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Стаття надійшла 26.03.2020 p.

DOI 10.26724/2079-8334-2021-1-75-129-134

UDC 612:84:617.753-053.5

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ANALYSIS OF THE DYNAMICS OF REFRACTION DISORDERS IN SCHOOLCHILDREN THROUGHOUT THE YEAR

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The article used a retrospective analysis to investigate the state of the visual system of students of different ages and genders. For this purpose, refractive errors (myopia, hyperopia, astigmatism and myopia or hyperopia with astigmatism) and contrast sensitivity in the dynamics of the year were determined. There was an incredible increase in refractive errors (from 60.12 % to 65.32 %): myopia (from 33.53 % to 36.88 %) and hyperopia (from 20.23 % to 21.97 %). The study of contrast sensitivity revealed its reduction from 2.5 (limit value) to 2.0 in 10.15 % of cases. The use of corrective means prevented the progression of refractive errors. At the same time, their non-use is accompanied by the progression of refractive errors in 97.67 %. It was found that the limit value of the contrast sensitivity index =2.5 is important for further prediction of changes in the visual system of schoolchildren and can be used for preclinical rapid diagnosis of visual impairment. Students with contrast sensitivity 2.5 are at risk and need careful monitoring of their refractive apparatus for a long time, which allow us to detect refractive errors of the visual analyzer in the early stages and to apply corrective means in a timely manner.

Key words: myopia, hyperopia, astigmatism, visual analyzer, refractive errors.

О.І. Плиська, Л.Б. Харченко, М.М. Груша, В.В. Лазоришинець, І.Д. Шкробанець АНАЛІЗ ДИНАМІКИ ПОРУШЕНЬ РЕФРАКЦІЇ У ШКОЛЯРІВ ПРОТЯГОМ РОКУ

У статті за допомогою ретроспективного аналізу дослідили стан зорової системи учнів різного віку і різної статі. Для цього визначали порушення рефракції (міопія, гіперметропія, астигматизм і міопія або гіперметропія з астигматизмом) та контрастну чутливість в динаміці року. Було встановлено невірогідне зростання порушень рефракції (з 60.12 % до 65.32 %): міопії (з 33.53 % до 36.88 %) і гіперметропії (з 20,23 % до 21.97 %). Дослідження контрастної чутливості виявило його зменшення з 2.5 (межове значення) до 2.0 в 10.15 % випадків. Застосування корекційних засобів попереджувало прогресування порушень рефракції. В той же час їх невикористання супроводжувалось їх прогресуванням в 97,67 %. Було встановлено, що межове значення індексу контрастної чутливості=2,5 має значення для подальшого прогнозу змін в зоровому апараті школярів та може бути використано для доклінічної експрес-діагностики порушень зору. Школярі з контрастною чутливістю 2,5 складають групу ризику і потребують ретельного спостереження за їх рефракційним апаратом, протягом тривалого часу, що дає змогу виявити порушення рефракції зорового аналізатора на ранніх стадіях і своєчасно застосувати корекційні засоби.

Ключові слова: міопія, гіперметропія, астигматизм, зоровий аналізатор, порушення рефракції.

The work is fragment of the research project "Hygienic assessment of the impact of PCs on the body of children and adolescents with disabilities", state registration No. 0117U002749.

The problem of visual impairment and loss is extremely relevant around the world. According to statistics from the World Health Organization (WHO), there are currently 45 million blind people in the world, including 1.5 million children, and 135 million have severe visual impairments [9]. Almost every minute in the world, for various reasons, one child loses his sight. The scale of the problem led to the adoption of the WHO international program "VISION-2020: The Right to Sight", which was joined by Ukraine. The aim of this program is to eliminate preventable blindness and low vision [4]. In recent years, the number of children with pathology of the visual organ has increased significantly in our country as well. According to the Ministry of Health of Ukraine, 840,000 cases of ophthalmic diseases

