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Effectiveness of a physical therapy program on visual acuity and ocular condition in patients with presbyopia

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Ефективність програми фізичної терапії на показники гостроти та стану органу зору в пацієнтів із пресбіопією

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Introduction

In Ukraine, as elsewhere in the world, the incidence of ophthalmological diseases and, in particular, disability due to visual impairment continues to rise. According to the World Health Organization, approximately 285 million people worldwide suffer from some form of visual impairment. Moreover, the prognosis for the future of these diseases is bleak [1].

Presbyopia is a global problem affecting over a billion people worldwide, with the number of presbyopes set to increase further against a backdrop of an ageing global population where the median age could reach 40 years by 2050. In the younger human eye, the accommodation mechanism acts to enable individuals to view targets clearly at various distances [2; 3; 4; 5; 6; 7].

Presbyopia is a highly prevalent, progressive condition in which the eye's ability to focus on near objects reduces with increasing age. This reduction is due to the decreased ability of the lens to change shape to focus on near objects, known as "accommodation." Loss of accommodation is likely due to lens hardening caused by the loss of viscoelasticity of the crystalline lens and contraction power in the ciliary body [2; 5; 8; 9].

The aging process of the lens epithelium follows the same patterns as that of proliferating tissues. Pathological conditions associated with lens aging have long been known, including presbyopia and age-related cataracts [2; 10]. Accommodation disorders in the elderly are most often caused by age-related changes in the lens: its size, mass, color, shape, and, most importantly, consistency, which are primarily related to the characteristics of its growth and biochemical shifts.

J. Wolffsohn, L. Davies [2], A. Pašalić [11] in their works they cite research Holden and colleagues. They are identified two different presbyopia definitions in epidemiological studies of presbyopia: 1) functional presbyopia, defined as needing a significant optical correction added to the presenting distance refractive correction to achieve a near visual acuity absolute (such as N8 or J1) or relative (such as 1 line of acuity improvement) criteria; or 2) objective presbyopia, where the significant optical correction is defined (such as ≥ 1.00*D*) and added to the best optical distance correction to achieve a defined near visual acuity [8].

Katz et al. [12] note women over 40 years of age have higher rates of presbyopia than men in the same age group. The increased need for presbyopia correction in women is hypothesized to be caused by differences in tasks performed and viewing distance requirements, rather than physiological gender differences in accommodation mechanisms.

The problem of declining uncorrected visual acuity near age is a pressing social issue, given the widespread prevalence of presbyopia. This most common refractive disorder today causes impairment in daily functioning and emotional well-being, and reduces the quality of life for approximately 1.8-2 billion people worldwide. Importantly, presbyopia symptoms not only hinder intellectual functioning but also complicate professional and everyday tasks [3; 8; 9].

Presbyopia is affecting an increasing number of aging population, and its treatment has become a major research focus in ophthalmology [13].

The aim of the study to study and evaluate changes in intraocular pressure, visual acuity, peripheral vision and the state of the fundus of patients with presbyopia under the influence of the use of a physical therapy program.

Object, materials and research methods

Participants. The study included 48 female patients diagnosed with presbyopia, aged 40 to 52 years. Inclusion criteria were pressbyopia and a disease duration of 2 to 10 years. Exclusion criteria included refusal to participate in the study. To ensure homogeneity of the groups, subjects were randomized into a control group (CG) (24 female patients) and a main group (MG) (24 female patients). The patients were blinded to group allocation. The assessors were blinded during interviews, examinations, and data processing. The average age of patients in the main group was 46.3 ± 0.35 years, while in the control group it was 47,6 ± 0,61 years.

All study participants were informed of their voluntary participation and the confidentiality of the information received. They were also provided with comprehensive written information regarding the study's main goals and objectives, its duration, and its nature. Patients participated in the study entirely voluntarily, as confirmed by personally signing the corresponding consent form. Each patient was personally informed of their responsibilities and rights, as well as the opportunity to terminate the study at any time without any consequences or explanation.

Patients in the main group were given a differentiated comprehensive physical therapy program for patients with presbyopia, methods of combined use of accommodation training, kinesitherapy and independent exercises using therapeutic exercises, corrective exercises for the spine, and breathing exercises, special exercises designed to correct functional disorders of the visual analyzer, improve visual performance and the quality of visual life in individuals with presbyopia who do not have concomitant visual pathology; patients in the control group were engaged in a physical therapy program for patients with general visual impairments according to the W.H. Bates [14] method, kinesitherapy, independent exercises.

The patients were examined before the start of a physical therapy program (initial examination) and after 3 months of using a comprehensive physical therapy program (repeat examination).

The studies were conducted according to compliance with international documents regulating biomedical research: "Declaration of the Ethnic Principles for Medical Research Involving Human Subjects" (World Medical Association, 2013); "Universal Declaration on Bioethics and Human Rights" (UNESCO, 2005); «The Convention on the Protection of Human Beings», adopted by the Council of Europe (1997).

Procedure. Physical therapy for patients in the main group was performed to improve near vision and prevent progressive visual acuity decline. The following goals were set: improve blood circulation and trophic processes in the visual organs; restore normal tone of the extraocular muscles; and improve the condition of the cervical and thoracic spine.

