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OBESITY IN CHILDREN AS A PREDICTOR OF THE DEVELOPMENT OF MYOPIA

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Summary

Despite a sufficient number of scientific studies devoted to the study of myopia risk factors, the influence of obesity on the degree of myopia risk in childhood has not been sufficiently studied, which prompted us to study this issue using children as an example.

***The aim** is to study the frequency and degree of myopia risk in overweight and obese children.*

***Material and Methods.** The sample of children for the study was formed step by step in the process of randomization. The first stage included a one-time epidemiological study of children aged 10-18 years during preventive examinations in schools of Chernivtsi and Chernivtsi region (1,035 persons). The primary screening included anthropometry and assessment of physical development. For detailed examination 205 persons were selected: with overweight (OW, 65 persons), with obesity (75 persons) and with normal body weight (65 persons, comparison group).*

The ophthalmologic examination included: visometry without and with correction, autorefractokeratometry before and after cycloplegia, biomicroscopy, ophthalmoscopy, optical biometry of the eye.

To reveal the statistical difference between indicators in normally distributed groups, the Student's t criterion of reliability was used, the degree of significance – r. Comparison of groups on a qualitative basis was performed using Pearson's $\chi 2$ test. Differences were considered statistically significant at $p < 0.05$.

The research design and all methods used in this study were reviewed and approved by the Bioethics Committee of the Bukovinian State Medical University (Protocol No. 10, dated 18.05.2002).

The study was conducted within the research work «Early diagnosis, treatment and prevention of combined pathology of gastrointestinal tract and thyroid gland in children» (state registration number 0116U002937, implementation period 02.2016-11.2022).

***Results.** The frequency of myopia in children with OW and obesity was significantly higher than in children with average body weight ($\chi 2 = 3.2$, $p < 0.05$). Children with obesity and myopia were 2.7 times more likely to have diseases of the musculoskeletal system, 1.8 times more likely to have pathology of the autonomic nervous system, and 3.1 times more likely to have chronic diseases of the oropharynx than children in the control group. In all groups of children, the additional risk was greatest in children whose mother or father was myopic (49.6 and 41.3 %, respectively). Minimal additional risk was associated with a history of childhood infections (<1.6 %), helminthiasis (<3.9 %), nasal polyps (<3.4 %), adenoids (<2.4 %), and spinal cord injury at birth (<9.1 %). The odds ratio for the development of low myopia in the group with OW and obesity compared to the control group (normal weight) were 1.25 [95 % CI 0.56-2.82] and 0.88 [95 % CI 0.49-1. 58], for the development of moderate myopia – 1.22 [95 % CI 0.57-2.59] and 0.82 [95 % CI 0.46-1.49], respectively, and for the development of high myopia – 1.37 [95 % CI 0.51-3.66] and 0.80 [95 % CI 0.49-2.09], respectively.*

***Conclusion.** The risk of myopia is higher in children with overweight and obesity, which emphasizes the importance and necessity of taking into account the somatic condition of the child.*

***Key words:** Children; Overweight; Obesity; Myopia.*

Introduction

It is well known that the prevalence of myopia has increased significantly worldwide in recent years [1]. According to WHO statistics, approximately 290 million people worldwide have vision problems, including 19 million children under the age of 18 [2].

Sociologists believe that by 2025, there will be approximately 50 million myopic people in the world [3]. In East Asia, Singapore, Africa, Taiwan and South Korea, myopia has reached epidemic proportions, with nearly 90 % of 18-year-olds being myopic [4-7]. In Western Europe, this indicator varies from 40 to 50 % in adolescents and 10 % in children [8, 9]. In Ukraine the disease is diagnosed in 25-30 % of school graduates, of which 5 % have high, 33 % moderate and 62 % low degree of progressive myopia [10]. In the early 2020s, 30-68 % of myopia will occur between the ages of 15 and 18 years. The progressive course of myopia in the world is one of the most important medical and social problems, because such a course leads to the fact that progressive myopia is one of the most frequent diseases in the structure of children's disability [11]. The high frequency of myopia in the pediatric population, as well as the tendency to develop progression of this disease, make it an important object of research in medical practice. It not only reduces vision, but also worsens the quality of life and limits the choice of occupation.