are registered in children in Ukraine every year. Today in Ukraine there is one blind child per 10,000 children, which correlates with global trends [1, 7, 12], per 1,000 children there are 4.3 children with blindness (one or both eyes), and 38.0 with low vision [2]. In fact, 10.7 thousand blind and partially sighted children live in our country, and every year their number increases by 1 thousand [5]. The results of annual preventive examinations of Ukrainian schoolchildren show that the pathology of vision is observed in 14 % of students: the diagnosis of myopia is most often registered, less often – hyperopia, astigmatism, strabismus [4]. It is noted that the frequency of detection of students with reduced visual acuity (VA) during schooling increases 3-5 times, and in the 11th grade the share of students with ophthalmic pathology is 30 % [5]. Therefore, the rapid progression of ophthalmic pathology in our time is an important medical and social problem [12]. At the same time, there is a shortage of scientific research related to a comprehensive analysis of various aspects of the lives of people with visual impairments and the peculiarities of their integration into society. Education as an important step towards the successful self-realization of any individual plays an extremely important role in the process of gaining equal status in society for children with certain physical limitations, physiological pathologies, including the visual system (VS). Therefore, failure is compared with her disease, which must be diagnosed and treated in time. [8].

The purpose of the work was to access of the state of refraction of schoolchildren according to the index of contrast sensitivity throughout the year.

Material and methods. In order to standardize the age ranges of groups of female and male students, the scheme of human age periodization adopted at the VII Conference on Age Morphology, Physiology and Biochemistry (1965) was used. Given the study contingent (children, adolescents and adolescents in high school), our study included individuals: in the age of the first childhood (girls aged 6–7 years, who were age group G1, boys aged 6–7 years – group B1), in the age of the second childhood (girls aged 8–11 years, who were age group G2, boys aged 8–12 years – group B2), adolescence (girls aged 12–15 years, who were age group group G3, boys aged 13–16 years – group B3) and adolescents (girls aged 16-17 years, who were age group G4, young men aged 17 years – group Yu) [11]. The study was performed with the participation of 173 students, of which 90 were females and 83 males, which were divided according to the scheme of age periodization of man above [11]. Contrast sensitivity (CS) and refractive index were determined twice a year in all study participants. The first study was carried out in 2019, the next – in 2020. A prerequisite for the participation of a person in the study in 2020 was the presence of the index of CS=2.5 according to the study of CS 2019.

Study participants were divided into age groups as follow s: group G1 – 19 girls, group G2 – 31 girls, group G3 – 27 girls, group G4 – 13 girls, group B1 – 12 boys, group B2 – 33 boys, group B3 – 29 boys, group Yu – 9 young men.

In each of the subjects, the CS was determined using a table of contrasting optotypes [10] and VA using Golovin-Sivtsev tables [6]. These indices were determined for each eye separately. Given the lack of significant difference between the samples of data obtained from the study of the right and left eye, the numerical characteristics in the work are presented solely by the results of studies of the right eye. Examination of the visual apparatus revealed the presence of astigmatism, not burdened by other disorders of refraction of the AP in only one of the girls in group G3.

The value of CS=2.5 was considered the boundary between pathology and norm, the value of CS ≥ 3.0 was considered to be normal, and the value of CS < 2.0 was considered to indicate the presence of pathological changes in the VS.

The performed research fully complies with the legislation of Ukraine on health care, the principles of the Declaration of Helsinki of the World Medical Association (2013) and the Union of Europe Convention on Human Rights and Biomedicine. Parents or relatives of each patient signed an informed consent to participate in the study. The study took the necessary measures to ensure the anonymity of patients.

Results of the study and their discussion. First, in 2019, we analyzed female and male students by distribution by different age groups. It was found that according to this characteristic, the sample of persons of different sexes did not differ statistically significantly $\chi^2(3, n=173)=2,162, p=0,539$. A retrospective analysis of the condition of the Armed Forces of 173 students revealed the absence of refractive errors (RE) in 39.88 % of schoolchildren (n=69) with a CC index of 2.5 (2019 study). Refractive errors were found in 60.12 % of schoolchildren (n=104), among whom only astigmatism was 0.58 % (n=1), myopia of mild or moderate degree – 33.53 % (n=58), hyperopia of mild or moderate degree – 20.23 % (n=35). In addition, 5.78 % of students (n=10) had such RE as myopia or hyperopia, which were accompanied by astigmatism (table 1).