The basis of the kinesitherapy complex and independent exercises were therapeutic exercises for medium and large muscle groups, correcting exercises for the spine, especially for the cervical-thoracic spine, and exercises to strengthen the abdominal muscles, acupressure self-massage with a general tonic effect and aimed at improving visual acuity, breathing exercises at rest and while walking with an emphasis on diaphragmatic breathing, as well as special exercises for the eyes, which were performed by patients during three parts of the session – preparatory, main and final.

In the preparatory part of the kinesitherapy complex, we used acupressure, self-massage of the neck and head, general developmental exercises for all muscle groups of the limbs, exercises for the oculomotor muscles, toning and relaxing, performed at a medium pace with the full amplitude of the initial positions "sitting", "standing", combined with breathing exercises. The number of repetitions of each exercise ranged from 4–6 to 10–12.

The main part of the complex consisted of corrective exercises for the spine, abdominal exercises, special exercises for the oculomotor muscles and exercises to relax them, and breathing exercises. The use of corrective exercises for the spine, primarily for the cervical and thoracic regions, is motivated by the significant role autonomic innervation plays in visual function. Attention was paid to posture correction and relaxation of the neck and shoulder muscles. Specific exercises for the oculomotor muscles were developed taking into account the involvement of both the rectus and oblique extraocular muscles, as well as the ciliary muscle. These exercises involved moving both eyes up and down, right and left, and diagonally, symmetrically, until a slight tension was felt. The ciliary muscle was trained through exercises involving moving objects closer and further away, as well as using stereoscopic images to focus and defocus vision. Palming (covering the eyes with the hands to block out light and imagining a black background without spots or stains) was used to relax the eyes. Breathing exercises, primarily abdominal ones, and abdominal strengthening exercises indirectly stimulate the flow of bile from the gallbladder, which in turn improves liver function, which, according to Eastern medicine, indirectly affects a person's health and visual acuity. All exercises were performed with full amplitude, at a medium to fast pace, starting from standing, walking, and sitting positions, with repetitions ranging from 4–6 to 10–12.

The final part of the kinesiotherapy program consisted of slow walking combined with breathing exercises, relaxation exercises, and autogenic training for 10–15 minutes. Session duration ranged from 40–45 minutes to 55–60 minutes.

Independent exercises were prescribed, which patients in the study group completed 5–6 times a day throughout the day. The kinesiotherapy program included exercises for the upper extremity muscles, special exercises for the oculomotor muscles, and adjustments to exercises for the cervicothoracic spine.

Patients in the control group underwent a physical therapy program that included vision correction using

the W. H. Bates method, kinesiotherapy, and independent exercises.

Instruments. To study the changes of visual acuity and visual function in patients with presbyopia, we analyzed and summarized the results of ophthalmological parameters: intraocular pressure, visual acuity, peripheral vision, and fundus function.

Ophthalmological examinations, such as visometry (visual acuity testing), are essential for assessing the effectiveness of rehabilitation measures. During the observation of patients, visometry was performed before and after the start of rehabilitation measures.

Visometry is a method for determining visual acuity. Sivtsev-Golovin tables were used for visometry. The table contains 12 rows of letters: the largest are located at the top, the smallest at the bottom. A person should normally be able to see the 10th line from 5 meters away, which corresponds to vision of a conventional unit (1.0) or 100 %. If a person can see the ninth line, then visual acuity is 90 % or 0.9, and so on. If only the top lines are visible during visometry, then this is considered 10 % vision (0.1). The test was conducted alternately with the right and left eyes. After the procedure, a record was made, for example:

– Vis OD = 0.4
– Vis OS = 1.0

This corresponds to a visual acuity of 40 % in the right eye without correction, and 100 % in the left.

The study was first conducted without correction, then with correction, using a special frame and a set of lenses. The recording then looked something like this:

– by ratio OD = 0.4 SPH –0.5 = 1.0
– by ratio OS = 1.0 without correction.

This means that a person sees 100 % of their vision in the right eye with a –0.5 diopter lens, which corresponds to mild myopia.

Refrakeratometry is a study of the optical properties of the human eye using specialized instruments called refractometers. The purpose of the study is to identify eye conditions such as myopia, hyperopia, or astigmatism. Refractometry is currently performed using automated (computerized) refractometers. We used the Huvitz MRK-3100P Autorefractometer (manufacturer: Huvitz, South Korea, serial number 32548987) for our studies.

Tonometry measures the pressure inside the eye. Intraocular pressure (IOP) is the effect of intraocular fluid on the cornea and sclera. Elevated IOP can lead to eye diseases, discomfort, headaches, and vision loss (in advanced cases). To perform Maklakov tonometry, we used the Maklakov NGm2-OFT-P (two small weight) and Filatov-Kalfa NGm5-OFT-P (five small weight) intraocular pressure kits (manufacturer: IP Gurov A. S., serial number 1079715). Normal intraocular pressure is considered to be between 19 and 26,6 mmHg.

