International Journal of Medicine and Medical Research
2018, Volume 4, Issue 2, p. 24-30

DOI 10.11603/IJMMR.2413-6077.2018.2.9694

PREVALENCE AND RISK FACTORS FOR VITAMIN D DEFICIENCY IN OVERWEIGHT AND OBESE ADOLESCENTS IN UKRAINE

A-M. A. Shulhai, H. A. Pavlyshyn
I. HORBACHEVSKY TERNOPIL STATE MEDICAL UNIVERSITY, TERNOPIL, UKRAINE

Background. *Vitamin D affects the function of many organs and systems. Lipid metabolism disorder is established to be one of the risk factors for vitamin D deficiency, and the amount of adipose tissue is crucial.*

Objective. *The aim of the study was to determine the prevalence and risk factors for vitamin D deficiency in overweight and obese adolescents.*

Methods. *146 children with excessive weight and obesity as well as 63 healthy children with normal body weight were examined. In the study groups, there were no children taking vitamin D. Vitamin D status was evaluated by the level of 25(OH)D in blood serum. Vitamin D deficiency was diagnosed at the level of 25(OH)D between 20 and 29 ng/ml, and significant deficiency – below 20 ng/ml, normal calcidiol content was 30-100 ng/ml.*

Results. *The average level of 25(OH)D in the adolescents with normal body weight was 19.76±4.28 ng/ml, in the adolescents with excessive body weight – 15.24±3.47 ng/ml, and in the obese children – 13.87±2.71 ng/ml. The prevalence of vitamin D deficiency in the overweight adolescents was 70.62%, and in the adolescents with obesity – 77.19%.*

Conclusions. *Vitamin D deficiency is prevalent in the adolescents with overweight and obesity. To prevent the development of hypovitaminosis and vitamin D deficiency, it is necessary to carry out educational activities with adolescents for promotion of healthy lifestyle and healthy food, as well as to develop an optimal program for improving vitamin D status in the obese children.*

KEY WORDS: **vitamin D; children; calcidiol; prevalence; obesity**.

Introduction

Vitamin D, due to the biological properties of its derivatives, affects the function of many organs and systems. Vitamin D deficiency leads to a decrease in calcium concentration in blood, impairment of calcium and phosphorus absorption in intestines and kidneys because of its active metabolite 1.25-dihydroxyvitamin D [1]. It has been proved that vitamin-D endocrine system affects electrolytes concentration, cell proliferation, angiogenesis, stimulation of insulin synthesis, inhibition of renin secretion [2, 3, 4].

The presence of interconnections between calcidiol level as well as lipid and carbohydrate metabolism in children [5, 6] has been established. Moreover, special attention is paid by the researchers to the development of cardiometabolic risk factors and their relations with the concentration of calcium in blood and levels of parathyroid hormone in cases of vitamin D deficiency [7, 8].

The period of puberty is characterized by a rapid, peak increase in bone and muscle mass, and requires higher calcium and phosphorus intake, and, therefore, maintenance of proper levels of vitamin D metabolites in blood plasma [9]. However, adolescents frequently suffer from hypovitaminosis D and are characterized by increased tendency towards a sedentary lifestyle, spending much time at a computer or in front of the TV [10]. Leading a sedentary lifestyle in such children reduces the time spent in sunlight and outdoors, which is a direct risk factor for obesity and vitamin D deficiency [1].

Investigating metabolic abnormalities in children of different ages, researchers identified inverse relationship between vitamin D levels and metabolic factors, in particular, insulin resistance, body mass index, triglyceride levels and total testosterone, and direct relationship with insulin sensitivity [11].

It is established that lipid metabolism disorder is one of the risk factors for vitamin D deficiency, and the amount of adipose tissue is crucial in its metabolism and biological significance [12]. Numerous clinical studies have proved that for those suffering from obesity,

Corresponding author: Anna-Maria Shulhai, Department of Pediatrics No. 2, I. Horbachevsky Ternopil State Medical University, 1 Maydan Voli, Ternopil, 46001, Ukraine
E-mail: shulhai_aa@tdmu.edu.ua
Phone number: +380972171870

vitamin D intake should be 2-3 times higher than for those with normal body weight. There is a pathogenetic connection between obesity and vitamin D deficiency, since vitamin D is a fat-soluble substance, distributed in the adipose tissue, which leads to decrease in its concentration in plasma [13].

