• Clinical Research •

Effect of prisms on visual acuity, contrast sensitivity and nystagmus in patients with albinism

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Received: 2024-02-20 Accepted: 2024-05-24

Abstract

● **AIM:** To investigate the effect of using base-out prisms on nystagmus, visual acuity and contrast sensitivity in patients with albinism.

● **METHODS:** In this interventional study, patients with albinism who had nystagmus were enrolled. A comprehensive eye exam was conducted, which included refraction, assessment of far and near vision acuity, and contrast sensitivity measurements. To check for the nystagmus, a videonystagmography was used. The tests were carried out in three modes: without any correction, with optical correction, and with correction using base-out prisms in three different powers, including 4, 6, and 8 prism diopters.

● **RESULTS:** Totally 23 patients with average age of 28.65±12.13 were examined. It was found that the use of optical correction and optical correction with prisms resulted in a statistically significant improvement in both far (at least: P<0.006) and near visual acuity (at least: P<0.001 except for prism 8; P<0.02). In addition, contrast sensitivity significantly improved at all low and medium frequencies except for correction with prism 8 in frequency 1.5 (at least: P<0.01 except for prism 4, frequency 6; P=0.04). no significant improvement was observed in the evaluation of nystagmus characteristics.

● **CONCLUSION:** Optical correction with a prism can improve visual acuity and some spatial frequencies, but failed to improve nystagmus parameters.

● **KEYWORDS:** nystagmus; albinism; prism
DOI:10.18240/ijo.2024.10.13

Citation: Dashti M, Riazi A, Ashrafi M, Rahmani S, Tabatabaei SM. Effect of prisms on visual acuity, contrast sensitivity and nystagmus in patients with albinism. *Int J Ophthalmol* 2024;17(10):1864-1868

INTRODUCTION

Albinism is a genetic disorder which is caused by a mutation that affects the production or transfer of melanin in the skin, hair, or eyes. This decrease in melanin synthesis results in reduced pigmentation in the skin and eyes[1-2]. Albinism also affects the eyes, causing reduced visual acuity, nystagmus, photophobia, eye deviation, abnormal crossing of retinal ganglion cell axons in the chiasma, iris translucency, and reduced pigmentation. Additionally, it causes hypoplasia of the fovea, which leads to moderate to severe vision loss[3-6]. The main cause of nystagmus in these people is not yet known, but it may be due to hypoplasia of the fovea or the characteristics of incorrect routing of retinal nerves in the visual pathway, and part of the cause of vision loss in albino individuals with nystagmus is attributed to the reduction of the time the image stays on the center of the macula[7-8]. Various methods have been suggested for the treatment of nystagmus, including the use of medicines, biofeedback, vision exercises, acupuncture, optical such as prisms, contact lenses, and surgical procedures. By reducing the nystagmus in the convergence condition, the range of viewing angles with higher foveation quality can be prolonged, creating a wider neutral point. This capability can be achieved by using optical or surgical methods to create convergence for far distances, thereby reducing nystagmus. When the amplitude of nystagmus is lower in convergence mode, prisms can reduce nystagmus[9]. It is important to consider both visual function and aesthetic factors when evaluating the effectiveness of nystagmus treatments[10]. This study aimed to determine the effectiveness of using base-out prisms to improve visual functions and nystagmus control in patients with albinism.

SUBJECTS AND METHODS

Ethical Approval In this interventional study, patients with albinism and nystagmus were selected. Ethical considerations were followed under the instructions of the Ethics Committee of Shahid Beheshti University of Medical Sciences (Approval code; IR.SBMU.RETECH.REC.1401.430). A written informed consent was obtained from all participants.