Perimetry is used to determine the visual field (VF) during diagnosis, treatment effectiveness assessment, clinical examination, and prognosis of diseases of the optic nerve, retina, chiasm, major pathways, and visual cortex in ophthalmology and related specialties (neuro-ophthalmology, neurology, neurosurgery). Precise determination of visual field boundaries is performed using instrumental methods. These include compimetry, a method for studying the visual field on a flat surface, and perimetry, a method for studying the visual field on a concave spherical surface. The PNR-03 perimeter (manufacturer: IP Gurov A. S., serial number 1079713) was used in our studies.

Statistical Analysis. The study duration was 3 months. An initial survey was conducted before (days 1–2) and after (the last days of the month) the physical therapy program. Mathematical processing of the obtained data was performed using Statistica 13.0 (Dell Software Inc., USA). Before the main statistical analysis, a preliminary check of the sample for input errors and missing values was performed.

Next, the distribution of quantitative variables was assessed using the Shapiro-Wilk W-test, which allowed us to determine the suitability of the data for parametric analysis. For indicators with a normal distribution, the mean ($\bar{x}$) and standard error of the mean (m) were calculated.

To assess the significance of differences in the presence of a normal distribution of study results, a Student's t-test was used for dependent and independent samples; a difference was considered statistically significant at $p < 0.05$.

To determine the strength and direction of the relationship between ophthalmological parameters (visual acuity and optical correction parameters), the Pearson linear correlation coefficient (r) was calculated. The critical significance level for testing statistical hypotheses was set at $p < 0.05$ (95 % confidence level).

The strength and direction of correlations were interpreted according to a generally accepted scale: weak ($|r|$ = 0.1–0.3), moderate ($|r|$ = 0.3–0.7), and strong ($|r| > 0.7$).

Research results

An initial examination was conducted before the start of physical therapy.

Ophthalmological characteristics of the examined patients.

Ophthalmological parameters included visual acuity, reading correction, intraocular pressure, and peripheral vision (Table 1).

Ophthalmological examinations showed that patients in both groups had decreased near visual acuity OS 0.83 ± 0.03 and OD 0.81 ± 0.06 in MG and OS 0.82 ± 0.04 and OD 0.82 ± 0.06 in CG, the need for vision reading correction OS1, 1.54 ± 0.25 in MG and OS 1.51 ± 0.16 and OD 1.78 ± 0.20 in CG. Intraocular pressure was within the normal range OS 18.81 ± 0.53 and OD 17.09 ± 0.43 in MG and OS 18.09 ± 0.36 and OD 17.91 ± 0.47 in CG, peripheral vision did not go beyond the normal range, taking into account the anatomy. Differences between the indicators were statistically insignificant.

Table 1

Ophthalmological parameters of the examined patients during the initial examination

Indicators	Surveyed groups		t-criterion of Student	*p*
	main group, *n* = 24	control group, *n* = 24		
	$\bar{x} \pm m$	$\bar{x} \pm m$		
Visual acuity OS, diopters	0.83 ± 0.03	0.82 ± 0.04	0.21	> 0.05
Visual acuity OD, diopters	0.81 ± 0.06	0.82 ± 0.06	0.16	> 0.05
Reading correction OS, diopters	1.65 ± 0.18	1.51 ± 0.16	0.58	> 0.05
Reading correction OD, diopters	1.54 ± 0.25	1.78 ± 0.20	0.69	> 0.05
Intraocular pressure OS	18.81 ± 0.53	18.09 ± 0.36	1.12	> 0.05
Intraocular pressure OD	17.09 ± 0.43	17.91 ± 0.47	1.29	> 0.05
Peripheral vision upward OD, °	54.75 ± 0.51	54.62 ± 1.03	0.11	> 0.05
Peripheral vision upward OS, °	54.01 ± 0.30	53.63 ± 0.30	0.84	> 0.05
Peripheral vision upward inward OD, °	47.25 ± 1.56	49.52 ± 0.35	1.42	> 0.05
Peripheral vision upward middle OS °	44.45 ± 3.97	48.54 ± 0.43	1.02	> 0.05
Peripheral vision upward outward OD°	64.12 ± 1.35	64.87 ± 0.47	0.52	> 0.05
Peripheral vision upward outward OS °	63.91 ± 0.31	63.63 ± 0.33	0.59	> 0.05
Peripheral vision outward OD°	89.31 ± 1.01	88.63 ± 0.91	0.51	> 0.05
Peripheral vision outward OS °	88.36 ± 0.43	87.36 ± 0.63	1.31	> 0.05
Peripheral vision down OD°	69.23 ± 0.63	68.54 ± 1.32	0.47	> 0.05
Peripheral vision down OS °	68.91 ± 0.54	69.01 ± 0.41	0.13	> 0.05
Peripheral vision down outward OS °	87.72 ± 0.54	88.27 ± 0.41	0.81	> 0.05
Peripheral vision down inward OD°	44.56 ± 1.02	44.81 ± 0.35	0.23	> 0.05
Peripheral vision down inward OS °	44.18 ± 0.37	44.07 ± 0.26	0.25	> 0.05
Peripheral vision inward OD°	46.65 ± 2.87	47.37 ± 1.24	0.23	> 0.05
Peripheral vision inward OS °	44. 54 ± 3.91	48.54 ± 0.43	1.02	> 0.05
Peripheral vision down outward OD°	89.12 ± 0.42	87.81 ± 1.02	(1.18)	> 0.05

