Journal of Dietary Supplements

ISSN: 1939-0211 (Print) 1939-022X (Online) Journal homepage: https://www.tandfonline.com/loi/ijds20

High Dose Vitamin D Supplementation Is Associated With a Reduction in Depression Score Among Adolescent Girls: A Nine-Week Follow-Up Study

Afsane Bahrami, Seyed Reza Mazloum, Shahrokh Maghsoudi, Davood Soleimani, Sayyed Saeid Khayyatzadeh, Soheil Arekhi, Arsalan Arya, Seyed Jamal Mirmoosavi, Gordon A. Ferns, Hamidreza Bahrami-Taghanaki & Majid Ghayour-Mobarhan

To cite this article: Afsane Bahrami, Seyed Reza Mazloum, Shahrokh Maghsoudi, Davood Soleimani, Sayyed Saeid Khayyatzadeh, Soheil Arekhi, Arsalan Arya, Seyed Jamal Mirmoosavi, Gordon A. Ferns, Hamidreza Bahrami-Taghanaki & Majid Ghayour-Mobarhan (2018) High Dose Vitamin D Supplementation Is Associated With a Reduction in Depression Score Among Adolescent Girls: A Nine-Week Follow-Up Study, Journal of Dietary Supplements, 15:2, 173-182, DOI: 10.1080/19390211.2017.1334736

To link to this article: https://doi.org/10.1080/19390211.2017.1334736

Published online: 31 Jul 2017.

JOURNAL OF DIETARY SUPPLEMENTS
2018, VOL. 15, NO. 2, 173–182
https://doi.org/10.1080/19390211.2017.1334736

Taylor & Francis
Taylor & Francis Group

ARTICLE

High Dose Vitamin D Supplementation Is Associated With a Reduction in Depression Score Among Adolescent Girls: A Nine-Week Follow-Up Study

Afsane Bahrami, PhD[a,b], Seyed Reza Mazloum, PhD[c], Shahrokh Maghsoudi, MSc[d], Davood Soleimani, PhD[e], Sayyed Saeid Khayyatzadeh, PhD[e], Soheil Arekhi, MD[b], Arsalan Arya, MD[b], Seyed Jamal Mirmoosavi, MD, PhD[f,g], Gordon A. Ferns, MD, DSc[h], Hamidreza Bahrami-Taghanaki, MD, PhD[g], and Majid Ghayour-Mobarhan, MD, PhD[i]

[a]Department of Modern Sciences and Technologies, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran; [b]Student Research Committee, Mashhad University of Medical Sciences, Mashhad, Iran; [c]Evidence-Based Care Research Center, Medical Surgical Nursing Department, School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran; [d]Department of Management Nursing, School of Nursing and Midwifery, Mashhad University of Medical Sciences, Mashhad, Iran; [e]Department of Nutrition, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, Iran; [f]Traditional Medicine Research Center, Sabzevar University of Medical Sciences, Sabzevar, Iran; [g]Complementary and Chinese Medicine, Persian and Complementary Medicine Faculty, Mashhad University of Medical Sciences, Mashhad, Iran; [h]Brighton & Sussex Medical School, Division of Medical Education, Falmer, Brighton, Sussex, UK; [i]Metabolic Syndrome Research Center, Mashhad University of Medical Sciences, Mashhad, Iran

ABSTRACT

Although vitamin D deficiency is known to be a risk factor for some psychological disorders, there have been few studies on the effects of vitamin D supplementation on their symptoms. Depression and aggression are common mental disorders and are associated with disability and disease burden. We aimed to evaluate the effectiveness of high-dose vitamin D supplementation on depression and aggression scores in adolescent girls. Nine hundred forty adolescent girls received vitamin D_3 at a dose of 50,000 IU/week for 9 weeks. Anthropometric parameters and blood pressure were measured using standard protocols at the baseline and at the end of the study. Depression score was evaluated using the Beck Depression Inventory–II and aggression was evaluated using the Buss-Perry Aggression Questionnaire at baseline and at the end of the study. Comparison among the four categories of depression score (normal, mild, moderate, and severe) revealed no significant differences in demographic and anthropometric parameters at baseline. After 9 weeks of vitamin D supplementation, there was a significant reduction on mild, moderate, and severe depression score. However, vitamin D supplementation had no significant effect on aggression score. Our results suggest that supplementation with vitamin D may improve depressive symptoms among adolescent girls, as assessed by questionnaire, but not aggression score. Formal, larger, randomized controlled studies are required to confirm this effect on cases with different degrees of depression.