Moreover, attention is drawn to the fact that with the increase in the amount of adipose tissue there is a limitation of the bioavailability of vitamin D, which is associated with its engulfment by adipocytes and deposition in the adipose tissue. Thus, Spanish researchers have established existing relations between low-level serum concentration of 25(OH)D with high triglyceride levels regardless of age, sex, body mass index and physical activity [14].

Childhood obesity is an important public health problem. In Ukraine, 12% of children aged 7 to 17 years old suffer from excessive weight [15], among which about 10% are diagnosed with obesity by body mass index. Moreover, the number of obese children has a positive annual increasing rate.

Taking into consideration the increase in the number of overweight and obese adolescents in Ukraine, it has become necessary to determine the prevalence of vitamin D deficiency among the overweight and obese adolescents and to identify the main factors affecting the vitamin D status of such children.

The aim of the research is to determine the prevalence and risk factors for vitamin D deficiency in the adolescents with excessive weight and obesity.

Methods

The research was conducted in the period of 2016-2018 at the Communal Institution of the Ternopil Regional Council "Ternopil Regional Children Clinical Hospital". The Patient Safety Rules and the Ethical Standards and Procedures for Research Involving Human Beings (2000) have been followed in carrying out the study. In all cases, informed consent has been obtained from the patients and/or their parents.

The research involved on 146 adolescents (78 boys and 68 girls) aged 12 to 17 years old, which, depending on the body mass index (BMI), were divided into two groups: the overweight children and the obese children. The adolescent age of each child was determined according to the Tanner scale (2-5 stages) [5, 12]. The control group consisted of 63 healthy children aged 12-17 years old, who lived in the city of Ternopil and sought medical consultations for various reasons and chronic diseases. None of the causes of seeking medical help and disease affected their growth, body structure, nature of nutrition, physical activity. The experimental groups did not include children, whose obesity was due to endocrine diseases (hypothyroidism, hypercorticism, hypopituitarism, traumas of hypothalamic-pituitary area), taking antiepileptic drugs or glucocorticoids.

All children were Ukrainian (Caucasians) and lived in Ternopil region, Ukraine. In anthropometric studies, body height and weight were determined, and BMI was calculated according to the formula (mass (kg)/height^2 (m^2)).

Anthropometric examinations: body weight (within the accuracy of 0.1 kg), height (within the accuracy of 0.1 cm), were carried out by the established methods by means of floor weight, height meter and flexible centimeter tape. BMIs were evaluated according to standard percentile tables [5, 14]. Thus, children with BMI from 15 to 85 percentiles were assigned to have normal body mass, the excessive body mass corresponded to 85-95 percentiles and over 95 percentiles – to obesity.

To determine the factors affecting vitamin D status, the children were asked to fill in a questionnaire, which included data that ascertained the age of the child, sex, place of residence (city or village), the season of the questionnaire (November-March, April-October), income per family member (above or below the average living wage), daily milk consumption (up to 1 cup per day, from 1 to 3 cups and more), the use of vitamin D supplements, fish oil, the state of physical activity, which was determined by the number of active hours per week (up to 2 hours, from 2 to 5 hours, more than 5 hours), the duration of the daily stay in the open air (up to 30 minutes, more than 30 minutes), passive rest in front of the computer or TV (up to 2 hours per day, 2-4 hours per day, more than 4 hours per day).

