Research Article

The Effect of Weighted Contact Lens on Physiological Nystagmus in Young Healthy Subjects

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Highlights

- Nystagmus is accompanied by oscillopsia and vertigo
- Lens can be used to control spontaneous nystagmus

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ABSTRACT

Background and Aim: Contact lenses correct the visual functioning of patients with low vision due to congenital nystagmus. This research presents a new method to reduce nystagmus using contact lenses in healthy subjects.

Methods: Thirty-three normal people (13 women, 20 men) aged 18 to 25 with an average age of 23.3 years participated in this study. In the studied subjects, nystagmus was evoked by an optokinetic stimulus. Then, it was measured and recorded. Next, the Conventional Contact Lens (CCL) and a special lens that was designed and made heavier than the conventional lenses were placed in the eyes of the participants. Once again, nystagmus was recorded with the optokinetic stimulus while the contact lens was placed in the participant's eyes.

Results: No significant difference was observed for the Slow Phase Velocity (SPV) and gain of nystagmus with and without CCL ($p>0.05$), but this parameter had a significant difference with and without Weighted Contact Lenses (WCL) ($p<0.05$). Also, the comparison between the two lenses demonstrated a significant difference ($p<0.05$), which indicates the positive effect of the WCL in reducing the SPV and gain of nystagmus.

Conclusion: Using weighted contact lenses can significantly reduce the SPV and gain of optokinetic nystagmus in healthy subjects. Investigating the effect of this lens in inhibiting pathological nystagmus is recommended in future research.

Keywords: Nystagmus; optokinetic nystagmus; weighted contact lens

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Introduction

The ocular motor system has several subsystems, contains the saccade system, the pursuit system, the fixation, the Vestibular Ocular Reflex (VOR), and the vergence system. All these subsystems help the gaze stabilize during eye and head movements. The disturbance of one of these systems can cause eye instability (e.g. nystagmus) or insufficient eye movement causing a mismatch between head and eye movement (e.g. bilateral vestibular hypo function). In this condition, the subjects report a movement of the world (oscillopsia) which is very annoying [1]. Oscillopsia is a hallucination of an unstable vision caused by the perception of the movement of the environment. The oscillopsia concept refers to the relationship between the physiological mechanisms that cause eye movements and those related to maintaining stable visual perception [1, 2].

Nystagmus is an involuntary, repetitive, and rhythmical eye movement [3]. Nystagmus has two types: physiological and pathological. The physiological type is a normal nystagmus variant of oculomotor function that includes end-point, optokinetic, vestibular ocular reflex, and caloric nystagmus [4]. Pathological nystagmus is categorized as acquired and congenital types. Visual acuity in patients with congenital nystagmus is often low; it may be normal in some patients. The level of low vision is often inversely related to the severity of nystagmus. One of the most important factors affecting low vision is the reduction of the foveation period, and in theoretical terms, decreasing the intensity of nystagmus can amend eyesight [5-7].

Non-surgical methods have been used to treat nystagmus since half a century ago; the most important include medicinal, acupuncture, biofeedback, contact lenses, and prism glasses [8-10]. In 1962, the use of contact lenses in the treatment of nystagmus was proposed for the first time [11]. Since then, in some patients that vision improvement and nystagmus intensity reduction have been reported by using hard or soft contact lenses [12-19].

Contact lenses reduce the amplitude and frequency of nystagmus by different mechanisms. In the first mechanism, the sensory feedback caused by the movement of the edge of the lens versus the edges and inside of the lids as the eyes oscillate causes the person to consciously control the movement of the eyes and reduce the intensity of nystagmus. This phenomenon does not seem to be regarding the lens's mass [14]. The second mechanism in Conventional Contact Lenses (CCL) with power is to improve vision and reduce visual symptoms caused by nystagmus [20-23].

In different methods of nystagmus treatment, the speed of eye movement has been indirectly reduced. Many of these methods have not been effective for all patients. Also, medicinal and surgical treatment can be accompanied by side effects, while no side effects have been reported when using contact lenses and eyeglasses [13-17]. The hypothesis of this study is the effect of increasing the mass of the contact lens in reducing the Slow Phase Velocity (SPV) and the gain of physiological optokinetic nystagmus. This research aimed to investigate using a lens with a greater mass than CCL to the extent that the individual can tolerate it. This study can provide the basis for using contact lenses with power and greater mass to reduce the intensity of nystagmus and its effects.

