

ORIGINAL PAPER

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

Anna-Mariia A. SHULHAI¹✉, Halyna A. PAVLYSHYN¹, Olexandra M. SHULHAI²

¹ Department of Pediatrics №2, State Institution of Higher Education „I. Horbachevsky Ternopil State Medical University of the Ministry of Health of Ukraine“, Ternopil, Ukraine

² Department of Children Diseases with Pediatric Surgery, State Institution of Higher Education „I. Horbachevsky Ternopil State Medical University of the Ministry of Health of Ukraine“, Ternopil, Ukraine

Received 24 Dec 2018, Accepted 17 Febr 2019

<https://doi.org/10.31688/ABMU.2019.54.1.08>

ABSTRACT

Introduction. Lipid metabolism disorder is recognized as one of the risk factors for vitamin D deficiency, and the amount of adipose tissue is crucial in its metabolism and biological role. Childhood obesity is an important public health problem in Ukraine, especially among adolescents.

The objective of the study was to determine peculiarities of the prevalence and risk factors for vitamin D deficiency in overweight and obese adolescents in Ukraine.

Material and methods. 146 children, aged 12 to 17 years, with excessive weight and obesity, and 63 healthy children with normal body weight were examined. The vitamin D status was determined by the level of 25(OH) D in blood serum. The multiple logistic regression analysis was used to determine the risk factor affecting the development of vitamin D deficiency.

RÉSUMÉ

Caractéristiques de la prévalence et des facteurs de risque de carence en vitamine D chez les adolescents en surpoids et obèses en Ukraine

Introduction: Le métabolisme anormal des graisses est reconnu comme l'un des facteurs de risque de la carence en vitamine D. L'obésité chez les enfants est un problème de santé publique important en Ukraine, en particulier chez les adolescents.

But: Déterminer les particularités de la prévalence et des facteurs de risque de carence en vitamine D chez les adolescents en surpoids et obèses en Ukraine.

Méthodes: Au cours de l'étude, 148 enfants, âgés de 12 à 17 ans, souffrant d'embonpoint et d'obésité et 63 adolescents en bonne santé, ayant un poids corporel normal ont été examinés. Le statut en vitamine D a été déterminé par le niveau de 25 (OH) D dans le sérum. L'influence des facteurs de risque sur l'apparition

✉ Address for correspondence:

Anna-Mariia SHULHAI
Department of Pediatrics №2, State Institution of Higher Education
„I. Horbachevsky Ternopil State Medical University of the Ministry of Health
of Ukraine“, Ternopil, Ukraine
Address: 46001 Ternopil, Maydan Voli, 1, Ukraine
E-mail: shulhai_aa@tdmu.edu.ua; phone: +380972171870

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

Conclusions. The study has established the main risk factors and prevalence features for vitamin D deficiency in overweight and obese adolescents.

Keywords: vitamin D, children, calcidiol, prevalence, obesity.

Abbreviations: 25(OH)D – 25-hydroxycholecalciferol, calcidiol; C.I. – Confidence interval (95%); OR – Odds ratio; B – Beta, regression coefficient; S.E. – Standard error.

INTRODUCTION

Vitamin D, due to the biological properties of its derivatives, is involved in the function of many organs and systems. Vitamin D deficiency leads to a decrease in calcium concentration in the blood, impairment of calcium and phosphorus absorption in the intestines and kidneys, because of its active metabolite 1,25-dihydroxyvitamin D¹. It has been shown that vitamin D endocrine system affects electrolytes concentration, cell proliferation, angiogenesis, stimulation of insulin synthesis, inhibition of renin secretion²⁻⁴.

The presence of interconnections between calcidiol level and lipid and carbohydrate metabolism in children^{5,6} has been established. Moreover, special attention is paid by the researchers to the assessment of cardiometabolic risk factors and their combinations with the concentration of calcium in the blood and levels of parathyroid hormone, under the conditions of vitamin D deficiency^{7,8}.

The period of puberty is characterized by a rapid, peak increase in bone and muscle mass, requiring higher calcium and phosphorus intake, and, therefore, maintenance of proper levels of vitamin D metabolites in blood plasma⁹. However, adolescents frequently suffer from hypovitaminosis D and are characterized by an increase in the tendency towards a sedentary lifestyle, spending much time on the computer or in front of the TV¹⁰. 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 deficiency¹.

Investigating metabolic abnormalities in children of different ages, researchers identified inverse

d'une carence en vitamine D a été déterminée à l'aide d'une analyse logistique par régression.