Vitamin D status was determined according to the level of 25(OH)D in blood serum. For this, fasting blood test from the vein was taken. By centrifugation, serum was isolated, frozen and stored at -80 °C. The level of calcidiol was determined by the immunoassay method using 25-OH Vitamin D ELISA test kit (EUROIMMUN, Germany), with an intra-assay CV 3.2-4.9% and an inter-assay CV 4.0-7.8%. An assessment of the results of 25(OH)D level was conducted according to the recommendations of the International Society of Endocrinology (2011) [12]. Vitamin D insufficiency was established at a level of calcidiol ranging 20-29 ng/ml (50-75 nmol/l), vitamin D deficiency was established at 25(OH)D below 20 ng/ml (less 50 nmol/l), the normal calcidiol level was at 25(OH)D 30-100 ng/ml (76-250 nmol/l). The content of 25(OH)D above 100 ng/ml (250 nmol/l) was considered to be excessive.

The attained results of the research were subjected to statistical processing. Descriptive statistics was used to evaluate the concentration of calcidiol in serum and to determine the weight-height ratios of BMI. The level of calcidiol in serum was presented in the form of mean values and their standard errors. The comparison of frequency indices in the study groups was carried out using the Wilcoxon signed-rank test for continuous variables and the chi-square test, or the Fisher's exact test for categorical variables. The comparison of mean values and their standard errors in different study groups with their accurate distribution was performed by the Student's t-test for independent samples, and if distribution of the values is not normal the nonparametric Mann–Whitney U test was used.

The multiple logistic regression was used to determine the effect of each independent variable of the probable risk factor in the development of a 25(OH)D deficiency in the adolescents with obesity. All statistical studies were conducted using SPSS (Statistical Package for Social Sciences) for Windows software 21.0 version. The differences between the values were statistically significant at $p<0.05$.

Results

The research has established low levels of 25(OH)D in serum. In the adolescents with normal body weight, the mean values of 25(OH)D were 19.76±4.28 ng/ml, in the adolescents with overweight – 15.24±3.47 ng/ml, and in the children with obesity – 13.87±2.71 ng/ml.

The results of the study of 25 (OH) D levels, depending on the body mass index, are presented in Table 1.

Vitamin D status in the adolescent children of 25(OH)D in most cases was manifested by its deficiency. In the adolescents with normal body weight, in blood serum of 14.32% of the children the level of 25(OH)D remained within the normal levels and in 29.46% was deficient.

The highest deficiency rate of vitamin D was determined in the adolescents with obesity, which prevailed with a significant difference in comparison with the incidence of vitamin D deficiency ($p=0.022$) in the control group of adolescents with normal body weight.

It has been confirmed that with the increase in BMI, a simultaneous increase in the proportion of vitamin D deficiency and a decrease in the proportion of individuals with normal levels and insufficiency of calcidiol was observed.

According to the results of statistical processing of the children's answers in the questionnaire, the frequency of manifestations of the main risk factors with underlying vitamin D deficiency in the adolescents with normal body weight, overweight and obesity has been established. The predicted risk factors for vitamin D deficiency development among the study groups, depending on the body mass index, are presented in Table 2.

Actual data have established that sex and place of residence do not have a significant impact on the prevalence of vitamin D deficiency in the adolescents with overweight and obesity. The frequency of diagnosis of vitamin D deficiency is more common in the adolescent boys with obesity, which was 42.2% ($p=0.193$). Other factors that strongly influenced the significantly greater prevalence of vitamin D were: the season of blood serum collection from November to March, low income per family member, daily milk consumption, failing to take vitamin D supplements or fish oil, low physical activity, spending much time at the computer or in front of the TV. The time spent in the open air, both with overweight ($p=0.448$) and obesity ($p=0.417$), had no effect on the incidence of vitamin D deficiency in the adolescents. For the adolescents with overweight, the duration of physical activity during the week did not influence a reliable dependence on low levels of calcidiol ($p=0.450$).

Table 1. Level of 25(OH)D in adolescents depending on the body mass index (%)

Level 25(OH)D, ng/ml	Normal body weight, (%) p=63	Excessive body weight, (%) n=68	Obesity, (%) n=78
30-100	14.32	6.75	3.83
20-29	29.46	22.61	19.17
<20	57.35	70.72	77.19*

Notes. * – significant difference between the values compare to the group with normal body weight ($p<0.05$).