KEYWORDS

adolescent; aggression; depression; mood disorders; vitamin D

CONTACT Majid Ghayour-Mobarhan ghayourm@mums.ac.ir Metabolic Syndrome Research Center, Mashhad University of Medical Sciences, Mashhad, Iran; Hamidreza Bahrami-Taghanaki BahramiHR@mums.ac.ir Complementary and Chinese Medicine, Persian and Complementary Medicine Faculty, Mashhad University of Medical Sciences, Mashhad, Iran.

Introduction

Depression and aggression are both common and important psychological disorders in the general population worldwide (Lopez, 2005). The prevalence of depression is comparatively low in childhood, but biological and social alterations through the course of adolescence may lead to a rise in its prevalence (Hankin et al., 1998; Lewinsohn et al., 1999). The high prevalence of violence and aggression among Iranian youth and adolescents is considered a warning sign to the social system. These disorders are also known to increase further during the pubertal transition and during pregnancy among adolescent girls (Ryan, Milis, & Misri, 2005). These problems among adolescents are a major cause of educational disruption and social problems such as substance misuse and suicide (Fletcher, 2010; Keenan-Miller, Hammen, & Brennan, 2007). The etiology of these mood disorders is multifactorial and involves complex interactions among genetic, biological, and environmental factors (Krishnan & Nestler, 2010). One potentially important environmental factor contributing to susceptibility is nutritional status. Various studies have demonstrated that nutritional insufficiency and deficiency of the vitamin B group (e.g., niacin and folate), minerals (e.g., zinc, selenium and iron), essential fatty acids, antioxidants, and vitamin D are associated with mental and mood disorders (Jacka et al., 2012; Skarupski et al., 2010). Recently, there has been increased interest in the role of vitamin D supplementation in behavioral disorders (Lopez, 2005).

Vitamin D is a steroid hormone that is made through dermal synthesis from sunlight or dietary intake. Recently, it has been found that vitamin D receptors and 1-α-hydroxylase enzyme are widely expressed in the central nervous system, including the limbic system, which has a key role in the control of behavior, emotions, and memory (Eyles et al., 2003; Lewis-Fernandez et al., 2005; McCann & Ames, 2008). In a large community-based study, Karakis et al. (2016) found that serum vitamin D was related to hippocampal size and neuropsychological function. Moreover, vitamin D may have an indirect effect on brain function, as vitamin D is crucial for muscle function (Bischoff-Ferrari, Orav, & Dawson-Hughes, 2006) and vitamin D supplementation could increase well-being and physical activity. Epidemiological data have shown an inverse association between serum vitamin D level and risk for mental disorders such as depression in adults (Ganji et al., 2010; Hoang et al., 2011; Stewart & Hirani, 2010). In a large prospective study, higher concentrations of 25-hydroxy vitamin D_3 were associated with lower levels of depression among children and early adolescents (Tolppanen et al., 2012). In adults, the efficacy of vitamin D supplementation in depression has been reported in several randomized controlled trials, but these results are inconsistent (Spedding, 2014). In contrast to the reports on the relation between the levels of vitamin D and depression, we did not find any reports that examine the association between aggressive behaviors and serum vitamin D (Bischoff-Ferrari, Orav, & Dawson-Hughes, 2006). There have been some inconsistent reports about anxiety and vitamin D status. Some of these studies failed to present any association between vitamin D deficiency and stress or anxiety (Black et al., 2014). Therefore, the purpose of the current trial was to evaluate the effectiveness of high-dose vitamin D supplementation on depression and aggression scores among adolescent girls.

Methods and materials

Study design and population

The current intervention was undertaken within the framework of the study on effects of vitamin D supplementation on different aspects of physical and mental health in adolescent

girls. Participants were selected using a cluster randomized sampling method from various regions within the cities of Mashhad and Sabzevar, Iran. The study protocol was approved by the Ethical Committee of Mashhad University of Medical Sciences, Iran. In the initial study, the consent forms were taken from all participants. This study was registered in the Iranian Registry of Clinical Trials website (IRCT no. 201509047117N7). In the screening phase, participants were screened according to the inclusion criteria. The inclusion criteria in this study were absence of any autoimmune diseases; cardiovascular diseases; metabolic bone disorders; thyroid, parathyroid, or adrenal diseases; hepatic failure; kidney diseases; malabsorption; or cancer. Participants taking anti-inflammatory, antidepressant, antidiabetic, or antiobesity drugs; vitamin D or calcium supplement; or hormone therapy within the past 6 months were excluded.