Résultats: L'étude a montré que le taux moyen de 25 (OH) D chez les adolescents de masse corporelle normale était de $19,76 \pm 4,28$ ng / ml, chez les adolescents de poids corporel excessif – $15,24 \pm 3,47$ ng / ml, chez les enfants obèses – $13,87 \pm 2,71$ ng / ml. La prévalence de la carence en vitamine D chez les adolescents ayant un excès de poids était de 70,62% et chez les adolescents souffrant d'obésité – 77,19%.

Conclusions: Le niveau de prévalence et les principaux facteurs de risque de la carence en vitamine D chez les adolescents en surpoids et obèses ont été établis.

Mots-clés: vitamine D, enfants, calcidiol, prévalence, obésité.

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 sensitivity¹¹.

Lipid metabolism disorder is recognized as one of the risk factors for vitamin D deficiency, and the amount of adipose tissue is crucial for its metabolism and biological role¹². Numerous clinical studies have shown that in patients suffering from obesity, vitamin D intake should be 2-3 times higher than in 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 plasma¹³.

Moreover, attention is drawn to the fact that with an 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 discovered the relations between a low-level of 25(OH)D in serum and high triglyceride levels, regardless of age, sex, body mass index and physical activity¹⁴.

Childhood obesity is an important public health problem. In Ukraine, 12% of children aged 7 to 17 years suffer from excessive weight¹⁵, among whom about 10% are diagnosed with obesity by body mass index. Moreover, the number of obese children has a positive annual growth rate.

Taking into consideration the growth of the number of overweight and obese adolescents in Ukraine, it has become necessary to determine the prevalence of vitamin D deficiency among overweight and obese adolescents, and to identify the

main factors affecting the vitamin D status of such children.

THE OBJECTIVE OF THE STUDY was to determine the prevalence and risk factors for vitamin D deficiency in overweight and obese adolescents in Ukraine.

MATERIAL AND METHODS

The research was conducted in the period of 2016-2018, on the basis of the communal institution of the Ternopil Regional Council „Ternopil Regional Children Clinical Hospital“, Ukraine. The Ethic Committee of the I. Horbachevsky Ternopil State Medical University approved the study on the 14th of June 2018, session's protocol number 59. The study was conducted according to the ethical standards in the Helsinki Declaration of 1975, as revised in 2008(5), as well as the national law. In all cases, informed consent was obtained from patients and their parents.

Research was conducted on 146 adolescents (78 boys and 68 girls), aged 12 to 17 years, who were divided into two groups, depending on the body mass index (BMI): overweight children and 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 to 17 years, who lived in the city of Ternopil and sought medical consultations for various reasons and chronic diseases. None of the causes of applying for medical help and disease affected the 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 the hypothalamic-pituitary area), taking antiepileptic drugs or glucocorticoids.

All children were 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) / height² (m²)).

Anthropometric examinations – body weight (within the accuracy of 0.1 kg), height (within the accuracy of 0.1 cm) – were carried out, with the use of generally accepted methods with the help 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 the normal body mass, the excess body mass corresponded to 85-95 percentiles and over 95 percentiles – to the obesity.

To determine the factors affecting vitamin D status, 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 with the use of 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 in the range of 20 ng/mL to 29 ng/mL (50 -75 nmol/L), vitamin D deficiency was determined at 25(OH)D below 20 ng/mL (less 50 nmol/L), the normal calcidiol level was 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 obtained results of the research were subject to statistical processing. Descriptive statistics were used to assess the concentration of calcidiol in serum and in determining 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 Fisher's exact test for categorical variables. The comparison of mean values and their standard errors in different study groups, with the correct distribution, was performed by determining the Student's t-test for independent samples, and in the case of an incorrect distribution of the values using the nonparametric Mann-Whitney U test.

The multiple logistic regression was used to determine the relative effect of each independent variable of the probable risk factor in the development of a 25(OH) D deficiency in adolescents with obesity. All statistical studies were conducted using

Table 1. Supply of adolescents with 25 (OH) D 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*

*: Likely difference with the values in the group with normal body weight p<0.05.

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

Characteristics	Specific proportion of children with deficiency 25 (OH) D in 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)	

SPSS (Statistical Package for the Social Sciences) for Windows software version 21.0.

The significance of the differences between the values considered reliable at $p < 0.05$.

RESULTS

The conducted research has determined low levels of 25 (OH) D in serum. In adolescents with normal body weight, the mean values of 25 (OH) D were 19.76 ± 4.28 ng/mL, in adolescents with excess body weight 15.24 ± 3.47 ng/mL, and in 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 was deficient in the majority of adolescent children. 14.32% of adolescents with normal body weight had a normal level of 25 (OH) D in the blood serum and 29.46% of them had an inadequate level.

The highest deficiency rate of vitamin D was determined in 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 an 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 were observed.