Table 1

The state of refraction of female and male students with the rate of CS=2.5 IU according to the study 2019–2020

Groups of students		G ₁	G ₂	G ₃	G ₄	B ₁	B ₂	B ₃	Yu
2019	NV (n=69)	3	10	14	7	3	14	17	1
	Ast (n=1)			1					
	MM (n=57)	8	15	5	3	6	11	4	5
	MM and Ast (n=6)		1	2			1	1	1
	MM (n=1)						1		
	MH (n=33)	6	5	5	3	2	4	6	2
	MH and Ast (n=4)	1					2	1	
	MH (n=2)	1				1			
	Total (n=173)	19	31	27	13	12	33	29	9
2020	NV (n=60)	3	9	12	7	3	13	12	1
	Ast (n=1)			1					
	MM (n=63)	8	16	7	3	6	12	6	5
	MM and Ast (n=6)		1	2			1	1	1
	MM (n=1)						1		
	MH (n=36)	6	5	5	3	2	4	9	2
	MH and Ast (n=4)	1					2	1	
	MH (n=2)	1				1			
	Total (n=173)	19	31	27	13	12	33	29	9

Abbreviation: NV – normal vision, Ast – astigmatism, MM – mild myopia, MM – moderate myopia, MH – mild hyperopia, MH – moderate hyperopia.

Analysis of the state of the Armed Forces of the same 173 students with an annual interval (in 2020) revealed the absence of eye PR in only 34.68 % of students (n=60), which was not statistically significant from last year's results of the study $\chi^2(1, n=346)=1.001, p=0.317$. Refractive errors were found in 65.32 % of schoolchildren (n=113), among whom only astigmatism was 0.58 % (n=1), myopia of mild or moderate degree – 36.99 % (n=64), hyperopia of mild or moderate degree – 21.97 % (n=38). In addition, 5.78 % of schoolchildren (n=10) had refractive errors such as myopia or hyperopia, which were accompanied by astigmatism (table 1).

A retrospective analysis of the VS condition of 90 females who participated in the study revealed the absence of eye RE in 37.78 % of students (n=34) who had a 2.5 CS index (in the 2019 study). RE was detected in 62.22 % of schoolgirls of different age groups (n=56), among whom only astigmatism was 1.11 % (n=1), mild myopia – 34.44 % (n=31), hyperopia of mild or moderate degree – 22.22 % (n=20). In addition, 4.44 % of schoolgirls (n=4) had such RE as myopia or hyperopia, which were accompanied by astigmatism (table 1).

Analysis of the state of the VS of the same 90 students with an annual interval (in 2020) revealed the absence of eye RE in only 34.44 % of schoolgirls (n=31), which was not statistically significantly different from last year's results of the study $\chi^2(1, n=180)=0.217, p=0.642$. RE was detected in 65.56 % of students (n=59), among whom the increase in the number and redistribution of interest occurred only in the group of people with mild myopia and amounted to 37.78 % of people (n=34) (table 1).

A retrospective analysis of the state of the VS of 83 males who participated in the study revealed the absence of eye RE in 43.17 % of students (n=35) who had a CC index of 2.5 (in the 2019 study). RE was detected in 57.83 % of schoolchildren of different age groups (n=48), among which myopia of mild or moderate degree occurred in 32.53 % (n=27), hyperopia of mild or moderate – in 18.07 % (n=15). In addition, 7.23 % of students (n=6) had such RE as myopia or hyperopia, which were accompanied by astigmatism (table 1).

Analysis of the state of the VS of the same 83 students with an annual interval (in 2020) revealed the absence of eye RE in only 34.94 % of students (n=29), which was not statistically significant from last year's results of the study $\chi^2(1, n=166)=0.915, p=0.339$. RE was detected in 65.06 % of schoolchildren (n=54), among whom the increase in the number and redistribution of interest occurred only in groups of people with mild or moderate myopia to 36.14 % (n=30) and with mild or moderate hyperopia up to 21.69 % (n=18) (table 1).

It is noteworthy that the changes in refraction that occurred in persons who had in last year's study index CS=2.5 and the state of the refractive apparatus, which corresponds to the norm. The revealed fact indicates the need for an annual ophthalmological rapid examination of school contingents, in order to detect early RE. At the same time, special attention is needed by students who in previous studies had a value of CS=2.5.

In order to determine the state of the visual system of students who in the previous study (2019) had a normal refraction and an index of CS=2.5, we examined the state of their VS with an annual interval

(2020). In this year's study it was found that in 75.36 % (n=52) of such students there were no changes in CS, in 10.15 % (n=7) – there was a deterioration of CS to CS=2.0, and in 14.49 % (n=10) – the MS index increased to CS=3.0 (table 2).

