST backwards**	6.4±1.4	6.4±1.7	6.7±2.1	NS
DST raw score**	13.8±3.1	13.3±2.8	14.5±4.2	NS
Emotional state:				
HAD depression#	2.9±1.9	3.5±2.7	2.3±1.9	NS
HAD anxiety#	5.2±2.1	5.8±3.1	5.0±3.1	NS
POMS global score#	29.4±22.1	27.7±30.1	4.5±12.6	NS
POMS tension-anxiety#	7.6±4.1	7.1±5.3	5.5±2.5	NS
POMS depression-dejection#	11.7±7.1	11.7±8.4	4.2±3.6	NS
POMS anger-hostility#	13.9±7.6	12.6±7.1	8.2±3.1	NS
POMS vigor-activity##	18.6±4.7	18.4±5.8	19.2±0.5	NS
POMS fatigue-inertia#	10.1±4.5	10.6±4.6	6.2±3.3	NS
POMS confusion-bewilderment#	4.7±3.1	4.1±4.9	0.5±1.7	.011

Values are given as mean ± standard deviation.
DST, Digital Symbol Test; HAD, Hospital and Anxiety; POMS, Profile of Mood States; NS, not significant.
**The higher score denotes worse functioning.*
***The higher score denotes better functioning.*
#The higher score denotes worse emotional state.
##The higher score denotes better emotional state.

Our study showed a significant positive correlation between vitamin D concentration and BMI, contrary to the results of other studies where inverse correlations between vitamin D level and BMI [3] or fat mass [31] were detected. Kull et al. reported that BMI correlated with vitamin D status only in summer, and this association

Table 7 Body composition in different subgroups of military conscripts by vitamin D concentration

Parameter	Vitamin D deficiency (<12 ng/ml) n=30	Vitamin D insufficiency (12-20 ng/ml) n=35	Sufficient vitamin D (>20 ng/ml) n=6	P (Kruskal-Wallis test)
Body mass index, kg/m^2	22.3±3.7	22.9±3.5	27.0±4.7	.055
Fat body mass, kg	14.6±6.3	15.7±5.7	19.3±3.8	NS
Lean body mass, kg	62.6±10.3	64.6±9.5	72.2±16.4	NS
Water body mass, kg	44.7±7.6	46.2±6.8	52.0±11.8	NS

Values are given as mean ± standard deviation.

Table 8 Cognitive functioning and emotional state in different subgroups of military conscripts by vitamin D concentration

	Vitamin D deficiency (<12 ng/ml) n=30	Vitamin D insufficiency (12-20 ng/ml) n=35	Sufficient vitamin D (>20 ng/ml) n=6	P (Kruskal-Wallis test)
Cognitive functioning:				
Trail making A*	26.7±8.4	30.3±10.1	27.0±7.9	NS
Trail making B*	68.8±18.2	66.7±17.1	72.0±38.8	NS
DST forwards**	6.9±1.9	6.7±2.3	6.3±1.9	NS
DST backwards**	5.2±1.3	4.9±1.5	5.0±1.3	NS
DST raw score**	12.1±2.8	11.6±3.2	11.3±2.9	NS
Emotional state:				
HAD depression#	4.6±2.4	4.4±2.6	2.7±1.9	NS
HAD anxiety#	6.5±3.7	6.6±3.1	3.7±1.9	NS
POMS global score#	21.3±25.7	24.1±25.9	12.4±28.0	NS
POMS tension-anxiety#	6.7±5.1	7.0±5.2	3.4±4.4	NS
POMS depression-dejection#	10.0±9.0	10.4±7.7	6.8±6.9	.052
POMS anger-hostility#	9.0±6.4	9.9±5.8	11.2±9.5	NS
POMS vigor-activity##	14.5±5.1	15.2±4.5	16.6±1.1	NS
POMS fatigue-inertia#	6.9±4.7	8.1±5.1	5.6±5.1	NS
POMS confusion-bewilderment#	3.1±3.3	3.8±3.7	2.0±4.3	.032