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

Actual data have found that sex and place of residence do not have a significant impact on the prevalence of vitamin D deficiency in adolescents with overweight and obesity. The frequency of diagnosis of vitamin D deficiency is more common in 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 use 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 the excessive body weight ($p = 0.448$) and obesity ($p = 0.417$), had no effect on the incidence of vitamin D deficiency in adolescents. For adolescents with excessive body weight, the duration

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

Risk Factor	B (SE)	OR	95% CI	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

of physical activity during the week did not determine a reliable dependence on low levels of calcidiol ($p = 0.450$).

According to the results of multiple logistic regression analysis, it has been found 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 by 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 or TV ($p = 0.027$). Along with this, it has been found out that sex ($p = 0.869$), place of residence ($p = 0.156$), use 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 children with overweight and obesity.

DISCUSSION

The results of the study have showed that the prevalence of vitamin D deficiency in adolescents is significant and as prevalent as in many other countries^{2,3,12}. It has been established that there is an inverse relationship between the serum level of 25 (OH) D and the body mass index in adolescents. With excessive body weight, the frequency of diagnosing vitamin D deficiency increased by 1.23 times, and with obesity – by 1.35 times. The mean serum calcidiol content in blood serum of adolescents with obesity was 1.43 times lower than that of children with normal body weight. The data obtained during the study showed a similar trend of change in the status of vitamin D in children of different ages during 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 rays¹⁴.

According to the results of the conducted studies, it has been established that the prevalence of vitamin D deficiency in adolescents with obesity and overweight is unrelated to sex and place of residence. The latter was also not recognized as probably risk factors for vitamin D deficiency. However, according to Spanish pediatric school⁵, vitamin D deficiency was more often reported during puberty in obese girls.

Via the multiple logistic regression analysis, it has been defined a degree of influence independent

predictors affecting the development of vitamin D deficiency in adolescents with obesity and overweight. It has been proved that the greatest influence is produced by the season of blood collection in the period of „November-March“, in which the probability of development of vitamin D deficiency increases by 2.74 times compared with the season „April-October“. The amount of time spent at the computer and watching TV more than 4 hours a day increases by 1.91 times the chances of developing vitamin D deficiency and, together with low physical activity, belongs to the three main independent variables in the development of vitamin D deficiency in adolescents with obesity and overweight. Research results also indicate that the daily milk consumption of up to 3 cups or more reduces the development of vitamin D deficiency by 1.49 times compared with adolescents who do not consume or consume up to 1 cup of milk per day. Our data confirm the results of studies conducted by scientists from other countries^{8,10} concerning the degree of insufficiency or deficiency of vitamin D from 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 by 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 our case, the risk ratio was 1.36, while in the USA it was 1.6¹³, and in Canada 3.14¹⁴.

In our opinion, vitamin D deficiency 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 risk factors for its development in overweight or obese children were characterized and the main probable factors of its development were determined.

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, the use of small portions of milk (less than 1 cup per day) and low income per family member. To prevent the 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.

Compliance with Ethics Requirements:

„The authors declare no conflict of interest regarding this article“

„The authors declare that all the procedures and experiments of this study respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2008(5), as well as the national law. Informed consent was obtained from all the patients included in the study“

„This study was approved by the I. Horbachevsky Ternopil State Medical University Research Committee“

„No funding for this study“

REFERENCES

1. Barja-Fernández S, Aguilera CM, Martínez-Silva I, 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.
2. Antonucci R, Locci C, Clemente M, et al. Vitamin D deficiency in childhood: old lessons and current challenges. *J Pediatr Endocrinol Metab*. 2018;31(3):247-260.
3. Cheng L. The convergence of two epidemics: vitamin D deficiency in obese school-aged children. *J Pediatr Nurs*. 2018;38:20-26.
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.
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;13;7(3):e248.
6. Vierucci F, Del Pistoia M, Fanos M, 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.
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.
8. Salerno G, Ceccarelli M, Waure C, 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.
9. Balatska NI. Vitamin D deficiency in schoolchildren of Ternopil region. *Problems of osteology*. 2012;15(2):16-18.
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.
12. Plesner J, Dahl M, Fonvig C, et al. Obesity is associated with vitamin D deficiency in Danish children and adolescents. *J Pediatr Endocrinol Metab*. 2018;26;31(1):53-61.
13. Bolek-Berquist J, Elliott M, Gangnon R, et al. Use of a questionnaire to assess vitamin D status in young adults. *Public Health Nutrition*. 2008;12(2):236-243.
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.
15. Senatorova GS, Telnova LG, Dryll IS, Gladkov MO, Gladkova 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.