In the intervention phase, eligible individuals received a 50,000 IU soft-gel capsule vitamin D once a week for 9 weeks, in accordance with the guidelines by Holick et al. (2011). We requested that all participants not alter their physical activity levels, continue with their usual food intake, and not take any additional dietary supplements. Participants were requested to report any change in drug use and disease status during the trial. The adherence to the vitamin D supplementation was evaluated each week by a phone call or face-to-face interview.

Anthropometric and cardiac assessments

Anthropometric parameters were assessed using standard protocols in participants with light clothes and without shoes by trained paramedics at inclusion and at the end of the trial in health centers. Waist circumference (WC) was measured using a nonstretched tape measure (Seca, Hamburg, Germany) at the minimum circumference between the last rib and iliac crest. An electronic scale (Seca, Hamburg, Germany) was used to measure body weight to the nearest 0.1 kg after overnight fasting. For height assessment, a nonelastic tape measure (Seca, Hamburg, Germany) was used to measure to the nearest 0.1 cm. To calculate body mass index (BMI), we divided weight in kilograms by height in meters squared. For blood pressure measurement, the patients sat in a resting position for at least 5 minutes and then their systolic and diastolic blood pressures were measured two times in 5-min intervals using a digital sphygmomanometer (Omron M3, Kyoto, Japan).

Psychological assessment

The Persian version of the Beck Depression Inventory (BDI Persian) was used to assess depressive symptoms at inclusion and at the end of the study (Beck, Steer, & Brown, 1996). The BDI Persian was validated with high internal consistency (Cronbach's alpha = 0.87) and test-retest reliability (r = 0.74) among Iranian students (Mohammadi, 2006; Ju, Lee, & Jeong, 2013). The BDI is a self-report questionnaire with 21 items; each item has four statements. The participants choose the one out of four statements that the best describes their feelings and status within the past 2 weeks. In this scale, each item has a score between 0 (absence of any specific symptoms) and 3 (the highest degree of the presence of symptoms). The total BDI score range is 0–63; this is computed by summing all the values. From the total BDI score, depression status is stratified into four categories in this scale as follows: normal (score of 0–13); mild depression (score of 14–19); moderate depression (score of 20–28); severe depression (score of 29–63).

The Persian version of the Buss-Perry Aggression Questionnaire (BPAQ; 1992) was used to assess aggression at inclusion and at the end of the study (Motevalian et al., 2011; Kelishadi

et al., 2016). The BPAQ is a self-report questionnaire with 29 items comprising four subscales of aggressive disorder: physical aggression (9 items), verbal aggression (5 items), anger (7 items), and hostility (8 items). Validity of these questionnaires has been established among the Iranian population (Mohammadi, 2006).

Statistical analysis

A Kolmogrov-Smirnow test was used to compare normally distributed variables. We applied independent sample *t* test to compare demographic and anthropometric measurements in individuals with and without high aggression scores. One-way analysis of variance (one-way ANOVA) was also used to compare the demographic and anthropometric parameters of the study population in the depression categories. Scores for the BDI and BPAQ before and after vitamin D intervention were compared using Wilcoxon signed-rank tests. A p value $< .05$ was considered statistically significant. All statistical analyses were performed using Statistical Package for Social Sciences version 17 (SPSS Inc., Chicago, Illinois, USA).

Results

Among the cohort of 1,026 girls initially considered for inclusion, 988 fulfilled the inclusion criteria and participated in the intervention phase; 940 participants completed the intervention. Analyses were performed in all these participants (Figure 1). Baseline