An analysis of the literature on the etiology of myopia revealed that there is no single theory of myopia development [12-16]. For a long time, the main etiopathogenetic theory of the onset and progression of myopia was the theory of Avetisov ES, the main points of which are the relationship between the size of the axial length of the eye, heredity, visual stress at near, weak accommodation, scleral collagen insufficiency, relatively high intraocular pressure. Today, some links of this theory are still being discussed and studied. In particular, the convergent-accommodative-hydrodynamic-metabolic theory of the pathogenesis of myopia is of interest [17]. Potential risk factors for myopia include sun exposure, serum D levels, low birth weight, cervical and spinal cord injuries during birth, disrupted sleep quality trajectory from childhood to adolescence, poor nutrition, poor visual hygiene, congenital, general and infectious diseases (scoliosis, flat feet, tonsillitis, sinusitis, frontitis, atopic dermatitis, seborrhea,

syndrome of undifferentiated connective tissue dysplasia, etc.) [18-23]. Overweight and obesity in children are also considered to be independent risk factors for the development of myopia [24]. In almost all countries of the world, the number of children and adolescents suffering from obesity is increasing, with the number doubling every three decades [25]. Obesity is known to be associated with an increased risk of developing insulin resistance. Insulin resistance leads to increased levels of insulin and insulin-like factor-1 in the blood, which affect the axial length of the eye, resulting in myopia [26]. Despite a sufficient number of scientific studies devoted to the study of myopia risk factors, the influence of obesity on the degree of myopia risk in childhood has not been sufficiently studied, which prompted us to study this issue using the example of children.

The aim is to study the frequency and degree of myopia in overweight and obese children.

Material and Methods. The sample of children for the study was formed in three stages in the process of randomization using a stratified random 10 % representative sample. The first stage included a one-time epidemiological study during preventive examinations in schools of Chernivtsi and Chernivtsi region (1,035 people). Primary screening included a survey, anthropometry (height, weight, calculation of body mass index (BMI), waist circumference (WC), hip circumference (HC), calculation of WC/HC ratio) and assessment of physical development. Physical development was evaluated according to centile tables. Excess body weight and obesity were diagnosed based on the order of the Ministry of Health of Ukraine dated 09/24/2022 № 1732 [27]. Out of 1035 people, 205 people were selected for a detailed study: with excess body weight (EBW, 65 people), with obesity (75 people) and 65 with normal body weight (comparison group).

Weighing was performed on the Bodi Fat Analyzer BF-662W scale with determination of the percentage of fat mass. WC was measured with a marked centimeter tape in the middle of the distance from the lower edge of the costal arch to the top of the iliac bone, the circumference of the hips of HC was measured at the level of the acetabulum of the femurs, the accuracy of the measurement was 0.005 m. The value of WC was interpreted according to centile nomograms. Excess body weight in all children was determined by the fat component in the body composition, the content of fat mass in the child's body was 29-42 %, which corresponds to the criterion of obesity according to the standards of H. D. McCarthy.

The detailed research program of the second stage included questionnaires of children and their parents, as well as study of anamnestic data (genealogical, social, obstetrical anamnesis) on the basis of information from medical records (F № 112, F № 003 / 0).

Comprehensive ophthalmologic examination included: visometry without and with correction, autorefractokeratometry before and after cycloplegia, biomicroscopy, ophthalmoscopy, optical biometry of the eye (IOL Master 500 Carl Zeiss, Germany). Low degree of myopia was diagnosed up to and including 3.0 diopters, moderate degree – up to and including 6.0 diopters, high degree – over 6.0 diopters.

All studies were conducted after children and parents signed informed consent. Ethical principles are observed in the work, taking into account the main provisions of the GCR ICH and the Helsinki Declaration of the World Medical Association on Biomedical Research (World Medical Association Declaration of Helsinki 1964, 2000, 2008).