After four months of applying the physical therapy program, during a repeat examination of patients in the main and control groups, positive changes were observed in such parameters as visual acuity and reading correction. In the main group, visual acuity indicators OS increased from 0.83 ± 0.03 D to 0.98 ± 0.01 D and OD – from 0.81 ± 0.06 D to 0.93 ± 0.03 D, reading correction determined by the lens selection method decreased from OS 1.65 ± 1.18 D to 0.86 ± 0.15 D and OD – 1.54 ± 0.25 D to 0.87 ± 0.19 D. The changes of the studied indicators between the initial and repeat examinations were statistically significant. At the same time, changes in the results of tonometry and perimetry did not reach statistical significance, which indicates the absence of influence of both the author's and the generally accepted program on the indicators of peripheral vision and intraocular pressure (Table 2).

In the control group, visual acuity indicators changed from OS 0.82 ± 0.04 D to 0.83 ± 0.04 D and OD from 0.82 ± 0.06 D to 0.83 ± 0.05 D, reading correction changed from OS 1.51 ± 0.16 D to 1.55 ± 0.16 D and OD 1.78 ± 0.20 D to 1.73 ± 0.18 D, and the changes of the studied indicators was statistically insignificant.

To establish the degree of relationship between the studied parameters and assess the systematicity of the therapeutic impact of the author's physical therapy program, a Pearson correlation analysis was conducted (Table 3).

Analysis of the intercorrelation matrix revealed a stable, strong relationship between visual acuity parameters and the required optical correction power for reading for both the left ($r = –0.72$; $p < 0.05$) and right eyes ($r = –0.74$; $p < 0.05$) (Table 3). This finding mathematically confirms the program's optimization effect due to improved visual acuity due to stabilization of the accommodative apparatus, accompanied by a gradual reduction in the need for addition for near work.

A reliable direct correlation between the visual acuity of both eyes ($r = 0.79$; $p < 0.05$) and correction parameters ($r = 0.82$; $p < 0.05$) indicates the symmetry of the functional restoration of the sensitivity of the visual analyzer as a result of the implemented physical therapy interventions.

Discussion of research results

There are currently many strategies for treating presbyopia and the most common methods of correcting presbyopia include spectacles or contact lenses [2; 15; 16], drugs [9; 17;18], refractive surgery [19; 20], scleral surgery [21; 22] and intraocular lens (IOL) implantation [4; 23; 24]. No single treatment is ideal for all patients with presbyopia, new medical and surgical strategies increase the number of options available when addressing different stages of presbyopia and dysfunctional lens syndrome [5; 13].

Despite its prevalence, there are limited treatment options for presbyopia.

Modern and most common non-surgical methods of rose correction at close distances are considered to be

Table 2

Ophthalmological indicators of patients during the primary and repeated examination of the main and control groups (± *S*)