Values are given as mean ± standard deviation.
DST, Digital Symbol Test; HAD, Hospital and Anxiety; POMS, Profile of Mood States; NS, not significant.
**The higher score denotes worse functioning.*
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#The higher score denotes worse emotional state.
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lost its significance in winter when adjusting for sun-exposure habits. This suggests that most probably it is not the weight *per se* that influences vitamin D status, but its effect on sun exposure [29]. The study by Liel et al. also reported that greater adiposity was associated with lower levels of vitamin D [32]. The most likely explanations are that fat tissue may limit bioavailability of vitamin D by reducing its entry into the circulation [32,33] and individuals with a higher BMI receive less sun exposure because they spend less time outside and expose less skin when they are outdoors [34] or that vitamin D is sequestered in fat tissue, thus reducing its entry into the circulation [32,33]. However, these data are from the studies that included obese subjects with higher than normal BMI. In our study, subjects had a normal BMI (average BMI, 23.0±3.8 kg/m^2). The most likely explanation of positive correlations between vitamin D concentration and BMI may be that the higher BMI means the greater skin surface that could receive sun exposure.

The main finding of our study is that the emotional state is worse in young healthy persons with lower vitamin D concentrations (tendency to depression-dejection and higher confusion-bewilderment score). This is similar to the results of other studies reporting that low vitamin D level is significantly associated with a higher depression score [35,36].

Contrary to the findings of other studies, no significant associations were found between vitamin D concentration and cognitive functions [1,36,37]. However, these studies enrolled mostly older adults, and the participants of our study were young healthy persons. The study conducted by McGrath et al. found no association between lower vitamin D levels and cognitive function [9].

It is well known that vitamin D activates receptors on neurons in regions implicated in the regulation of behavior, stimulates neurotrophin release, and protects the brain by buffering antioxidant and antiinflammatory defenses against vascular injury and improving metabolic and cardiovascular function [36]. Vitamin D exhibits

Table 9 Significant correlations between vitamin D concentration and parameters of body composition or psychological state

Group	Correlations between		r (Pearson test)	P (Pearson test)
All participants	Vitamin D concentration	Body mass index	.221	.012
Military conscripts	Vitamin D concentration	Body mass index	.253	.013
Medical students	Vitamin D concentration	POMS confusion-bewilderment	-.324	.017
	Vitamin D concentration	POMS depression-dejection	-.317	.021
	Vitamin D concentration	POMS anger-hostility	-.275	.046

functional attributes that may prove neuroprotective through antioxidative mechanisms, neuronal calcium regulation, immunomodulation, enhanced nerve conduction, and detoxification mechanisms. Compelling evidence supports a beneficial role for the active form of vitamin D in the developing brain as well as in adult brain function [37]. Data of studies on mice confirm that mutation of vitamin D receptors leads to the altering of emotional/anxiety states, but it does not play a major role in depression or in the regulation of some sensory and cognitive processes [38].

It is not clear whether possible alterations in the vitamin D endocrine system may be due to genetic/biologic or lifestyle factors or a combination of these [39].

The main limitation of our study was a relatively small sample size. However, our study can be considered as a pilot study. Other shortcomings should be mentioned: we did not evaluate the dietary and sun exposure history, outdoor time, physical activity, supplement use, socioeconomic state, or place of residence of the participants (urban or rural). In addition, no serum parathyroid hormone levels were assayed. These limitations will serve as guidelines for further investigations.

Despite these limitations, our study showed the vitamin D status in young healthy male residents of Lithuania in winter and the associations between vitamin D concentration and psychological state and body composition. These findings are necessary for a complex understanding of health-related well-being in young healthy persons.

In conclusion, almost half of young healthy males participating in the study were detected to have vitamin D deficiency in winter. Low vitamin D concentrations are associated with a worse emotional state. Ways to increase the serum vitamin D concentration include increased exposure to sunlight, vitamin D or fish oil supplementation, and increased intake of products that contain vitamin D. The strategy to effectuate these increases will differ according to country and population and should be the subject of further study. These studies should ideally include measures of health and psychological state and quality of life to support the need for this increase in serum vitamin D concentration.