Totally 23 patients with albinism who had nystagmus were included in this study and individuals with binocular visual acuity worse than 1 logMAR, manifest eye deviations, and any retinal or eye problems not related to albinism disease (such as retinal detachment or cataracts) were excluded from the study. Additionally, individuals with a history of eye surgery related to extraocular muscles for controlling nystagmus and those using medicines that affect the severity of nystagmus were excluded. Comprehensive eye examinations were performed, including refraction, measurement of far and near vision acuity and contrast sensitivity, and examination of ocular deviations. The individual's far and near vision acuity and contrast sensitivity were initially measured without optical correction. The best subjective refraction was then placed in front of the patient's eye to provide the best near and far vision acuity, and vision and contrast sensitivity were checked again. Then 4, 6, and 8 prisms based out added in front of the eyes. The patient's far and near vision acuity, as well as contrast sensitivity, were checked at each stage. Binocular visual acuity (far and near) was measured using the standard logMAR chart at a distance of 6 m and of 30 cm. To measure contrast sensitivity, a computer-based system (M&S Technologies) was used showing a sinusoidal pattern at a distance of 1 m (1.5, 3, and 6 cycles per degree). The logarithm of the contrast sensitivity was recorded for each spatial frequency. Eye deviations were measured with a semi-transparent cover and prism alternate cover test method for both near and far distance. Once the optical correction and specified prisms were in place, the patient was asked to use them for 15-20min for near and far distances to assess the prism adaptation test. The patient is also instructed to report any discomfort, dizziness, or double vision that they may experience. A videonystagmograph (Synapsys Ulmer, France) was used to check nystagmus parameters, such as amplitude, frequency, and intensity with and without optical correction, as well as with optical correction and prisms with three powers for at least 60s. During the test, the patient sits 1.5 m away from a screen and focuses on a target inside the screen holding their head in the initial position. During the test, the eye movements are recorded using infrared sensors and a special camera[11]. The recorded graph is then analyzed for measuring eye movements from the center of the pupil of the right eye, due to the conjugated nystagmus in the participants. The examiner controls the frequency and amplitude, which are calculated directly from the recorded graphs. A part of the data, free of blinking and noise, is analyzed for a maximum of 8s and a minimum of 2s to examine nystagmus measures. The magnitude of the eye position change with each oscillation is measured as amplitude, the number of eye movements per second as frequency, and amplitude×frequency is considered intensity. For determination of the sample size, α and β were considered 0.05 and 0.1, respectively. The data is analyzed using SPSS 26 statistical software, and the significance level is considered $P<0.05$. The normality of the distribution of the variables is determined using the Shapiro-Wilk test. For variables with a normal distribution, a paired-sample *t*-test is used, and for variables with a non-normal distribution, the Wilcoxon test is used.

RESULTS

A study was conducted on 23 patients, with an average age of 28.65±12.13, including 15 males (65.2%) and 8 females (34.8%). From these, 20 people had albinism type 1 (87%), and 3 had albinism type 2 (13%). However, in four cases, good-quality images of eye movements could not be recorded due to the lack of Iris pigment in these individuals and the inability of the videonystagmography device (which is based on infrared light) to detect pupils as a reference for eye movements.

The study found that the average spherical refractive error was 3.90±4.71, with 80.43% of individuals having a hyperopic spherical refractive. Astigmatism refractive error was observed in all 46 examined eyes, with an average of -3.07±1.63. Further, 84.78% of the observed astigmatism cases were with the rule.

The use of optical correction could significantly increase near and far vision acuity ($P<0.0001$), and the use of base-out prisms was also able to show a statistically significant improvement (far: $P<0.001$ with prism 4, $P=0.006$ with prism 6, and $P=0.004$ with prism 8, near: $P=0.001$ with prism 4, $P=0.001$ with prism 6, and $P=0.02$ with prism 8; Table 1 and Figure 1).

Contrast sensitivity in all 3 spatial frequencies of 1.5, 3, and 6 cycles/degree after optical correction showed a significant improvement ($P<0.0001$, $P<0.0001$, $P=0.003$). The use of prisms with a power of 4 prism diopters in all 3 spatial frequencies of 1.5, 3, and 6 cycles per degree created a significant improvement ($P=0.004$, $P=0.002$, and $P=0.041$). With the power of the 6 prism diopter, it was significant at 2 spatial frequencies of 1.5 and 3 cycles/degree ($P=0.013$, $P=0.005$), and with the prism with the power of the 8 prism diopter, it was only at the spatial frequency of 3 cycles/degree ($P=0.010$). Increasing the amount of prism did not show any significant difference in contrast sensitivity at any of the spatial frequencies (Table 2 and Figure 2).

In general, no significant improvement was observed in the evaluation of nystagmus characteristics, including amplitude,

Table 1 Mean, standard deviation and significance level of the visual acuity

Parameters	Mean±standard deviation					*P* (compared to optical correction)			
	Without correction	With correction	With correction and prism 4	With correction and prism 6	With correction and prism 8	Without correction	With correction and prism 4	With correction and prism 6	With correction and prism 8
Far VA (logMAR)	0.81±0.20	0.72±0.18	0.70±0.19	0.70±0.18	0.70±0.18	0.000	0.000	0.006	0.004
Near VA (logMAR)	0.66±0.18	0.57±0.17	0.56±0.16	0.55±0.16	0.55±0.16	0.000	0.001	0.001	0.020

VA: Visual acuity.

Table 2 Mean, standard deviation and significance level of the contrast sensitivity

Parameters	Mean±standard deviation					*P* (compared to optical correction)			
	Without correction	With correction	With correction and prism 4	With correction and prism 6	With correction and prism 8	Without correction	With correction and prism 4	With correction and prism 6	With correction and prism 8
CS log in spatial frequency 1.5	0.93±0.71	1.50±0.47	1.57±0.49	1.56±0.49	1.55±0.54	0.000	0.004	0.013	0.075
CS log in spatial frequency 3	0.39±0.49	0.71±0.50	0.81±0.52	0.83±0.52	0.80±0.51	0.000	0.002	0.005	0.010
CS log frequency 6	0.10±0.21	0.20±0.33	0.24±0.36	0.23±0.34	0.23±0.34	0.003	0.041	0.059	0.102

CS: Contrast sensitivity.

frequency, and intensity, after optical correction and adding base-out prisms with different powers (Table 3 and Figure 3). It is noteworthy to observe a significant decrease in the amplitude parameter which was found in 6 cases (31.57%) of the examined people. Instead, in 5 cases, a significant increase in the amplitude parameter (26.31%) was observed.