Statistical data analysis was performed using the Statistica 10.0 software package. Results are presented as mean and standard deviation ($M \pm \sigma$). The nature of the distribution was determined using the Kolmogorov-Smirnov criterion. Student's t-test was used to compare values with their normal distribution. Pearson's $\chi 2$ test was used to compare groups on a qualitative basis. Differences were considered statistically significant at $p < 0.05$.

The study was conducted as part of the research project «Early diagnosis, treatment and prevention of combined pathology of the gastrointestinal tract and thyroid gland in children» (state registration number 0116U002937, implementation period 02.2016-11.2022).

Results and discussion. The gender and age characteristics of children with EBW and obesity are presented in Table 1.

Table 1

Gender and age characteristics of children with EBW and obesity

Age (years)	Gender			
	Boys (n=76)		Girls (n=64)	
	Abs.	%	Abs.	%
10-11	13	17.1	4	6.2
12-13	17	22.4	11	17.2
14-15	20	26.3	23	35.9
16-18	26	34.2	26	40.6
Total	76	100	64	100

Among children with EBW and obesity, boys predominated (34 of 65, 52.3 % with EBW and 42 of 75, 56 % with obesity). The mean age of the patients (Me, 25Q – 75Q) in the general group was 15.7 (10-18) years. Analyzing the age of the examined patients, it was found that EBW and obesity were most frequently registered in boys older than 15 years (59.4 %) and in girls aged 14-16 years (64.2 %).

The frequency of myopia in children with EBW and obesity was probably higher than in children with average body weight indicators ($\chi 2=3.2$, $p<0.05$; Table 2).

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Table 2

Frequency of different degrees of myopia in children depending on body weight

The degree of myopia	Children with EBW (n=65)	Children with obesity (n=75)	Comparison group (n=65)
	%		
Low	13.8	9.3	13.8
Moderate	9.2	10.7*	4.6
High	6.1	14.7*	3.1
Total	29.2	34.7*	21.5

*Note. * – a probable difference between indicators in children with obesity and in children of the comparison group, p<0.05.*

It was found that obese and short-sighted children are 2.7 times more likely to have diseases of the locomotive system, 1.8 times more likely to be diagnosed with pathologies of the autonomic nervous system, 3.1 times more likely to have chronic diseases of the oropharynx than children in the control group. Attention is drawn to the frequency of acute infectious diseases of the respiratory tract in these children, which indirectly indicates a decrease in immunological protection, characterized by an immunological deficiency of the T-cell type, which contributes to the progression of myopia.

The strength of the relationship between the influence of the factor and the disease is better characterized by the value of the relative risk, which varies widely in the studied groups of children with myopia and obesity and myopia without obesity (from 1.2 to 87.3, Table 3).

Table 3

Risk factors for the development of myopia in children

Factors	Groups of children			Risk	
	Children with EBW and myopia (n=19)	Children with obesity and myopia (n=26)	Comparison group with myopia (n=14)	AI	RR
	%				
Myopia in parents	57.8±23.2	73.1±26.4	31.3±13.1	47.8	87.3
father	15.8±1.2	19.2±3.2	17.1±2.2	41.3	15.6
mother	36.8±2.3	46.2±17.7	14.2±3.4	49.6	13.2
father + mother	5.2±1.4	7.7±0.2	-	6.4	59.8
Children's infectious diseases	10.5±1.2	15.3±2.8	7.1±1.1	1.6	2.4
Helminthiasis	26.3±7.5	30.8±13.2	14.2±9.9	3.9	2.7
Tonsillitis	47.3±23.7	61.5±20.1	21.4±11.2	11.9	3.4
Nasal polyps	5.2±0.2	19.2±3.6	7.1±1.7	3.4	2.1
Adenoids	10.5±3.1	23.1±4.2	14.2±3.8	2.4	1.3
Multiple caries	42.1±19.2	53.8±13.9	7.1±1.1	13.3	3.7
Spinal injuries during childbirth	10.5±3.2	11.5±2.3	7.1±1.1	9.1	1.2
Diseases of the musculoskeletal system	21.1±7.2	65.3±33.1	28.5±10.4	10.8	3.5
Vegitative-vascular dysfunctions	31.5±13.3	69.2±27.2	35.7±15.4	23.4	3.9

Note. AR – attributive risk; RR – relative risk

These factors are real risks for developing myopia in children with EBW and obesity. The additional risk is greatest in children with a history of myopia in either the mother or father (49.6 % and 41.3 %, respectively). Minimal attributive risk is associated with a history of childhood infections (<1.6 %), helminthiasis (<3.9 %), nasal polyps (<3.4 %), adenoids (<2.4 %), and spinal cord injury at birth (<9.1 %).