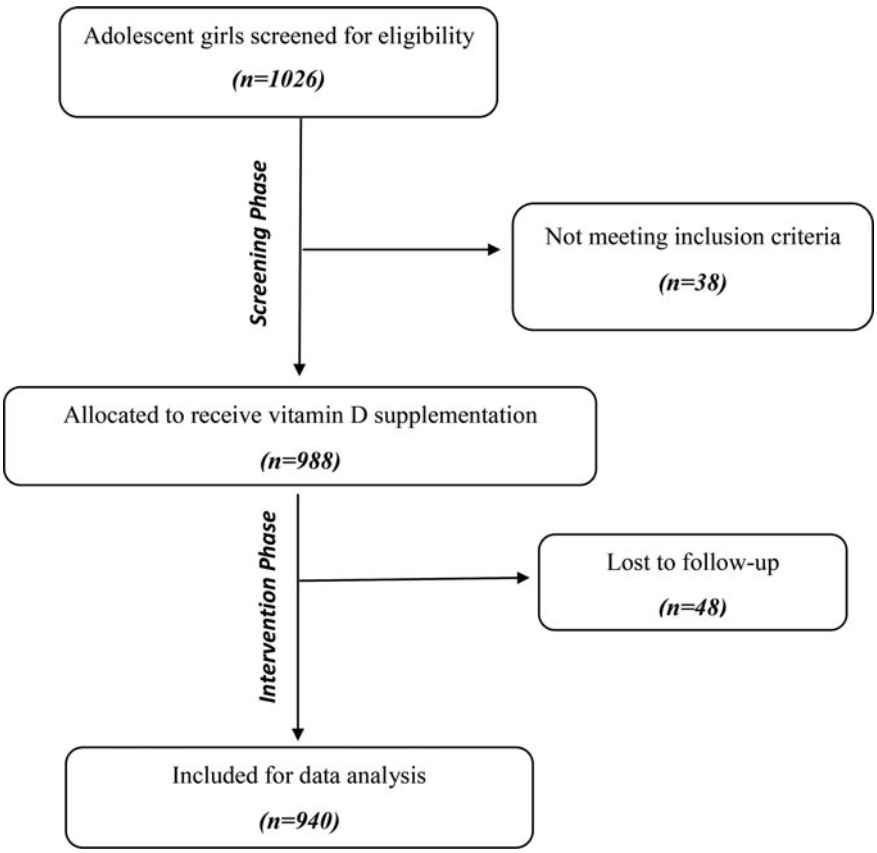

Figure 1. Flow diagram of study.

Table 1. Demographic and anthropometric characteristics of study participants.

Variable	Baseline value
Age, years	14.56 ± 1.53
Menstruation, *n* (%)	828 (88.1%)
Exposed to smoking, *n* (%)	305 (32.4%)
Weight, kg	52.88 ± 11.95
Height, cm	157.63 ± 6.19
BMI, kg/m^2	21.18 ± 4.3
WC, cm	70.42 ± 9.12
PA, MET/h/day	45.28 ± 3.58
SBP, mmHg	96.29 ± 14.19
DBP, mmHg	62.39 ± 13.36

BMI = body mass index; WC = waist circumference; PA = physical activity; SBP = systolic blood pressure; DBP = diastolic blood pressure. Data are expressed as mean ± standard deviation (*SD*).

characteristics of participants are described in Table 1. With respect to percentiles for the body mass index for age in Iranian children and adolescents (Kelishadi et al., 2016), 6.2% of the whole study population were underweight, while 13.6% of the whole study population had excess weight, of whom 3.7% were considered obese. The medians of physical, verbal, anger, and hostility aggression scores were 27, 16, 23, and 29, respectively.

The baseline characteristics of participants are shown separately for categories of depression status in Table 2. The comparison between these groups showed no significant differences in mentioned demographic characteristics at baseline. In addition, the linear regression analysis showed no significant association between total aggression score and these variables. The baseline demographic characteristics of participants are separately shown for aggressive and nonaggressive groups in Table 3. As presented in Table 3, the mean diastolic blood pressure in the nonaggressive group was significantly greater than that in the aggressive group. However, according to the linear regression analysis, there was no significant association between total aggression score and the aforementioned variable at baseline. However, we found a positive significant association between total depression score and total aggression score ($r = .39$, $p > .001$) at baseline study.

The effects of vitamin D supplementation on psychological assessment are shown in Table 4. There was a significant increase in the median serum 25 (OH) vitamin D concentrations (6.7 ng/mL at baseline vs. 35.5 ng/mL after intervention; $p > .001$). Elevated serum 25 (OH) vitamin D concentrations implied a good adherence of the whole study population to vitamin D supplementation. Although supplementation with vitamin D was associated with

Table 2. Demographics characteristic at baseline for categories of depression status.