Table 2. Frequency of manifestations of risk factors in the adolescents with deficiency of 25(OH)D depending on BMI % (95% CI)

Characteristics		Specific proportion of the children with deficiency 25(OH)D n the study group, % (95% CI)					
		Normal body weight, n=63	p	Excess body weight, N=68	p	Obesity, N=78	p
Sex			0.184		0.481		0.193
	men	36.1 (25.4-50.8)		40.2 (31.4-49.3)		42.2 (31.2-53.1)	
	women	25.0 (17.5-37.2)		31.3 (22.5-42.1)		35.9 (26.9-43.6)	
Place of residence			0.569		0.725		0.515
	rural areas	27.2 (18.3-36.5)		34.8 (24.1-46.2)		35.5 (24.3-46.4)	
	city	31.9 (22.7-46.3)		39.7 (27.9-48.1)		43.6 (34.9-51.7)	
Season			0.026		0.035		0.002
	April-October	18.6 (9.1-27.7)		29.4 (19.1-41.3)		26.2 (20.5-35.9)	
	November-March	41.3 (32.5-53.1)		44,1 (36.8-54.2)		52.8 (44.6- 61.1)	
Income per family member			0.019		0.032		0.006
	Above the average	15.7 (10.5-25.6)		20.5 (10.2-31.8)		28.8 (22.1-38.5)	
	Below the average	41.0 (31.6-45.9)		48.5 (36.8-61.3)		50.6 (43.4-59.5)	
Milk consumption			0.035		0.003		0.001
	Up to 1 cup per day	37.7 (26.1-44.6)		50.6 (40.2-62.5)		60.5 (51.3-69.8)	
	From 1 to 3 cups a day and more	20.8 (11.4-29.7)		20.1 (10.8-31.4)		19.8 (14.1-29.5)	
Use of vitamin D (fish oil) supplements			0.178		0.002		0.001
	yes	23.4 (12.9-32.3)		20.3 (11.8-30.9)		14.2 (7.8-23.9)	
	no	32.5 (23.8-44.2)		52.4 (42.6-67.6)		62.1 (53.8-70.2)	
Physical activity			0.198		0.450		0.001
	Up to 2 hours/week	21.2 (12.7-30.4)		30.9 (20.6-41.2)		48.7 (39.2-57.8)	
	From 2 to 5 hours per week	22.8 (14.3-31.5)		21.5 (14.7-33.8)		17,9 (11.5-25.6)	
	More than 5 hours per week	12.3 (6.3-22.8)		19.1 (11.8-32.4)		12.8 (6.4-20.5)	
Daily stay in the open air			0.251		0.484		0.417
	Up to 30 min/day	34.5 (23.8-45.3)		29.3 (20.8-38.2)		41.9 (30.6-50.1)	
	More than 30 min/day	23.0 (17.5-34.9)		41.2 (32.9-50.4)		35.5 (28.2-44.3)	
Time spent at the computer or in front of the TV			0.059		0.034		0.001
	Up to 2 hours/day	9.3 (4.8-19.2)		12.2 (6.8-22.1)		14.4 (9.3-21.8)	-
	From 2 to 4 hours/day	21.3 (12.7-33.2)		25.9 (17.5-38.4)		28.8 (23.1-36.5)	-
	More than 4 hours/day	28.2 (19.4-39.3)		35,3 (23.5-46.2)		45.4 (36.2-56.4)	

According to the results of the multiple logistic regression analysis, it has been found out that factors affecting the development of vitamin D deficiency include excessive body weight and obesity (Table 3). Moreover, in the presence of this factor, the likelihood of vitamin D deficiency increases in 1.54 times.