In addition to the genetic factor, the development of myopia is influenced by prolonged and intense visual stress at close range (95.8 %), poor workplace lighting (67.4 %), incorrect posture when reading and writing (77.6 %), excessive TV and computer use (96.4 %).

Children who are overweight and obese are at risk of developing myopia (odds ratio for myopia in the EBW and obesity group relative to the comparison group (normal weight) was 1.28 [95 % CI 0.46-2.91] and 0.84 [95 % CI 0.53-1.78], respectively), which depends on the degree of myopia. Thus, the odds ratio for mild myopia in the group with EBW and obesity relative to the comparison group was 1.25 [95 % CI 0.56-2.82] and 0.88 [95 % CI 0.49-1.58], respectively, for moderate myopia in the EBW and obesity groups relative to the comparison group – 1. 22 [95 % CI 0.57-2.59] and 0.82 [95 % CI 0.46-1.49], respectively, and for high myopia – 1.37 [95 % CI 0.51-3.66] and 0.80 [95 % CI 0.49-2.09], respectively.

Discussion. Myopia is a medical, social and economic problem, because progressive myopia is one of the most common diseases in the structure of childhood disability and childhood blindness in Ukraine, and significant financial resources are spent on the treatment of this disease [28-30]. The risk of developing myopia is multifactorial. Both genetic and environmental factors play a role in the development and progression of the disease. Published studies suggest possible risk factors,

including parental myopia, reduced outdoor activity, low serum vitamin D, higher education, high body mass index, and high socioeconomic status [31-37]. Uncorrected high myopia can lead to amblyopia and lower school performance in children, while myopia itself can lead to blinding eye diseases such as retinal detachment and myopic degeneration. In our study, using univariate logistic regression, age, sex, presence of myopia in parents, concomitant diseases (childhood infectious diseases, helminthiasis, tonsillitis, nasal polyps, adenoids, multiple caries, spinal injuries during childbirth, musculoskeletal diseases, vegetative-vascular dysfunctions, etc.). Factors were simultaneously adjusted in multivariate logistic regression analysis, where $p < 0.05$ was considered statistically significant. Age is one of the major risk factors for myopia. Axial growth of the eyeball in children accelerates most between the ages of 7.5 and 11.9 years. In this study, the proportion of myopia stabilized after 15 years, while the proportion of high myopia continued to increase until 16 years. EBW and obesity were a special subject of research, since the prevalence of obesity in children is gaining the characteristics of a non-infectious epidemic, and the frequency of myopia in children is also increasing very rapidly due to socio-economic, sanitary, hygienic and epidemiological factors of influence. The study conducted revealed a high prevalence of myopia in children, depending on age and sex, and the presence of myopia in parents, more on the maternal side, is closely related to myopia. A strong association between parental and child myopia has been reported by others [38, 39], with an even greater risk in children with two myopic parents than in children with one or no myopic parents. The influence of excess body weight on the development of myopia is still controversial. Separate studies suggest that overweight and obesity are also risk factors for the development and progression of myopia in children [24, 26]. In our study, high myopia was more common in obesity. For high myopia, the odds ratio for the EBW and obesity groups was 1.37 [95 % CI 0.51-3.66]. Other possible risk factors, such as comorbidities, were not significantly associated with the prevalence of myopia. This study had several limitations. In particular, the ethnic and religious affiliation of the subjects, their social status, and other possible confounders were not taken into account.

Conclusion. The development of myopia in children is determined by a complex of closely related factors. Overweight and obese children have a higher risk of developing myopia (odds ratio for myopia 1.28 [95 % CI 0.46-2.91]), which emphasizes the importance and need to consider the somatic condition of the child. Identification of risk factors for the development of myopia, especially overweight and obesity, will provide an opportunity for early detection of pathology in children and timely initiation of therapy.