Indicators	Group	Before experiment	After experiment	*t*-criterion of Student	*p*
		$\bar{x} \pm m$	$\bar{x} \pm m$		
Visual acuity OS, diopters	Main Control	0.83 ± 0.03 0.82 ± 0.04	0.98 ± 0.01 0.83 ± 0.04	5.78 0.08	< 0.05 > 0.05
Visual acuity OD, diopters	Main Control	0.81 ± 0.06 0.82 ± 0.06	0.93 ± 0.03 0.83 ± 0.05	1.77 0.11	> 0.05 > 0.05
Reading correction OS, diopters	Main Control	1.65 ± 1.18 1.51 ± 0.16	0.86 ± 0.15 1.55 ± 0.16	2.99 0.27	< 0.05 > 0.05
Reading correction OD, diopters	Main Control	1.54 ± 0.25 1.78 ± 0.20	0.87 ± 0.19 1.73 ± 0.18	2.11 0.14	< 0.05 > 0.05
Intraocular pressure OS	Main Control	18.81 ± 0.41 18.09 ± 0.36	18.82 ± 0.41 18.25 ± 0.44	0.02 0.28	> 0.05 > 0.05
Intraocular pressure OD	Main Control	17.09 ± 0.43 17.91 ± 0.47	18.27 ± 0.50 18.81 ± 0.44	1.79 1.40	> 0.05 > 0.05
Peripheral vision upward OD, °	Main Control	54.75 ± 0.51 54.62 ± 1.03	54.65 ± 1.20 54.50 ± 0.03	0.08 0.12	> 0.05 > 0.05
Peripheral vision upward OS, °	Main Control	54.01 ± 0.30 53.63 ± 0.30	54.45 ± 0.05 54.70 ± 0.55	1.45 1.71	> 0.05 > 0.05
Peripheral vision upward OD, °	Main Control	47.25 ± 1.56 49.52 ± 0.35	48.05 ± 1.40 49.70 ± 0.24	0.38 0.42	> 0.05 > 0.05
Peripheral vision upward inward OS, °	Main Control	44.45 ± 3.97 48.54 ± 0.43	44.65 ± 2.75 49.85 ± 0.43	0.04 2.15	> 0.05 < 0.05
Peripheral vision upward outward OD, °	Main Control	64.12 ± 1.35 64.87 ± 0.47	64.27 ± 1.65 64.25 ± 0.30	0.07 1.11	> 0.05 > 0.05
Peripheral vision upward outward OS, °	Main Control	63.91 ± 0.31 63.63 ± 0.33	63.84 ± 0.62 64.60 ± 0.25	0.10 2.34	> 0.05 < 0.05
Peripheral vision outward OD, °	Main Control	89.31 ± 1.01 88.63 ± 0.91	88.75 ± 1.61 89.23 ± 0.60	0.29 0.55	> 0.05 > 0.05
Peripheral vision outward OS, °	Main Control	88.36 ± 0.43 87.36 ± 0.63	89.06 ± 0.34 88.30 ± 0.32	1.36 1.33	> 0.05 > 0.05
Peripheral vision downward OD, °	Main Control	69.23 ± 0.63 68.54 ± 1.32	69.00 ± 0.52 68.02 ± 1.03	0.28 0.31	> 0.05 > 0.05
Peripheral vision downward OS, °	Main Control	68.91 ± 0.54 69.01 ± 0.41	69.20 ± 0.34 68.51 ± 0.21	0.45 1.48	> 0.05 > 0.05
Peripheral vision downwards outwards OD, °	Main Control	89.12 ± 0.42 87.81 ± 1.02	89.45 ± 0.24 88.70 ± 1.12	0.68 0.59	> 0.05 > 0.05
Peripheral vision downwards outwards OS °	Main Control	87.72 ± 0.54 88.27 ± 0.41	87.17 ± 0.53 89.23 ± 0.21	0.73 2.08	> 0.05 < 0.05
Peripheral vision downwards inwards OD, °	Main Control	44.56 ± 1.02 44.81 ± 0.35	44.70 ± 1.02 44.32 ± 0.45	0.10 0.86	> 0.05 > 0.05
Peripheral vision downwards inwards OS, °	Main Control	44.18 ± 0.37 44.07 ± 0.26	44.98 ± 0.30 44.87 ± 0.52	1.68 1.38	> 0.05 > 0.05
Peripheral vision inwards OD, °	Main Control	46.65 ± 2.87 47.37 ± 1.24	47.56 ± 1.80 48.42 ± 1.04	0.27 0.65	> 0.05 > 0.05
Peripheral vision inwards OS, °	Main Control	44.54 ± 3.91 48.54 ± 0.43	44.35 ± 1.19 48.98 ± 0.65	0.05 0.56	> 0.05 > 0.05

reading, bifocal, or multifocal glasses and monovision or multifocal contact lenses [4; 11].

Eyeglasses are a simple, safe way to correct vision problems caused by presbyopia. Types of reading glasses include: Reading glasses are worn only when needed to see close objects and small print more clearly. Bifocals – correct for near and far vision. Trifocals – these glasses have corrections for near, close-up work, intermediate distance vision (such as for computer screens), and distance vision. Progressive multifocals – this type of lens has no visible horizontal lines, but has multiple powers for distance, intermediate distance and close-up corrections. Different areas of the lens have different focusing strengths. Refraction changes gradually in the lens from top to bottom. Office progressives – these lenses have corrections for computer-distance and close-up work [11].

Presbyopia is under-corrected in many countries, with reading glasses available for only 6–45 % of patients living in developing countries. In these parts of the world, the high prevalence of uncorrected presbyopia is due to a lack of adequate diagnosis and affordable treatment [12]. However, none can restore changes range of accommodation. Spectacle lenses have a number of undesirable properties, such as astigmatism, prismatic

Table 3

Matrix of the correlation structure of ophthalmological parameters of the main group after a course of physical therapy (n = 24)

Indicators	Visual acuity OS, diopters	Visual acuity OD, diopters	Reading correction OS, diopters	Reading correction OD, diopters
Visual acuity OS, diopters	1.00	0.79*	–0.72*	–0.65*
Visual acuity OD, diopters	0.78*	1.00	–0.69*	–0.74*
Reading correction OS, diopters	–0.72*	–0.69*	1.00	0.81*
Reading correction OD, diopters	–0.65*	–0.74*	0.82*	1.00

Note: * – statistically probable Pearson correlation coefficients (r) $p < 0.05$.

effects in the periphery, and spherical aberrations. As a result, problems with intolerance to glasses often arise, reducing the effectiveness of such correction in adulthood [2; 9; 13; 25].

The contact lens wearing presbyopia population is underserved worldwide. The presbyopia correction with contact lenses accounts for up to 25 to 35 % of the contact lens fittings. There are several available options, including single vision contact lenses and spectacle over-correction for near, monovision, rigid gas permeable (GP) multifocal and bifocal lens designs and soft bifocal lens designs [26]. Recent comparative studies concluded that contact lens multifocals perform better in many different forms of visual measurements, in some cases performing similar to best spectacle correction, than monovision wearers [27]. But some people prefer to wear contact lenses rather than eyeglasses. And this option may not work if the patient has certain conditions related to their eyelids, tear ducts or the surfaces of their eyes such as dry eye [11].