Methods

Study participants

This clinical trial was conducted on young, healthy subjects from December 2021 to November 2022. In this study, 33 healthy subjects (13 women, 20 men) participated, aged 18 to 25 years, with an average age of 23.3. They had no history of vestibular disease, nystagmus, visual impairment, or neurological and mental disorders. At first, a consent form and a questionnaire of personal characteristics and medical history were completed for all participants, then otoscopy (by Heine otoscope made in Germany), immittance test (by Interacoustic immittance tympanometer model AT235 made in Denmark), and pure tone audiometry (by Interacoustic audiometer model AC40 made in Denmark) were performed to check the condition of the hearing system, the health of the tympanic membrane, and the function of the middle ear. In the following, the Dizziness Handicap Inventory-Persian version (DHI-P) questionnaire ($r=0.90$, $p<0.001$) and Intraclass Correlation Coefficient (ICC=0.96) [23] were completed by the individual to check the conditions related to the existence of any dizziness and complaints due to dizziness. After receiving an acceptable score in the aforementioned questionnaire and detecting the absence of intervening dizziness in the test, the person was evaluated again by E-CLIPS Videonystagmography (VNG) Device (made by Interacoustic company in Denmark) to monitor the presence of any nystagmus. Failure to record spontaneous nystagmus in the VNG test indicates the person's eligibility to participate in the project. All the results matched the inclusion criteria, and if a discrepancy was observed, the person was excluded from the study process. In this study, to avoid the effect of sensory feedback that causes the person to consciously reduce the intensity of nystagmus by moving the eyes in the opposite direction, no training was given to control the eye movements while recording optokinetic nystagmus. The subjects were asked to only stare forwards; in contrast to previous research that used contact lenses with power to improve vision and reduce visual symptoms caused by nystagmus, this study used contact lenses without power.

Weighted contact lens features

The lens used in this research is made of silicone hydrogel with a diameter of 14 mm without power. Iran Lens Company made these lenses under the supervision of the relevant research team (audiologist, optometrist, and ophthalmologist). To determine the weight of the WCL, different lenses with different weights were made and tested, and the more tolerable and heavier lens was chosen. The selected lens was three times thicker than conventional lenses. Using silicone hydrogel lenses is much easier for those who have used the lenses for a long time and prevents eye fatigue. Due to the high oxygen supply, it prevents corneal edema, blurred vision, redness, and irritation of the eyes. More oxygenation of these lenses has made using weekly, monthly, and seasonal lenses easier. Using these lenses reduces the risk of hypoxia, so the person will not get an eye infection. The greater permeability of these lenses to oxygen has made them suitable and usable for various lens designs (toric lenses, customized and bad-sized eye lenses, and bifocal lenses) [19]. In the recent study, the conventional contact lens was made of silicone hydrogel with a diameter of 14 mm and without power.

Optokinetic test

Optokinetic Nystagmus (OKN) is a physiologic phenomenon created by tracking a succession of moving stimuli. These movements involve two phases: eye movements in the direction of the moving target (smooth pursuit) and nystagmus in the opposite direction. To perform the test, the person is placed at a distance of 120 cm from the screen, and a goggle is placed on the eyes and stares at the target [24]. The subject is asked to fix his eyes on the target. The stimulus used in this experiment was the movement of light points on the screen at a speed of 35°/s. The recording time for each direction was 30 s. The stimulus moved once from right to left and again from left to right on the screen. In the first stage, the test was performed without contact lenses and then by placing conventional and weighted contact lenses on the eyes.

Regarding nystagmus evoked by optokinetic stimulation, two parameters, SPV and gain, are examined. The more these values are in a person's eyes, the greater the intensity and magnitude of nystagmus [25].

Data analysis

The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to check the normal distribution of the data. If the data distribution is normal, the paired-sample t-test was used. In the non-normal distribution of the data, the non-parametric Wilcoxon matched-pairs signed rank test was used in the statistical analysis before and after the intervention and compared the changes with two types of conventional and weighted contact lenses. The statistical data analysis was performed using SPSS, version 17 (SPSS Inc., Chicago, IL, the USA), and $p<0.05$ were considered statistically significant for all tests.

Results

Initially, 37 people participated in this study, and four were excluded due to lens intolerance or failure to follow up and complete the test. Finally, 20 male and 13 female subjects were examined. In the recent research, gender was not analyzed. Table 1 shows the SPV's central indices, frequency distribution, and gain of optokinetic nystagmus with and without lenses.

Statistical tests of paired-samples t-test and Wilcoxon matched-pairs signed rank were used to investigate the effect of lenses CCL and WCL on the SPV and gain of optokinetic nystagmus. Table 2 shows the results of the comparison of SPV and gain of nystagmus when the stimulus is presented at 35°/s to the right and left with and without a CCL or WCL.