In addition, a significant effect on the development of vitamin D deficiency is due to winter-spring season of the study (p=0.002), low income per family member (p=0.015), low daily milk consumption (p=0.032), physical activity up to 2 hours per week (p=0.042) and more than 4 hours a day spent at the computer

PEDIATRICS

Table 3. Logistic regression analysis of probable risk factors for vitamin 25(OH)D deficiencies

Risk Factor	B (SE)	OR	CI 95%	p
Sex (men versus women)	-0.14 (1,05)	0.87	0.11-6.82	0.869
Place of residence (city versus rural areas)	0.16 (0.48)	1.07	0.39-2.18	0.156
Season (November-March versus April-October)	1.29 (0.55)	2.74	1.05-7.38	0.002
Income per family member (below the average versus above the average)	2.08 (1.17)	1.31	0.52-6,14	0.015
Milk consumption (up to 3 cups or more versus up to 1 cup)	-1.54 (0.95)	0.67	0.24-0.93	0.032
The use of vitamin D supplements (fish oil) (no versus yes)	0.91 (1.07)	1.46	0.31-5.79	0.698
Physical activity				
Up to 2 hours/week versus more than 5 hours/week	1.36 (0.42)	1.61	0.83-3.45	0.042
2 to 5 hours/week versus more than 5 hours/week	0.48 (0.76)	1.01	0.45-2.15	0.253
Daily stay outdoors				
Up to 30 minutes/day versus more than 30 minutes/day	-0.72 (0.93)	0.89	0.24-2.09	0.062
Time spent at the computer or in front of the TV				
2 to 4 hours/day versus 2 hours/day	0.32 (0.83)	1.27	0.28-7.03	0.720
More than 4 hours/day versus 2 hours/day	0.27 (0.69)	1.91	0.35-8.46	0.027
Excessive weight, obesity	0.43 (0.85)	1.54	0.37-3.02	0.012

or TV (p=0.027). Along with this, it has been found out that sex (p = 0.869), place of residence (p=0.156), taking of vitamin D supplements, fish oil (p = 0.698), daily outdoor exposure (p=0.062) have no significant effect on the development of vitamin D deficiency in the children with overweight and obesity.

Discussion

The results of the study have proved that the prevalence of vitamin D deficiency in the adolescents is significant as in many other countries [2, 3, 12]. It has been established that there is an inverse relationship between the level of 25(OH)D in blood serum and the body mass index in the adolescents. In cases of excessive body weight, the frequency of diagnosing vitamin D deficiency increased in 1.23 times, and with obesity – by 1.35 times. The mean serum calcidiol content in blood serum of the adolescents with obesity was 1.43 times lower than that of the children with normal body weight. The data attained during the study showed a similar trend of change in the status of vitamin D in the children of different ages according to the results of epidemiological studies in Ukraine but were lower compared with the data of the studies in the USA, Spain, and Italy [5, 9]. Researchers explain the low levels of 25 (OH) D in blood serum by depositing calcidiol in the adipose tissue, reducing bioavailability, and reducing its synthesis under the influence of ultraviolet rays [14].

According to the results of the conducted studies, it has been established that the prevalence of vitamin D deficiency in the adolescents with obesity and overweight is unrelated to sex and place of residence. The latter were also not recognized as probable risk factors for vitamin D deficiency. However, according to Spanish pediatric school [5], vitamin D deficiency was more often reported during puberty in obese girls.

Via the multiple logistic regression analysis, it has been established that the degree of influence of independent predictors do affect development of vitamin D deficiency in the adolescents with obesity and overweight. It has been proved that the greatest influence is exerted by the season of blood collection in the period of November-March, in which the probability of development of vitamin D deficiency increases in 2.74 times compared with the April-October season. The amount of time spent at the computer and watching TV more than 4 hours a day increases the chances of vitamin D deficiency development in 1.91 times and, together with low physical activity, belongs to the three main independent variables in the development of vitamin D deficiency in the adolescents with obesity and overweight. Research results also indicate that the daily milk consumption of up to 3 cups or more reduces development of vitamin D deficiency in 1.49 times compared with the adolescents, who do not consume or consume up to 1 cup of milk per day. Our data support the results of studies conducted by the scientists from other countries [8, 10] concerning the degree of insufficiency or deficiency of vitamin D caused by the above-mentioned risk factors.