There are also surgical treatment options, but similar to the nonsurgical options, vision quality is reduced by at least at 1 viewing distance [2]. Surgery also has its own set of challenges and risks, such as infection, loss of contrast sensitivity, optical aberrations, and potential risk of retinal detachment [9].

There are several possible surgical correction options for ocular presbyopia: laser thermal keratoplasty (LTK) and LASIK. Presbyopia correction with LTK is achieved using radio waves. These waves reshape the cornea and improve visual acuity in mild presbyopia. However, the lens's adaptive capacity continues to decline, and over time, LTK becomes less effective as a presbyopia correction method and may not be long lasting [11; 28; 29].

The general demand for spectacle independence has been growing strongly in recent times, and has made the correction of presbyopia one of the most important and last frontiers of refractive surgery. A more advanced surgical treatment for presbyopia is LASIK [11]. During this procedure, the eye with better visual acuity is designated as the dominant eye, and its cornea is reshaped using an excimer laser for distance vision. The cornea of the other eye is reshaped for near vision. At dawn, both eyes simultaneously achieve optimal visual clarity in a person with presbyopia. The most radical surgical correction method for presbyopia is crystalline lens replacement. In cases of age-related farsightedness and cataracts, this technique is the preferred treatment option for presbyopia. A multifocal lens is implanted in place of the removed lens. This lens can compensate for any refractive error, including presbyopia. However, complications after surgery are possible, such as infection, corneal edema, postoperative astigmatism, etc. The LASIK cannot treat the root cause of presbyopia, there are LASIK variations that can help reduce the patient's need for reading glasses. Refractive surgery changes the shape of cornea. For presbyopia, this treatment can be used to improve close-up vision in non-dominant eye [11].

Numerous accommodative and pseudo-accommodative approaches to treat presbyopia surgically exist. Each has its own benefits and limitations, and may involve some degree of compromise between the distance and near visual acuities. Accommodative approaches attempt to restore the true, changes and continuous range of the defocusing ability of the eye. Pseudo-accommodative approaches provide functional near vision from a variety of non-accommodative factors [11].

Modern ophthalmology does not consider physical rehabilitation as a method for restoring vision in presbyopia. However, the mechanisms of presbyopia, its etiology, and pathogenesis are not yet fully understood. Therefore, research into physiological processes, adaptation methods, and restoration of vision through physical therapy, taking into account modern advances, is becoming increasingly important.

By studying and analyzing scientific sources on vision correction various studies have been carried out on what physical exercise can do for eyesight improvement and for eye health. Numerous of them tested both subjective and objective parameters in different optical fields (myopia, presbyopia, resistance to optical illusions, etc.). The majority of them have tested long-term yoga training. G. Gopinathan, K. Dhiman, R. Manjusha [30] consider prevailing modality of treatment should be supplemented by some ocular strengthening therapy by which ocular health can be maintained and promoted search for such modality lead the investigators to Bates Eye exercise therapy, which is under-evaluated by modern science. However it is practiced in full pledged manner in many reputed institutes of India like School for perfect eyesight at Pondicherry and Moraji Desai institute of Yogic Science at New Delhi. The traditional Trataka Yoga Kriya system is practiced throughout India and is believed to improve eyesight. The purpose of the authors' study was to evaluate the effect of eye exercises and Trataka Yoga Kriya on Timir w.s.r. to ammetropia and presbyopia. Therapy consisted of Bates [14] method of eye exercises

are as follows: Sunning, Eye wash, Palming, Candle light reading, Shifting and Swinging, Playing with ball, Vaporization, Cold pad, and Trataka Yoga Kriya includes both Bahiranga and Antaranga Trataka. G. Gopinathan, K. Dhiman, R. Manjusha [30] came to the conclusion that In Snellen's chart reading one line improvement was noted. There was moderate improvement in clarity of vision, contrast sensitivity, and fineness of objects. The authors believe that a non-pharmacological, inexpensive relaxation technique can improve visual quality, whereby it indirectly controls the progression of the disease state Both these techniques act as adjuvant therapy hence one should adopt pharmacological interventions (medical management), life style, and diet modifications to get a better result.

McLeod R. [31] remark hyperopia is then a system stuck in a condition of long focal length, for which appropriate therapy consists of convergence and brightness-dependent exercises which couple in accommodation increases.