	Depression severity				
Variable	Normal	Mild	Moderate	Severe	*p* value
Participants, *n* (%)	634 (67.4)	149 (15.8)	117 (12.4)	40 (4.3)	
Age, years	14.57 ± 1.52	14.53 ± 1.50	14.64 ± 1.61	14.43 ± 1.50	.865
Weight, kg	53.06 ± 11.82	51.76 ± 10.81	53.63 ± 14.54	51.24 ± 8.38	.431
Height, cm	157.58 ± 6.35	157.50 ± 5.65	158.57 ± 6.11	157.24 ± 5.67	.390
BMI, kg/m^2	21.29 ± 4.33	20.71 ± 3.86	21.22 ± 5.05	20.71 ± 2.88	.430
WC, cm	70.50 ± 9.07	69.63 ± 8.15	71.20 ± 10.84	69.38 ± 7.10	.456
PA, MET/h/day	45.39 ± 3.42	45.13 ± 3.57	45.68 ± 4.31	45.99 ± 4.02	.444
SBP, mmHg	96.72 ± 13.97	95.09 ± 14.46	95.50 ± 15.52	95.22 ± 12.19	.521
DBP, mmHg	63.12 ± 13.09	60.66 ± 15.15	61.34 ± 13.03	60.29 ± 11.43	.103

BMI = body mass index; WC = waist circumference; PA = physical activity; SBP = systolic blood pressure; DBP = diastolic blood pressure; *p* values were derived from one-way analysis of variance (ANOVA). Data are expressed as mean ± standard deviation (*SD*).

Table 3. Demographics characteristic at baseline between participants with low and high aggression scores.

Variable	Aggression[a]		*p* value
	No	Yes	
Participants, *n* (%)	470 (50%)	470 (50%)	
Age, years	14.61 ± 1.54	14.53 ± 1.51	.445
Weight, kg	52.75 ± 11.90	53.01 ± 12.04	.733
Height, cm	157.55 ± 5.89	157.81 ± 6.48	.518
BMI, kg/m^2	21.19 ± 4.38	21.16 ± 4.25	.924
WC, cm	70.32 ± 9.14	70.56 ± 9.12	.686
PA, MET/h/day	45.48 ± 3.67	45.33 ± 3.48	.513
SBP, mmHg	96.85 ± 14.58	95.61 ± 13.75	.189
DBP, mmHg	63.50 ± 13.85	61.16 ± 12.70	.007

BMI = body mass index; WC = waist circumference; PA = physical activity; SBP = systolic blood pressure; DBP = diastolic blood pressure; p values were derived from independent *t* test. Data are expressed as mean ± standard deviation (*SD*)
[a]Median used as cutoff.

a significant reduction in total depression score (8 [4–16] vs. 7 [2–14]; $p = .001$), the change in total aggression score was not significant.

Discussion

We have found that vitamin D supplementation may improve depression scores in adolescent girls. There is good evidence of an inverse relationship between serum vitamin D levels and the risk of depression (Ju, Lee, & Jeong, 2013). To our knowledge, this study was the first large clinical trial evaluating the effects of vitamin D supplementation on aggression and depression scores in adolescent girls.

Receiving a high-dose 50,000 IU-vitamin D for 8 weeks is suggested for vitamin D deficiency (Holick et al., 2012). In the current study, by providing vitamin D capsules (50,000 IU/week cholecalciferol for 9 weeks) serum levels of 25 (OH) D were increased significantly ($p = .001$) by the end of intervention compared to at the baseline 6.69 ng/mL (91 nmol/L). In addition, it is has been proposed that the health benefits of vitamin D are seen at a concentration of 75–100 nmol/L for serum 25 (OH) D (Bischoff-Ferrari, 2008).

The results of our intervention showed that vitamin D supplementation appeared to have a beneficial effect in reducing the total depression score obtained using the BDI-II questionnaire. Recently, randomized controlled trials (RCTs) have been published with inconsistent results. In a meta-analysis including nine RCTs in adults, vitamin D supplementation had no significant effect on depression (standardized mean difference = 0.28; $p = .19$). With subgroup analysis, the authors showed that vitamin D supplementation with longer duration (>8 weeks) compared to shorter duration (<8 weeks) had significant and favorable effects on depressive symptoms (Gowda et al., 2015). Another meta-analysis including seven RCTs

Table 4. Effects of vitamin D supplementation on depression and aggression scores.