For a comparative assessment of the impact of poverty and the level of income per family members on vitamin D status, we included in the questionnaire the information about the income of the adolescent's family. It has been established that the level of low income per family member increases in 1.31 times the likelihood of vitamin deficiency in adolescents (p = 0.015). The findings confirm the results of other studies conducted in different countries, but in that case, the risk ratio was 1.36, while in the USA it was 1.6 [13], and in Canada – 3.14 [14].

On the other hand, we have not confirmed the significance of vitamin D supplements and fish oil as a factor for vitamin D deficiency. In our opinion, it is mainly due to the low amount of food and milk products enriched with vitamin D or their use in insufficient quantities, as well as irregular use of fish oil.

Consequently, according to the results of the conducted studies, the prevalence of vitamin D deficiency and factors of its development in the children with overweight and obesity have been defined as well as the main probable factors of its development.

Conclusions

Vitamin D deficiency is prevalent in adolescents with overweight and obesity. The main risk factors for vitamin D deficiency development include winter and spring seasons, spending more than 4 hours per day at the computer, low physical activity up to 2 hours per week, taking small portions of milk less than 1 cup per day and low income per family member. To prevent development of hypovitaminosis and vitamin D deficiency, it is necessary to carry out educational activities with adolescents aimed at healthy lifestyle and healthy eating, and to develop an optimal program for improving vitamin D status in obese children.

ПОШИРЕНІСТЬ ТА ФАКТОРИ РИЗИКУ РОЗВИТКУ ДЕФІЦИТУ ВІТАМІНУ Д У ПІДЛІТКІВ З НАДМІРНОЮ МАСОЮ ТІЛА ТА ОЖИРІННЯМ

А-М. А. Шульгай, Г. А. Павлишин

ТЕРНОПІЛЬСЬКИЙ ДЕРЖАВНИЙ МЕДИЧНИЙ УНІВЕРСИТЕТ ІМЕНІ І. Я. ГОРБАЧЕВСЬКОГО, ТЕРНОПІЛЬ, УКРАЇНА

Вступ. *Вітамін Д бере участь у функціонуванні багатьох органів і систем організму. Одним з факторів ризику розвитку гіповітамінозу Д є порушення обміну ліпідів, і кількість жирової тканини відіграє вирішальну роль за даних обставин.*

Метою дослідження *стало вивчення поширеності та факторів ризику розвитку недостатності вітаміну Д серед підлітків з надмірною масою тіла та ожирінням.*

Методи дослідження. *Обстежено 146 дітей з надмірною масою тіла та різним ступенем ожиріння та 63 здорових дітей з нормальною вагою. Усі включені у дослідження підлітки не вживали препарати вітаміну Д. Для оцінки стану забезпеченості організму визначали рівень кальцидіолу 25(OH)D у сироватці крові. Недостатність вітаміну Д діагностували при значеннях показника 20-29 нг/мл, а його дефіцит – при рівні менше 20 нг/мл. Нормальний вміст кальцидіолу коливається в межах 30-100 нг/мл.*

Результати. *Середній рівень 25(OH)D у підлітків з нормальною масою тіла склав (19,76±4,28) нг/мл, з надмірною масою тіла – (15,24±3,47) нг/мл, з ожирінням – (13,87±2,71) нг/мл. Поширеність дефіциту вітаміну Д у дітей з надмірною масою тіла склала 70,62 %, з ожирінням – 77,19 %.*

Висновки. *Дефіцит вітаміну Д переважає серед підлітків з надмірною масою тіла та ожирінням. Для профілактики розвитку його недостатності необхідно пропагувати здоровий спосіб життя, заохочувати фізичну активність та здоровий спосіб харчування та розробити оптимальні програми для покращення ситуації серед дітей з ожирінням.*

КЛЮЧОВІ СЛОВА: **вітамін Д; діти; кальцидіол; поширеність; ожиріння.**

References

1. Barja-Fernández S, Aguilera CM, Martínez-Silva I, Vazquez R, Gil-Campos M, Olza J et al. Hydroxyvitamin D levels of children are inversely related to adiposity assessed by body mass index. J Physiol Biochem. 2018;74(1):111-118. PMID: 28744831. doi: 10.1007/s13105-017-0581-1.