Exercise for presbyopia is theoretically ineffective. However, some studies have reported favorable subject responses, although the reasons were not detected. And researchers Y. Tsuneyoshi, K. Negishi, K. Tsubota [32] decided to investigate one of these exercises for presbyopia. Twenty-three volunteers (48.5 ± 5.0 years) viewed near (30–40 cm) and far (> 5 m) points back and forth 20 times in one set and repeated this four times daily. After 2 months, the accommodation or near visual acuity did not improve. The pupillary size under accommodative stimulation decreased significantly (p = 0.04) from 4.03 ± 0.84 to 3.75 ± 0.98 mm, and the convergence amounts increased significantly (p = 0.03) from 0.71 ± 0.25 to 0.98 ± 0.46 mm. The overall satisfaction with the near vision improved significantly (p = 0.02). The changes in the pupillary sizes and convergence amounts did not differ between subjects with improved satisfaction (positive group) and those without improvement (negative group) (p = 0.50 and p = 0.94, respectively). The pupillary size after exercise was significantly (p = 0,04) smaller in the positive group (3.19 ± 0.82) than in the negative group (4.08 ± 0.94). Based on the results of the indicators, they concluded that the exercise they used for presbyopia was fundamentally ineffective in improving accommodation, however, it strengthened miosis while viewing near and might improve satisfaction for near vision.

Other researchers T. Bianchi, R. Bellen [7], indicate that various studies have been carried out on what yoga can do for eyesight improvement and for eye health. Numerous of them tested both subjective and objective parameters in different optical fields (myopia, presbyopia, resistance to optical illusions, etc.). The majority of them have tested long-term yoga training. But in the literature, the authors did not find evidence of an immediate effect of yoga exercises on visual abilities. In their study, the authors tested some yoga exercises that directly involved the eyes to improve morphoscopic visual acuity. Twenty participants have been examined for morphoscopic visual acuity on Snellen chart. After this, participants were asked to perform several eye yoga exercises for 6 minutes. Exercises included eye movement, focusing, concentration/purification (trātaka) and relaxation (palming). Participants have been subjected again to the Snellen chart examination. Each eye has been examined separately. According to the results of the first and second studies, the Snellen charts were compared, which resulted in an average improvement in visual acuity of 2.28 %. The differences between second and first examination ranged from –22.22 % to +24.44 %. Each eye has been examined separately. In literature, T. Bianchi, R. Bellen [7] found some critical analyses of the effects of eye yoga exercises on eyesight. Some studies deny every form of improvement in this field. However, the results of their research and the evidence found in literature testify the effectiveness of improvements. In their opinion, some more studies would be useful to determine the efficacy of yoga training – both short- and long-term – on visual abilities, on refractive errors, on presbyopia, and on most serious eye pathologies.

We believe that the use of specialized vision correction exercises is the safest and most accessible form of vision correction for presbyopia. Special therapeutic exercises improve blood circulation and create favorable conditions for regenerative processes; trophism of the crystalline lens is improved; and normal tone of the extraocular muscles and ciliary muscle is restored.

For presbyopia, massage of the collar zone is sometimes used as a general strengthening measure and to improve cerebral circulation. However, most ophthalmologists believe that massage is not an effective method for restoring or improving vision in presbyopia.

Prospects for further research

The subsequent phase of the study will aim to evaluate the efficacy of the physical therapy program in improving visual acuity and the functional status of the visual system in men with presbyopia. Additionally, it will investigate the impact of the developed physical therapy program on the vision-related quality of life (VRQoL) in both men and women with presbyopia, utilizing validated international instruments: the National Eye Institute Visual Function Questionnaire-25 (NEI VFQ-25) and the Quality of Life and Vision (QLV) scale.

Conclusions

The implementation of the author's physical therapy program for women with presbyopia confirmed a statistically significant positive dynamics of key visual parameters in the control group compared to the main group, thereby proving its effectiveness in utilizing special exercises for the oculomotor and ciliary muscles, breathing, and corrective exercises to optimize visual functions and reduce dependence on optical correction for presbyopia. Specifically, the obtained visual acuity data in women of the CG revealed an increase in the parameters of the left eye (OS) from 0.83 ± 0.03 diopters to

0.98 ± 0.01 diopters and the right eye (OD) – from 0.81 ± 0.06 diopters to 0.93 ± 0.03 diopters. In comparison, the degree of presbyopia – correction need in the CG significantly decreased: for OS – from 1.65 ± 1.18 diopters to 0.86 ± 0.15 diopters, and for OD – from 1.54 ± 0.25 diopters to 0.87 ± 0.19 diopters.

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Purpose: to study and evaluate the changes of intraocular pressure, visual acuity, peripheral vision and the state of the fundus of patients with presbyopia under the influence of the use of a physical therapy program.

Material and methods. The study included 48 female patients diagnosed with presbyopia, aged 40 to 52 years. The average age of patients in the main group was 46.3 ± 0.35 years, while in the control group it was 47.6 ± 0.61 years. Patients in the main group were given a differentiated comprehensive physical therapy program for patients with presbyopia; patients in the control group were engaged in a physical therapy program for patients with general visual impairments according to the W. H. Bates method, kinesitherapy, and independent exercises.

Results. Following the implementation of the physical therapy program, positive changes were observed in the main group (MG) women's indicators: OS visual acuity increased from 0.83 ± 0.03 diopters to 0.98 ± 0.01 diopters, and OD from 0.81 ± 0.06 diopters to 0.93 ± 0.03 diopters; reading correction, determined by the lens selection method, decreased from OS 1.65 ± 1.18 diopters to 0.86 ± 0.15 diopters, and OD from 1.54 ± 0.25 diopters to 0.87 ± 0.19 diopters. The correlation between the visual acuity of both eyes ($r = 0.79$; $p < 0.05$) and the correction parameters ($r = 0.82$; $p < 0.05$) demonstrates the symmetry of the functional recovery of visual analyzer sensitivity resulting from the implemented physical therapy interventions.