Variable	Before	After	*p* value
Depression score			
Normal	5 (2–8)	4 (1–9)	.904
Mild	16 (15–18)	15 (9–18)	.002
Moderate	23 (21–26)	20 (11–24)	.001
Severe	33 (30.75–40.5)	26 (9–34)	.001
Aggression score	77.0 (63.0–93.0)	76.0 (62.0–93.0)	.188
25 (OH) vitamin D, (ng/mL)	6.69 (3.96–10.1)	35.45 (25.01–46.44)	.001

Data are expressed as median and interquartile range; *p* values were derived from Wilcoxon signed-rank test.

in adults showed vitamin D supplementation had promising effects on depressive symptoms for individuals with moderate and severe depression (standardized mean difference −0.60; $p = .046$), although the supplementation had no effect on depression score for individuals without depression (standardized mean difference −0.04; $p = .61$) (Shaffer et al., 2014). Because of these previous reports, we used subgroup analysis for severity of depression based on BDI-II categories. This subgroup analysis supports the beneficial effect of vitamin D supplementation in adolescent girls with mild, moderate, and severe depression. However, these results showed no beneficial effects for vitamin D in nondepressed adolescent girls. It is worth mentioning that we should consider the difference in dose of vitamin D, duration of intervention, study population (i.e., age and culture), and type of instruments used to assess depression, when comparing our results (Li et al., 2013). Therefore, there is good evidence that vitamin D deficiency has a role at least in cases with relevant depressive symptoms. Potential neuroendocrine and neurobiological mechanisms have been suggested for this link, including a key role of vitamin D in areas processing depressive mood of brain, in dopaminergic and serotoninergic function (Patrick & Ames, 2014), and in systemic inflammation being related to depression (Berk et al., 2013). There is some biological evidence for a causal contribution of vitamin D deficiency in depression; the findings of the present study suggest that vitamin D supplementation to decrease depressive symptoms for individuals without clinically significant depression may be effective.

We also found that the baseline diastolic blood pressure was different between participants with and without aggression. Nevertheless, according to the results obtained, there was no significant association between total aggression score and the aforementioned variable. In addition, we found that supplementation with vitamin D had no significant beneficial effect in reducing the total aggression score obtained from the Buss-Perry Aggression Questionnaire. To our best knowledge, there is no similar study in this context and age group to compare our results. However, in a recent study performed by Bičíková and coworkers (2015), levels of 25(OH)D3 were significantly lower in patients with anxiety disorders compared to the normal control group.

Studies show many aspects of metabolite function of vitamin D in the brain such as neuroprotection, immunomodulation, biosynthesis of neurotransmitters, and brain development (Garcion et al., 2002; Kalueff & Tuohimaa, 2007). Vitamin D is involved in endocrine, paracrine, and autocrine systems through vitamin D receptors (Morris & Anderson, 2010). The specific receptors of vitamin D and the key enzyme in the activation of vitamin D were detected in many areas of the human central nervous system, such as the limbic system, which has a key role in controlling behavior, emotions, and memory (Eyles et al. 2003; Eyles et al., 2005). Therefore, there is a biological plausibility supporting a causal role for vitamin D in controlling mood and behavior.

The main limitation of the present study was the absence of a placebo group for comparing with the intervention group. We could not have a placebo group because of ethical considerations. We also should mention several points as strengths of our study, such as a large sample size, a population-based study, subgroup analysis, and focus on a specific population.

Conclusion

In summary, our results indicate that vitamin D supplements at a dose of 50,000 IU once a week for 9 weeks can improve depression scores in adolescent girls. Further studies with a follow-up phase are necessary to identify the long-term effects of this vitamin on mood disorders.

Acknowledgment

This article was part of the PhD thesis (941524) of Afsane Bahrami. We are grateful to all study participants and their parents. We would like to acknowledge the management of Al-Zahra University for their contribution to this study. We also want to thank all the school personnel, students and their parents for their cooperation.

Declaration of interest

The authors declare no conflicts of interest. The authors alone are responsible for the content and writing of the article.

Funding

This study was funded by Mashhad University of Medical Sciences (Code: 941524, 931188), Sabzevar University of Medical Sciences, and Al-Zahra University.

About the authors

Afsane Bahrami is a PhD student of Molecular Medicine and has expertise in drug and vitamin analysis by HPLC. Also, she studies menstrual problems in adolescents.

Seyed Reza Mazloum has a PhD in Nursing Education.

Shahrokh Maghsoudi has an MSc in Nursing Education.

Davood Soleimani is a PhD student of Clinical Nutrition.

Sayyed Saeid Khayyatzadeh is a PhD student of Clinical Nutrition and is interested particularly in the effect of supplements on anthropometric parameters and performance.

Soheil Arekhi is an MD student and very active member of the student research committee. Her interest is in psychiatric disorder and evidence-based medicine.

Arsalan Arya is an MD student and very active member of the student research committee. Her research interests are in psychiatric disorders, nutrition and evidence-based medicine.