2. Antonucci R, Locci C, Clemente M, Chicconi E, Antonucci L. Vitamin D deficiency in childhood: old lessons and current challenges. J Pediatr Endocrinol Metab. 2018;31(3):247-260. DOI: https://doi.org/10.1515/jpem-2017-0391.

3. Cheng L. The Convergence of Two Epidemics: Vitamin D Deficiency in Obese School-aged Children. J Pediatr Nurs. 2018;38:20-26. doi: 10.1016/j.pedn.2017.10.005.

4. Kumaratne M, Early G, Cisneros J. Vitamin D deficiency and association with body mass index and lipid levels in Hispanic American adolescents. Glob Pediatr Health. 2017; 7(4):41-45. PMID: 29242817.

5. Durá-Travé T, Gallinas-Victoriano F, Chueca-Guindulain MJ, Berrade-Zubiri S. Prevalence of hypovitaminosis D and associated factors in obese Spanish children. Nutr Diabetes. 2017 Mar;13;7(3):e248. doi: 10.1038/nutd.2016.50.

6. Vierucci F., Del Pistoia M., Fanos M., Gori M, Carlone G, Erba P et al. Vitamin D status and predictors of hypovitaminosis D in Italian children and adolescents: a cross-sectional study. Eur J Pediatr. 2013;172(12):1607-17. PMID: 23959324 DOI: 10.1007/s00431-013-2119-z.

7. Censani M, Hammad H, Christos P, Schumaker T. Vitamin D deficiency associated with markers of cardiovascular disease in children with obesity. Glob Pediatr Health. 2018;12(5): 23-26. doi: 10.1177/2333794X17751773.

8. Salerno G, Ceccarelli M, Waure C, D'Andrea M, Buonsenso D, Faccia V et al. Epidemiology and risk factors of hypovitaminosis D in a cohort of internationally adopted children: a retrospective study. Ital J Pediatr. 2018;44(1):86-90. PMID: 30053889.

9. Balatska NI. Vitamin D deficiency in schoolchildren of Ternopil region. Problems of osteology. 2012;15(2):16-18. [In Ukrainian].

10. Turer ChB, Lin H, Flores G. Prevalence of vitamin D deficiency among overweight and obese us children. Pediatrics 2017; 131(1):151-161.

11. Iqbal A, Dahl A, Lteif A, Kumar S. Vitamin D Deficiency: A potential modifiable risk factor for cardiovascular disease in children with severe obesity. Children 2017;4(9): 56-59. doi: 10.3390/children 4090080.

12. Plesner J, Dahl M, Fonvig C, Nielsen TR, Kloppenborg JT, Pedersen O et al. Obesity is associated with vitamin D deficiency in Danish children and adolescents. J Pediatr Endocrinol Metab. 2018 Jan;26;31(1):53-61. DOI: https://doi.org/10.1515/jpem-2017-0246.

13. Bolek-Berquist J, Elliott M, Gangnon R, Gemar D, Engelke J, Lawrence SJ et al. Use of a questionnaire to assess vitamin D status in young adults. Public Health Nutrition. 2008;12(2):236-243. PMID: 18752694. doi: 10.1017/S136898000800356X.

14. Greene-Finestone L, Garriguet D, Brooks S, Whiting S. Overweight and obesity are associated with lower vitamin D status in Canadian children and adolescents. Paediatr Child Health. 2017;22(8):438-444. DOI: 10.1093/pch/pxx116.

15. Senatorova GS, Telnova LG, Dryll IS, Gladkov O, Gladkovva IM. A comparative survey of the physical growth and development of the schoolchildren who live in the urban and rural area. Sovremennaya pediatriya. 2013;56(8):154-158. [In Ukrainian].

Received: 2018-09-05