Table 2

Changes in CS according to a re-study in 2020 of female and male students with normal refraction and CS=2.5 IU in 2019

Groups of students		G ₁	G ₂	G ₃	G ₄	B ₁	B ₂	B ₃	Yu	Total
CS index										
2019	2.5	3	10	14	7	3	14	17	1	69
2020	2.0		1	2			1	3		7
	2.5	3	8	8	5	3	13	11 (2)*	1	52 (2)*
	3.0		1	4	2			3		10

* – the number of people with first detected RE (myopia) in a study.

The obtained results indicate a really limit value of the CS index=2.5 relative to the further forecast of changes in the visual apparatus of schoolchildren. It should be noted that when examining all individuals with normal refraction and CS=2.5 according to a previous study (2019), in which this year's study (2020) found a decrease in CS to 2.0 also determined and RE, corresponding to mild myopia, or mild hyperopia. In addition, among individuals with saved CS at the index level CS=2.5, two individuals with RE were found to correspond to mild myopia.

Thus, the number of people with normal refraction and CS=2.5 according to a previous study (2019), who during the year had disorders of the visual system, is 13.04 % (n=9) people (table 2).

In our previous study (2019), we considered that students who had a CS at the level of the MS=2.5 were at risk and needed a thorough examination of the refractory apparatus. Thanks to this screening approach, we were able to initially identify a significant number of students with RE (table 3).

Table 3

Screening of RE of female and male students with a rate of CS=2.5 IU according to the previous (2019) and repeated (2020) study

Gender of students	State of refraction	Number of students	Refractive error detected		
			A	B	C
Female	NV	31			
	Ast	1	1		
	WM	34	30	1	3
	MM and Ast	3	1	2	
	WH	19	18	1	
	MH and Ast	1	1		
	MH	1		1	
	Total	90	51	5	3
Male	NV	29			
	WM	29	25	1	3
	MM and Ast	3	3		
	MM	1	1		
	WH	17	13	1	3
	MH and Ast	3	3		
	MH	1	1		
	Total	83	46	2	6

A – Refractive error detected for the first time in the definition CS in 2019, B – earlier, to determine CS, C – for the first time in the definition CS in 2020. Abbreviation: NV – normal vision, Ast – astigmatism, MM – mild myopia, MM – moderate myopia, MH – mild hyperopia, MH – moderate hyperopia.

According to the results of 2019 in the group of girls of different ages, the number of people who were initially diagnosed with RE after determining the CS index at the level of CS=2.5 is 56.67 % (n=51), and according to the results of this year's study (in 2020) – already 60.00 % (n=54). In the group of boys of different ages, the number of people who were initially diagnosed with RE after determining the CS index at the level of CS=2.5 in 2019 was 55.42 % (n=46). Moreover, according to this year's study, (in 2020) it already was 62.65 % (n=52), which was not statistically significantly different from the results in the group of females $\chi^2(1, n=203)=0.054, p=0.816$. Thus, according to the results of 2019, the group of people who were diagnosed with RE after screening the MS index at the level of CS=2.5 as a whole was 56.07 % (n=97), and according to the results of this year's study (in 2020) – 61.27 % (n=106).

It is well known that the timely vision correction helps to slow down the processes that cause the progression of RE. Therefore, special attention in our study was paid to the timeliness of the application of vision correction in children who, according to a previous study (2019) on the background of the preserved CS at the level of the CS=2.5 index had RE. All such children (as well as their parents) were educated on the need to use vision correction to prevent the progression of RE. When performing a repeated study (with an interval of 1 year) in such children, the state of refraction was determined, its indices were compared with last year's values and correlated with the fact that the child uses vision therapy aids during the year.

We determined that among the 173 students of different ages who participated in our study this year, 104 students according to a previous study (in 2019) RE on the background of the preserved CS at the level of the CS=2.5. At the same time, in 90.65 % of people (n=97) such violations were initially detected during our last year's study, and in 9.35 % of people (n=7) these RE were detected earlier, according to the results of previous requests for medical care in connection with the deterioration of their vision (table 3). In this year's study (2020) we found that among the above 104 people, only 58.65 % of people (n=61) used the correction during the year, and 41.35 % of people (n=43) during the year such correction was not used. We found that in all cases, the use of means of correction of deterioration of refraction in such students did not occur. The latter, in our opinion, was facilitated by rehabilitation measures [3]. In contrast, only the 1st schoolgirl from the group of persons who did not use the means of correction, the state of refraction remained at last year's level. In other cases, accounting for 97.67 % of persons (n=42) from the group of persons who do not use means of correction (n=43), there was a progression of pathological changes in the refractive apparatus (table 4). This progression of RE is probably due to the increase in the load on the visual system of schoolchildren during the school year, which is consistent with the results of research by other authors [9].