Seyed Jamal Mirmoosavi has an MD and a PhD in Chinese Medicine. He is a Vice Chancellor of Health State of Sabzevar University of Medical Sciences.

Gordon A. Ferns has a DSc, MD, MRCS, FRCP, FRCPath, EuSpLM, FRSA, and SFHEA. He is a professor of Medical Education and Metabolic Medicine and Head of the Department of Medical Education, Brighton and Sussex Medical School.

Hamidreza Bahrami-Taghanaki has an MD, MPH, and PhD in Chinese Medicine. He is an associate professor of Chinese Medicine and Vice Chancellor of Health State of Mashhad University of Medical Sciences. His research interests are in acupuncture in pain and psychiatry, medical education, family physician, and public health.

Majid Ghayour-Mobarhan has an MD and PhD in Nutrition. He is a full Professor of Clinical Nutrition, Director of the Department of New Sciences and Technology and the founding member of Cardiovascular Research Center, Mashhad, Iran. His research interest is in atherosclerosis, from laboratory science to clinical studies.

References

Beck AT, Steer RA, Brown GK. Beck depression inventory. Manual for the Beck Depression Inventory-II. San Antonio, TX: Psychological Corporation, 1996.

Berk M, Williams LJ, Jacka FN, O'Neil A, Pasco JA, Moylan S, et al. So depression is an inflammatory disease, but where does the inflammation come from? BMC Med. 2013;11(1):200.
Bicíková M, Dusková M, Vítku J, Kalvachová B, Ripova D, Mohr P, et al. Vitamin D in anxiety and affective disorders. Physiol Res. 2015;64:S101.
Bischoff-Ferrari HA. Optimal serum 25-hydroxyvitamin D levels for multiple health outcomes. In: J. Reichrath (ed.), Sunlight, Vitamin D and Skin Cancer. Adv Exp Med Biol. 2008;624:55–71.
Bischoff-Ferrari HA, Orav EJ, Dawson-Hughes B. Effect of cholecalciferol plus calcium on falling in ambulatory older men and women: a 3-source randomized controlled trial. Arch Intern Med. 2006;166(4):424–430.
Black LJ, Jacoby P, Allen KL, Trapp GS, Hart PH, Byrne SM, et al. Low vitamin D levels are associated with symptoms of depression in young adult males. Aust N Z J Psychiatry. 2014;48(5):464–471.
Eyles D, Brown J, Mackay-Sim A, McGrath J, Feron F. Vitamin D 3 and brain development. Neuroscience. 2003;118(3):641–653.
Eyles DW, Smith S, Kinobe R, Hewison M, McGrath JJ. Distribution of the vitamin D receptor and 1α-hydroxylase in human brain. J Chem Neuroanat. 2005;29(1):21–30.
Fletcher JM. Adolescent depression and educational attainment: results using sibling fixed effects. Health Econ. 2010;19(7):855–871.
Ganji V, Milone C, Cody MM, McCarty F, Wang YT. Serum vitamin D concentrations are related to depression in young adult US population: the Third National Health and Nutrition Examination Survey. Int Arch Med. 2010;3(1):29.
Garcion E, Wion-Barbot N, Montero-Menei CN, Berger F, Wion D. New clues about vitamin D functions in the nervous system. Trends Endocrinol Metab. 2002;13(3):100–105.
Gowda U, Mutowo MP, Smith BJ, Wluka AE, Renzaho AM. Vitamin D supplementation to reduce depression in adults: meta-analysis of randomized controlled trials. Nutrition. 2015;31(3):421–429.
Hankin BL, Abramson LY, Moffitt TE, Silva PA, McGee R, Angell KE. Development of depression from preadolescence to young adulthood: emerging gender differences in a 10-source longitudinal study. J Abnorm Psychol. 1998;107(1):128.
Hoang MT, DeFina LF, Willis BL, Leonard DS, Weiner MF, Brown ES. Association between low serum 25-hydroxyvitamin D and depression in a large sample of healthy adults: the Cooper Center longitudinal study. Mayo Clin Proc. 2011;86(11):1050–1055.
Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP, et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. J Clin Endocrinol Metab. 2011;96(7):1911–1930.
Holick MF, Binkley NC, Bischoff-Ferrari HA, Gordon CM, Hanley DA, Heaney RP, et al. Guidelines for preventing and treating vitamin D deficiency and insufficiency revisited. J Clin Endocrinol Metab. 2012;97(4):1153–1158.
Jacka FN, Maes M, Pasco JA, Williams LJ, Berk M. Nutrient intakes and the common mental disorders in women. J Affective Disord. 2012;141(1):79–85.
Ju S-Y, Lee Y-J, Jeong S-N. Serum 25-hydroxyvitamin D levels and the risk of depression: a systematic review and meta-analysis. J Nutr Health Aging. 2013;17(5):447–455.
Kalueff AV, Tuohimaa P. Neurosteroid hormone vitamin D and its utility in clinical nutrition. Curr Opinion Clin Nutr Metab Care. 2007;10(1):12–19.
Karakis I, Pase MP, Beiser A, Booth SL, Jacques PF, Rogers G, et al. Association of serum vitamin D with the risk of incident dementia and subclinical indices of brain aging: The Framingham Heart Study. J Alzheimer's Dis. 2016;51(2):451–461.
Keenan-Miller D, Hammen CL, Brennan PA. Health outcomes related to early adolescent depression. J Adolesc Health. 2007;41(3):256–262.
Kelishadi R, Qorbani M, Hosseini M, Bahreynian M, Djalalinia S, Motlagh ME, et al. Percentiles for anthropometric measures in Iranian children and adolescents: the CASPIAN-IV study. J Pediatr Endocrinol Metab. 2016;29(9):1069–1076.
Krishnan V, Nestler EJ. Linking molecules to mood: new insight into the biology of depression. A J Psychiatry. 2010;167(11):1305–1320.
Lewinsohn PM, Rohde P, Klein DN, Seeley JR. Natural course of adolescent major depressive disorder: I. Continuity into young adulthood. J Am Acad Child Adolesc Psychiatry. 1999;38(1):56–63.