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References

[1] McCann JC, Ames BN. Is there convincing biological or behavioral evidence linking vitamin D deficiency to brain dysfunction? FASEB J, 2008, 22, 982-1001

[2] Peterlik M, Cross HS. Vitamin D and calcium deficits predispose for multiple chronic diseases. Eur J Clin Invest, 2005, 35, 290-304

[3] Gannagè-Yared MH, Chedid R, Khalife S, Azzi E, Zoghbi F. Vitamin D in relation to metabolic risk factors, insulin sensitivity and adiponectin in young Middle-Eastern population. Eur J Endocrinol, 2009,160, 965-71

[4] Ernst B, Thurnheer M, Schmid SM, Wilms B, Schultes B. Seasonal variations in the deficiency of 25-hydroxyvitamin D(3) in mildly to extremely obese subjects. Obes Surg, 2009, 19, 180-3

[5] Wilkins CH, Scheline YI, Roe CM, Birge SJ, Morris JC. Vitamin D deficiency is associated with low mood and worse cognitive performance in older adults. Am J Geriatr Psychiatry, 2006, 14, 1032-40

[6] Oudshoorn C, Mattace-Raso FU, van der Velde N, Colin EM, van der Cammen J. Higher serum vitamin D_3 levels are associated with better cognitive test performance in patients with Alzheimer's disease. Dement Geriatr Cogn Disord, 2008, 25, 539-43

[7] Berk M, Sanders KM, Pasco JA, Jacka FN, Williams LJ, Hayles AL, et al. Vitamin D deficiency

may play a role in depression. Med Hypotheses, 2007, 69, 1316-9
[8] Basaran S, Guzel R, Coskun-Benlidayi I, Guler-Uysal F. Vitamin D status: effects on quality of life in osteoporosis among Turkish women. Qual Life Res, 2007, 16, 1491-9
[9] McGrath J, Scragg R, Chant D, Eyles D, Burne T, Obradovic D. No association between serum 25-hydroxyvitamin D_3 level and performance on psychometric test in NHANES III. Neuroepidemiology, 2007, 29, 49-54
[10] Hoogendijk WJ, Lips P, Dik MG, Deeg DJ, Beekman AT, Penninx BW. Depression is associated with decreased 25-hydroxyvitamin D and increased parathyroid hormone levels in older adults. Arch Gen Psychiatry, 2008, 65, 508-12
[11] Lansdowne AT, Provost SC. Vitamin D3 enhances mood in healthy subjects during winter. Psychopharmacology (Berl), 1998, 135, 319-23
[12] Armstrong DJ, Meenagh GK, Bickle I, Lee AS, Curran ES, Finch MB. Vitamin D deficiency is associated with anxiety and depression in fibromyalgia. Clin Rheumatol, 2007, 26, 551-4
[13] Sherman SS, Hollis BW, Tobin JD. Vitamin D status and related parameters in a healthy population: the effects of age, sex and season. J Clin Endocrinol Metab, 1990, 71, 405-13
[14] Budak N, Cicek B, Sahin H, Tutus A. Bone mineral density and serum 25-hydroxyvitamin D level: is there any difference according to the dressing style of the female university students. Int J Food Sci Nutr, 2004, 55, 569-75
[15] Poduje S, Sjerobabski-Masnec I, Ozanić-Bulić S. Vitamin D – the true and the false about vitamin D. Coll Antropol, 2008, 32(Suppl 2), 159-62
[16] Hintzpeter B, Mensink GB, Thierfelder W, Müller MJ, Schneidt-Navel C. Vitamin D status and health correlates among German adults. Eur J Clin Nutr, 2008, 62, 1079-89
[17] Manicourt DH, Devogelaer JP. Urban tropospheric ozone increases the prevalence of vitamin D deficiency among Belgian postmenopausal women with outdoor activities during summer. J Clin Endocrinol Metab, 2008, 93, 3893-9
[18] Binkley N, Krueger D, Gemar D, Drezner MK. Correlation among 25-hydroxyvitamin D assays. J Clin Endocrinol Metab, 2008, 93, 1804-8
[19] Ginde AA, Mansbach JM, Camargo CA Jr. Association between serum 25-hydroxyvitamin D level and upper respiratory tract infection in the Third National Health and Nutrition Examination Survey. Arch Intern Med, 2009, 169, 384-90
[20] Saintonge S, Bang H, Gerber LM. Implications of a new definition of vitamin D deficiency in a multiracial US adolescent population: the National Health and Nutrition Examination Survey III. Pediatrics, 2009, 123, 797-803
[21] Egan KM, Signorello LB, Munro HM, Hargraves MK, Hollis BW, Blot WJ. Vitamin D insufficiency among African-Americans in the southeastern United States: implications for cancer disparities (United States). Cancer Causes Control, 2008, 19, 527-35
[22] Zargar AH, Ahmad S, Masoodi SR, Wani AI, Laway BA, Shah ZA. Vitamin D status in apparently healthy adults in Kashmir Valley of Indian subcontinent. Postgrad Med J, 2007, 83, 713-6
[23] Pèrez-Llamas F, Lòpez-Contreros MJ, Blanco MJ, Lòpez-Azorin F, Zamora S, Moreiras O. Seemingly paradoxical seasonal influence on vitamin D status in nursing-home elderly people from a Mediterranean area. Nutrition 2008, 24, 414-20
[24] McNair O, Lorr M, Droppleman LF. EDITS Manual for the Profile of Mood States. San Diego (Calif.): Educational and Institutional Testing Service; 1992
[25] Zigmond AS, Snaith RP. The hospital anxiety and depression scale. Acta Psychiatr Scand, 1983, 67, 361-70
[26] Retain RM. A research program of the psychological effects of brain lesions in human beings. In: Ellis (ed.), International Review of research in mental retardation. New York: England Medical Center, 1977
[27] Wechsler D. WAIS-R Manual. New York: Psychological Corp. 1981
[28] Bruyère O, Malaise O, Neuprez A, Collette J, Reginster JY. Prevalence of vitamin D inadequacy in European postmenopausal women. Curr Med Res Opin, 2007, 23, 1939-44
[29] Kull MJr, Kallikorm R, Tamm A, Lember M. Seasonal variance of 25-(OH)vitamin D in the general population of Estonia, a Northern European country. BMC Public Health, 2009, 9, 22-30
[30] Burstad M, Alsaker E, Engelsen O, Aksnes L, Lund E. Vitamin D status of middle-aged women at 65-71 degrees N in relation to dietary intake and exposure to ultraviolet radiation. Public Health Nutr, 2004, 7, 327-35
[31] Moschonis G, Tanagra S, Koutisikas K, Nikolaidou A, Androutsos O, Manios Y. Association between serum 25-hydroxyvitamin D levels and body composition in postmenopausal women: the Postmenopausal Health Study. Menopause, 2009, 16, 701-7
[32] Liel Y, Ulmer E, Shary J, Hollis BW, Bell NH. Low circulating vitamin D in obesity. Calcif Tissue Int,