Further research is needed to establish causal relationships.

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ОЖИРІННЯ В ДІТЕЙ ЯК ПРЕДИКТОР РОЗВИТКУ МІОПІЇ

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Резюме.

Вступ. Незважаючи на достатню кількість наукових досліджень, присвячених вивченню факторів ризику міопії, вплив ожиріння на ступінь ризику розвитку міопії в дитячому віці досліджений недостатньо, що спонукало нас на прикладі дітей зайнятися вивченням цього питання.

Мета – вивчити частоту та ступінь ризику розвитку міопії в дітей із надлишковою масою тіла та ожирінням.

Матеріал і методи. Вибірка дітей для дослідження формувалася поетапно в процесі рандомізації. Перший етап включав одномоментне епідеміологічне дослідження дітей віком від 10-18 років під час проведення профілактичних оглядів у школах м.Чернівці та Чернівецької області (1035 осіб). Первинний скринінг включав антропометрію та оцінку фізичного розвитку. Для детального дослідження відібрано 205 осіб: із надлишковою масою тіла (НМТ, 65 осіб), із ожирінням (75 осіб) та із нормальною масою тіла (65 осіб, група порівняння). Офтальмологічне обстеження включало: візометрію без корекції та з корекцією, авторефрактокератометрію до та після циклоплегії, біомікроскопію, офтальмоскопію, оптичну біометрію ока.

Для виявлення статистичної різниці між показниками в групах, розподілених нормально, застосовувався t-критерій достовірності Ст'юдента, ступінь значимості – p. Порівняння груп за якісною ознакою виконували за допомогою критерію $\chi 2$ Пірсона. Відмінності вважалися статистично значущими при $p < 0,05$.

Дизайн дослідження та всі методи, використані в цьому дослідженні, розглянуто та схвалено комісією з біоетики Буковинського державного медичного університету (протокол № 10 від 18.05.2023).

Дослідження проведено в рамках науково-дослідної роботи «Рання діагностика, лікування і профілактика поєднаної патології шлунково-кишкового тракту та щитоподібної залози у дітей» (номер державної реєстрації 0116U002937, термін виконання 02.2016-11.2022 рр.).

Результати дослідження. Частота міопії в дітей із НМТ та ожирінням була вірогідно вищою щодо дітей із середніми показниками маси тіла ($\chi 2 = 3,2$, $p < 0,05$). У школярів із ожирінням та міопією у 2,7 рази частіше спостерігаються захворювання опорно-рухового апарату, у 1,8 рази частіше діагностується патологія вегетативної нервової системи, у 3,1 рази частіше трапляються хронічні захворювання ротоносоглотки ніж у дітей групи порівняння. У всіх групах дітей додатковий ризик найбільший у дітей чиї мати чи батько хворі на міопію (відповідно 49,6 та 41,3 %). Мінімальний атрибутивний ризик асоціюється з дитячими інфекціями в анамнезі (< 1,6 %), гельмінтозами (< 3,9 %), носовими поліпами (< 3,4 %), аденоїдитами (< 2,4 %), травмами хребта під час пологів (< 9,1 %). Співвідношення шансів для розвитку міопії легкого ступеня в групі з НМТ та ожирінням щодо групи порівняння (нормальна маса тіла) становило 1,25 [95 % ДІ 0,56-2,82] та 0,88 [95 % ДІ 0,49-1,58] відповідно, для розвитку помірної міопії – 1,22 [95 % ДІ 0,57-2,59] та 0,82 [95 % ДІ 0,46-1,49] відповідно та для розвитку високого ступеня короткозорості – 1,37 [95 % ДІ 0,51-3,66] та 0,80 [95 % ДІ 0,49-2,09] відповідно.

Висновок. Ризик виникнення міопії вище у дітей із надлишковою масою тіла та ожирінням, що підкреслює важливість та необхідність урахування соматичного стану дитини.

Ключові слова: діти; надлишкова маса тіла; ожиріння; міопія.

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