Table 4

Changes in the state of refraction according to a repeat study in 2020 of female and male students with a rate of CS = 2.5 IU (2019) depending on the use of corrective means during the year, n

Group of students	State of refraction	Corrective means during the year	
		Apply	Do not apply
G ₁ (n=16)	Stable refraction in myopia	3	
	Progression of myopia		5
	Stable refraction in hyperopia	6	
	Progression of hyperopia		2
G ₂ (n=21)	Stable refraction in myopia	7	1
	Progression of myopia		8
	Stable refraction in hyperopia	3	
	Progression of hyperopia		2
G ₃ (n=13)	Stable refraction in myopia	4	
	Progression of myopia		4
	Stable refraction in hyperopia	3	
	Progression of hyperopia		2
G ₄ (n=6)	Stable refraction in myopia	2	
	Progression of myopia		1
	Stable refraction in hyperopia	3	
B ₁ (n=9)	Stable refraction in myopia	4	
	Progression of myopia		2
	Stable refraction in hyperopia	3	
B ₂ (n=19)	Stable refraction in myopia	6	
	Progression of myopia		7
	Stable refraction in hyperopia	2	
	Progression of hyperopia		4
B ₃ (n=12)	Stable refraction in myopia	2	
	Progression of myopia		3
	Stable refraction in hyperopia	5	
	Progression of hyperopia		2
Yu (n=8)	Stable refraction in myopia	6	
	Stable refraction in hyperopia	2	
Total	Stable refraction in myopia	34	1
	Progression of myopia		30
	Stable refraction in hyperopia	27	
	Progression of hyperopia		12

We determined that among the 173 students of different ages who participated in our study this year, 104 students according to a previous study (in 2019) RE on the background of the preserved CS at the level of the CS=2.5. At the same time, in 90.65 % of people (n=97) such violations were initially detected during our last year's study, and in 9.35 % of people (n=7) these RE were detected earlier, according to the results of previous requests for medical care in connection with the deterioration of their vision (table 3). In this year's study (2020) we found that among the above 104 people, only 58.65 % of people (n=61) used the correction during the year, and 41.35 % of people (n=43) during the year such correction was not used. We found that in all cases, the use of means of correction of deterioration of refraction in such students did not occur. The latter, in our opinion, was facilitated by rehabilitation measures [3]. In contrast, only in the first schoolchild from the group of persons who did not use the means of correction, the state of refraction remained at last year's level. In other cases, accounting for 97.67 % of persons (n=42) from the group of persons who do not use means of correction (n=43), there was a progression of pathological changes in the refractive apparatus (table 4). This progression of RE is probably due to the increase in the burden on the visual system of schoolchildren during the school year, which is consistent with the results of research by other authors [9].

Estimation of the frequency of use of correctional aids by students of different sexes shows that among 56 females 55.36 % of female students use correction (n=31), and among 48 male persons 62.50 % of male students apply correction (n=30). The results of statistical analysis indicate the absence of statistically significant differences between groups of students of different sexes in the frequency of use of corrective means $\chi^2(1, n=104)=0.544, p=0.461$.

Conclusion

During the year, students of different ages and genders tend to increase the frequency of RE, which does not reach statistically significant values. However, it was determined that RE is reflected in the CS of vision, which is manifested in a decrease in the CS index from 2.5 to 2.0. The latter, against the background of the lack of annual specialized ophthalmological examination of large contingents of students of different ages, creates a basis for the use of the method of determining the state of CS for preclinical rapid diagnosis of visual impairments. At the same time, the data obtained by us suggest that students with CS 2.5 are at risk and need careful monitoring of their refractive apparatus for a long time, which allows to detect refractive errors VS in the early stages and timely use of corrective measures. The use of means of correction of RE in schoolchildren during the year stops the progression of negative changes in the visual system of the eye. With the refusal to use the means of refraction correction in 97.67 % of people (n=42) in this group during the year there was a progression of pathological changes in the refractive apparatus.

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Стаття надійшла 16.02.2020 р.