1988, 43, 199-201
[33] Wortsman J, Matsuoka LY, Then TC, Lu Z, Holick MF. Decreased bioavailability of vitamin D in obesity. Am J Clin Nutr, 2000, 72, 690-3
[34] Harris SS, Dawson-Hughes B. Reduced sun exposure does not explain the inverse association of 28-hydroxyvitamin D with percent body fat in older adults. J Clin Endocrinol Metab, 2007, 92, 3155-7
[35] Jorde R, Waterloo K, Saleh F, Haug E, Svartberg J. Neuropsychological function in relation to serum parathyroid hormone and serum 25-hydroxyvitamin D levels. The Tromsø study. J Neurol, 2006, 253, 464-703
[36] Cherniak EP, Troen BR, Florez HJ, Roos BA, Levis S. Some new food role of vitamin D in the mental health of older adults. Curr Psychiatry Rep, 2009, 11, 12-9
[37] Buell JS, Dawson-Hughes B. Vitamin D and neurocognitive dysfunction: preventing "D"ecline? Mol Aspects Med, 2008, 29, 415-22
[38] Minasyan A, Keisala T, Lou YR, Kalueff AV, Touhimaa P. Neophobia, sensory and cognitive functions, and hedonic responses in vitamin D receptor mutant mice. J Steroid Biochem Mol Biol, 2007, 104, 274-80
[39] Holvik K, Meyer HE, Søgaard AJ, Haug E, Falch JA. Pakistanis living in Oslo have lower serum 1,25-dihydroxyvitamin D levels but higher serum ionized calcium levels compared with ethnics Norwegians. The Oslo Health Study. BMC Endocrine Disorders, 2007, 7, 9-15