Table 1. Central indices and frequency distribution of slow phase velocity and gain of optokinetic nystagmus with and without lenses (n=33)

Direction of movement	Variable		Min	Max	Mean(SD)
Right	SPV	Without of lens	28.40	36.14	32.03(2.72)
		With CCL	27.17	34.68	31.12(3.31)
		With WCL	15.84	22.24	16.95(1.71)
	Gain	Without of lens	0.84	1.09	0.95(0.11)
		With CCL	0.65	0.95	0.91(0.09)
		With WCL	0.43	0.57	0.49(0.05)
Left	SPV	Without of lens	28.51	36.11	31.70(2.95)
		With CCL	25.43	36.14	30.14(3.38)
		With WCL	15.37	22.86	17.22(2.39)
	Gain	Without of lens	0.81	1.28	0.95(0.11)
		With CCL	0.73	1.02	0.92(0.09)
		With WCL	0.43	0.57	0.46(0.05)

SPV; slow phase velocity, CCL; conventional contact lens, WCL; weighted contact lens

Table 2. The of slow phase velocity and gain changes with and without of conventional contact lens or weighted contact lens

Direction of movement	Variable		Min	Max	Mean(SD)
Right	SPV	Without of lens	28.40	36.14	32.03(2.72)
		With CCL	27.17	34.68	31.12(3.31)
		With WCL	15.84	22.24	16.95(1.71)
	Gain	Without of lens	0.84	1.09	0.95(0.11)
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		With WCL	0.43	0.57	0.49(0.05)
Left	SPV	Without of lens	28.51	36.11	31.70(2.95)
		With CCL	25.43	36.14	30.14(3.38)
		With WCL	15.37	22.86	17.22(2.39)
	Gain	Without of lens	0.81	1.28	0.95(0.11)
		With CCL	0.73	1.02	0.92(0.09)
		With WCL	0.43	0.57	0.46(0.05)

SPV; slow phase velocity, CCL; conventional contact lens, WCL; weighted contact lens

No significant difference was observed for the SPV and gain of nystagmus with and without CCL ($p>0.05$), but this parameter had a significant difference with and without WCL ($p<0.001$). Also, the comparison between the two lenses showed a significant difference ($p<0.001$), indicating the positive effect of the WCL in reducing the SPV and gain of nystagmus (Table 2).

Discussion

The study participants were healthy young people whose optokinetic stimulation created physiological nystagmus. This study used a special type of contact lens (WCL). One of the distinguishing features of this exclusive lens was its mass which is heavier than conventional contact lenses. The mentioned lens cannot correct the refractive error and is so-called without power. The main hypothesis of the present study was to decrease the SPV and gain of nystagmus by adding eye weight. In this study, considering the elimination of sensory feedback and the effect of contact lenses in vision correction, the only factor causing a significant difference between WCL and CCL is the difference in mass. As clearly shown in the descriptive and inferential statistics section, the SPV and gain values significantly differ with and without the WCL, representing decreased evoked nystagmus intensity. These findings concord with the results by Byford, which used a sensitive contact lens photoelectric eye movement recorder with more mass than conventional lenses, performed on three healthy subjects. In this research, an Electronystagmography (ENG) device was used to record eye movements, and it was found that the amplitude of optokinetic nystagmus decreased to one-third of the initial value compared to the condition without lenses [26]. These findings are close to the results of the present study, although the lens used in Byford's [26] research was a special lens designed to measure eye movement speed and had no therapeutic use. Apart from this research, no other research on the effect of contact lens weight on eye movement speed and nystagmus is available for comparison. Of course, there is a lot of research on using contact lenses to reduce the intensity of nystagmus.

Biousse et al. reported that contact lenses could improve the vision of low-vision sufferers caused by congenital nystagmus. In this study, 4 people with congenital nystagmus had two assessments apart by at least a week (one with eyeglasses, one with contact lenses) containing contrast sensitivity, visual acuity quality of life questionnaire, National Eye Institute Visual Function Questionnaire-25 (NEI VFQ-25), oscillopsia scale, and recording of eye movement with the VNG system. All the participants in this research preferred using contact lenses to eyeglasses. Their contrast sensitivity and Visual Function Questionnaire-25 (VFQ-25) scores were improved with contact lenses compared with eyeglasses alone. Some nystagmus parameters did not change in two people, worsened in one person, and improved in another. Therefore, much of the clinical amelioration in patients may be due to better optical correction of their refractive error with contact lenses than with eyeglasses rather than an actual attenuation effect of nystagmus by the contact lenses [14]. This study has investigated the positive impact of the lens on the control of congenital nystagmus and the improvement of vision without considering the effect of contact lens mass.