Conclusions. The study examined the effectiveness of physical therapy for patients with presbyopia and concluded that the developed and implemented physical therapy program is effective and helps improve visual acuity in presbyopia, reduce clinical symptoms, and enhance the function of key body systems. Our research demonstrates the need for more widespread use of physical therapy, including therapeutic exercises, breathing exercises, corrective exercises, and specific exercises for the oculomotor and ciliary muscles.

Key words: presbyopia, visual acuity, reading correction, intraocular pressure, peripheral vision status, physical therapy, women, vision correction.

Мета роботи – дослідити й оцінити динаміку показників внутрішньоочного тиску, гостроти зору, периферичного зору і стан очного дна хворих на пресбіопію під впливом застосування програми фізичної терапії

Матеріали та методи. Дослідження включало 48 пацієнток з діагнозом пресбіопія віком від 40 до 52 років. Критерії включення: пресбіопія, тривалість захворювання від 2 до 10 років. Критерії виключення – відмова осіб від участі в дослідженні. Для забезпечення однорідності груп особи були розділені на контрольну (24 хворих) та основну (24 хворих) групи шляхом рандомізації із засліпленням пацієнтів. Оцінювачі були засліплені під час інтерв'ю, обстеження та обробки отриманих даних. Середній вік хворих основної групи становив 46,3 ± 0,35 року, контрольної – 47,6 ± 0,61 року. Пацієнтам основної групи застосовувалася диференційована комплексна програма фізичної терапії для хворих на пресбіопію, методики поєднаного застосування тренування акомодації, кінезотерапії і самостійних занять із застосуванням терапевтичних вправ, коригувальних вправ для хребта, дихальних вправ, спеціальних вправ, призначених для корекції функціональних порушень зорового аналізатора, підвищення зорової працездатності і «якості зорового життя» в осіб із пресбіопією, що не мають супутньої зорової патології; пацієнти контрольної групи займалися за програмою фізичної терапії для хворих на загальні порушення зору за методикою Бейтса, кінезотерапією, самостійними заняттями. Після чого було проведено повторне обстеження хворих, яке дало змогу проаналізувати динаміку досліджуваних показників під впливом розробленої програми фізичної терапії і порівняти отримані результати з результатами групи контролю.

Результати. Після застосування програми фізичної терапії у жінок ОГ відбулися позитивні зміни в показниках: гострота зору OS збільшилася з 0,83 ± 0,03 дптр. до 0,98 ± 0,01 дптр., OD – з 0,81 ± 0,06 дптр. до 0,93 ± 0,03 дптр., корекція для читання, що визначалася за методом підбору лінз, зменшилася з OS 1,65 ± 1,18 дптр. до 0,86 ± 0,15 дптр., OD – 1,54 ± 0,25 дптр. до 0,87 ± 0,19 дптр. Динаміка досліджуваних показників між первинним і повторним обстеженням була статистично значущою. Водночас зміни результатів тонометрії та периметрії не досягли статистичної значущості, що свідчить про відсутність впливу як авторської, так і загальноприйнятої програми на показники периферичного зору та внутрішньоочного тиску. Аналіз інтеркореляційної матриці дав змогу виявити стійкий сильний звортний зв'язок між показниками гостроти зору та необхідною силою оптичної корекції для читання як для лівого ($r = –0,72$; $p < 0,05$), так і для правого ока ($r = –0,74$; $p < 0,05$). Кореляційний

зв'язок між гостротою зору обох очей ($r = 0,79$; $p < 0,05$) і параметрами корекції ($r = 0,82$; $p < 0,05$) свідчить про симетричність функціонального відновлення чутливості зорового аналізатору внаслідок упроваджених фізтерапевтичних інтервенцій.

Висновки. Впровадження авторської програми фізичної терапії для жінок із пресбіопією підтвердило статистично значущу позитивну динаміку ключових зорових параметрів в ОГ порівняно з КГ, чим довело свою ефективність у застосуванні спеціальних вправ для окорухових і циліарного м'язів, дихальних та коригувальних вправ для оптимізації зорових функцій та зниження залежності від оптичної корекції. Так, отримані дані гостроти зору в жінок ОГ виявили підвищення показників лівого ока (OS) з 0,83 ± 0,03 до 0,98 ± 0,01 та правого ока (OD) – з 0,81 ± 0,06 до 0,93 ± 0,03. Водночас сила оптичної корекції в ОГ суттєво знизилася: для OS – з 1,65 ± 1,18 дптр. до 0,86 ± 0,15 дптр., для OD – з 1,54 ± 0,25 дптр. до 0,87 ± 0,19 дптр.

Ключові слова: пресбіопія, гострота зору, корекція для читання, внутрішньоочний тиск, стан периферичного зору, фізична терапія, жінки, корекція зору.

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