Lewis-Fernandez R, Das AK, Alfonso C, Weissman MM, Olfson M. Depression in US Hispanics: diagnostic and management considerations in family practice. J Am Board Fam Pract. 2005;18(4):282–296.

Li G, Mbuagbaw L, Samaan Z, Falavigna M, Zhang S, Adachi JD, et al. Efficacy of vitamin D supplementation in depression in adults: a systematic review. J Clin Endocrinol Metab. 2013;99(3):757–767.

Lopez AD. The evolution of the Global Burden of Disease framework for disease, injury and risk factor quantification: developing the evidence base for national, regional and global public health action. Global Health. 2005;1(1):5.

McCann JC, Ames BN. Is there convincing biological or behavioral evidence linking vitamin D deficiency to brain dysfunction? FASEB J. 2008;22(4):982–1001.

Mohammadi N. [Primary survey of psychometric index of Buss-Perry questionnaire] in Persia. J Human Soc Sci Shiraz University, Iran. 2006;25(4):16 (in Farsi).

Morris HA, Anderson PH. Autocrine and paracrine actions of vitamin D. Clin Biochem Rev. 2010;31(4):129–138.

Motevalian SA, Asadi-Lari M, Rahimi H, Eftekhar M, editors. Validation of a Persian version of motorcycle rider behavior questionnaire. Ann Adv Automot Med. 2011;55:91–98.

Patrick RP, Ames BN. Vitamin D hormone regulates serotonin synthesis. Part 1: relevance for autism. FASEB J. 2014;28(6):2398–2413.

Ryan D, Milis L, Misri N. Depression during pregnancy. Can Fam Physician. 2005;51(8):1087–1093.

Shaffer JA, Edmondson D, Wasson LT, Falzon L, Homma K, Ezeokoli N, et al. Vitamin D supplementation for depressive symptoms: a systematic review and meta-analysis of randomized controlled trials. Psychosom Med. 2014;76(3):190.

Skarupski KA, Tangney C, Li H, Ouyang B, Evans DA, Morris MC. Longitudinal association of vitamin B-6, folate, and vitamin B-12 with depressive symptoms among older adults over time. Am J Clin Nutrit. 2010;92(2):330–235.

Spedding S. Vitamin D and depression: a systematic review and meta-analysis comparing studies with and without biological flaws. Nutrients. 2014;6(4):1501–1518.

Stewart R, Hirani V. Relationship between vitamin D levels and depressive symptoms in older residents from a national survey population. Psychosom Med. 2010;72(7):608–612.

Tolppanen AM, Sayers A, Fraser WD, Lewis G, Zammit S, Lawlor DA. The association of serum 25-hydroxyvitamin D3 and D2 with depressive symptoms in childhood—a prospective cohort study. J Child Psychol Psychiatry. 2012;53(7):757–766.