Although it was reported in the study of Biousse et al. that the mass factor had no effect on the velocity of nystagmus and they proposed sensory feedback as a factor in reducing the velocity of nystagmus [14], it should be noted that CCL with normal mass was used in the mentioned study, which is not expected the mass factor is effective. In our research as well as with the CCL, between the SPV and the gain with and without the lens, no significant difference was observed, which indicates the ineffectiveness of the mass of the CCL in reducing the SPV and the gain of nystagmus. While for the WCL, between the condition with and without the lens, a significant difference was observed (Table 2). The only difference between these two lenses is their mass.

A study by Allen and Davis showed that congenital nystagmus of unknown origin is associated with poor vision and is highly resistant to treatment [13]. It can be said that due to nystagmus, oscillopsia causes blurring of the visual field. This study has shown that following the use of contact lenses in people with congenital nystagmus, the blurring of the visual field is greatly reduced in 5 out of 8 cases, and this is in the condition that non-powered contact lenses were used [14]. These researchers have also stated that oscillopsia, one of the most common symptoms of vertigo, was well controlled in this case. No measurements were made on nystagmus in this study, and the results were reported only qualitatively from the patients' statements. In this study, an attempt has been made to treat poor visual acuity, and contact lenses have been used for this purpose.

Safran and Gambazzi researched to investigate the role of contact lenses in controlling congenital nystagmus [27]. These researchers reported that the symptoms caused by congenital nystagmus are considerably reduced by using contact lenses. A therapeutic trial on a 20-year-old patient with contact lenses that lasted 90 minutes had a beneficial effect on congenital nystagmus. After removing the lenses, the patient demonstrated a transient rebound phenomenon with oscillopsia lasting about 20 minutes. This report does not deny the positive effect of contact lenses in treating patients with congenital nystagmus. Still, it draws attention to the occasional occurrence of such a rebound phenomenon and discusses its theoretical importance [27].

Different theories have been explained for the influence of contact lenses on vision amelioration in nystagmus; the most significant is the optical theory. Because of the constant eye movements in these people, viewing through the optical center of the eyeglasses are often impossible [16-20]. This, in turn, creates continuous prismatic effects from the periphery of the corrective lenses and prevents long-term foveation. Also, magnification change induced by eyeglasses degrades image quality and may prevent fusion. Moving the refractive correction closer to the eye can theoretically reduce the optical problems mentioned above, provide a clearer retinal image, improve fixation and fusion abilities, have longer foveation time, better control of abnormal eye movements, and improve vision.

On the other hand, based on the optical theory, because contact lenses, contrary to eyeglasses, move with the eyes during involuntary movements, they stay for a longer time on the visual axes of the eyes, causing longer foveation time [1, 2, 4]. Also, by deleting the peripheral prismatic effect of corrective eyeglasses, contact lenses can reduce spherical and chromatic aberrations, aniseikonia, and eyeglasses' minification/magnification effect. They also enhance the visual field and eventually provide better binocular fusion. Another theory states that the reduction of the nystagmus intensity by using contact lenses is due to stimulation of both tactile and proprioceptive sensory nerve endings of the trigeminal nerve in the cornea and conjunctiva by constant touch between contact lenses with the eyelid margins and ocular surface. Some studies have shown that topical anesthetics can neutralize the effect of contact lenses on nystagmus. This theory also confirms that even the lenses without power can decrease the severity of nystagmus [8, 10].

Golubovic et al. [16] and Allen and Davis [13] reported that contact lenses are more effective for correcting higher refractive errors, and people with low refractive errors did not benefit from contact lenses. This result is in contrast to Matsubayashi et al. s' research, which emphasizes the positive effect of contact lenses, even without power, in reducing congenital nystagmus [17], and Jayaramchandran et al. who reported contact lenses did not decrease nystagmus [20].

Nystagmus often comes to the attention of clinical work when it causes visual symptoms. The first intervention step in dealing with patients with nystagmus is to improve their vision conditions. In some cases of nystagmus, visual symptoms are much less apparent, such as congenital nystagmus and nystagmus evoked by looking at one side. Therefore, nystagmus treatment is desirable and does not harm the eyes and vision [7].

Conclusion

According to the present study, using weighted contact lenses can significantly reduce the slow phase velocity and gain of optokinetic nystagmus in healthy subjects. Investigating the effect of this lens in inhibiting pathological nystagmus is recommended in future research.

Ethical Considerations

Compliance with ethical guidelines

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Authors' contributions

MA: Study design, analysis of the results and writing the manuscript; SR: Study design, stimulus preparation, data collection, interpretation the data and writing the manuscript; AAB: Analysis of the results.

Conflict of interest

The authors declared no conflicts of interest.

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