DISCUSSION

Nystagmus is a condition that affects vision and is caused by a variety of factors, including albinism, which accounts for around 30% of cases. This condition can lead to vision loss and has significant social and psychological consequences for those affected. Although some treatments are available, none can fully cure the condition[12-13], and some may have contraindications or complications. Therefore, it is important to compare different treatment methods, including the use of prisms, to determine their effectiveness in controlling nystagmus and improving visual functions. In 46 studied eyes, hyperopia refractive error had a high proportion, which was similar to some previous studies in albinism subjects[14-15]. However, some other studies have also reported a high percentage of myopic spherical refractive error[16]. Astigmatism was observed in all cases, and 84.78% of the astigmatism cases observed were with the rule, which is consistent with previous studies conducted in the albinism population[3]. One of the reasons for the high portion of astigmatism, especially with the rule type, is the presence of nystagmus in these people[17]. In the investigated subjects, the distance visual acuity of the subjects after optical correction showed a significant improvement compared to the state without optical correction, which shows the effect of optical correction on the improvement of vision in people with albinism despite the pathological conditions of the eye[18-19]. Although the addition of prisms to optical correction showed a statistically significant improvement in distant visual acuity, clinically, this increase was not significant (the major increase in distant visual acuity was 0.06 logMAR). Near visual acuity in people with albinism is generally better than

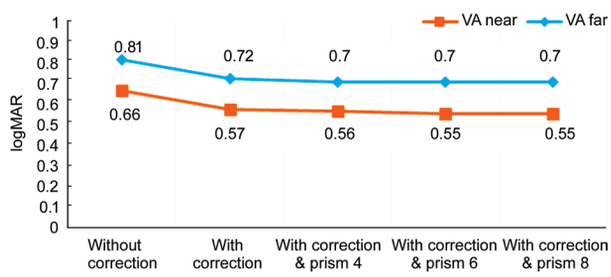

Figure 1 Far and near visual acuity without, with correction and with different power of prisms VA: Visual acuity.

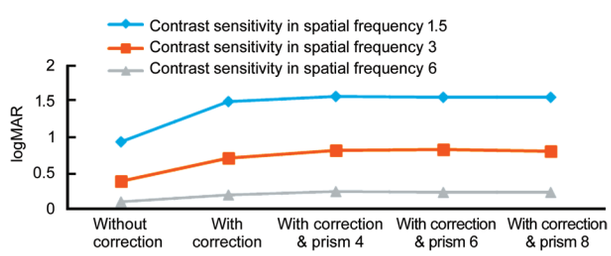

Figure 2 Contrast sensitivity without, with correction and with different power of prisms.

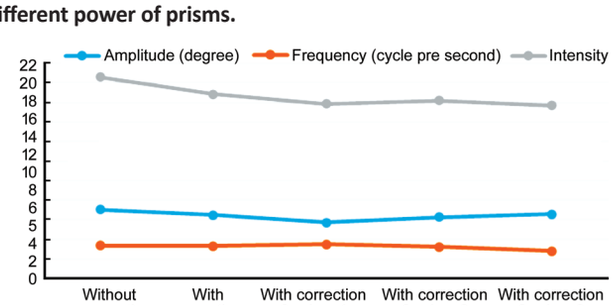

Figure 3 Nystagmus characteristics without, with correction and with different power of prisms.

distant visual acuity in these people, and optical correction in these cases also shows a significant improvement. The addition of prisms to optical correction showed statistically significant improvement in near visual acuity, but clinically, this increase was not significant (the highest increase in near visual acuity was 0.04 logMAR). Although in some studies the reason for the better near vision in people with congenital nystagmus is the decrease in the intensity of nystagmus caused

Table 3 Mean, standard deviation and significance level of the nystagmus

Nystagmus characteristic	Mean±standard deviation					*P* (compared to optical correction)			
	Without correction	With correction	With correction and prism 4	With correction and prism 6	With correction and prism 8	Without correction	With correction and prism 4	With correction and prism 6	With correction and prism 8
Amplitude (degree)	7.02±5.79	6.49±4.23	5.71±4.38	6.27±3.97	6.58±4.58	0.638	0.163	0.872	0.287
Frequency (cycles per second)	3.36±1.44	3.29±1.47	3.47±1.42	3.22±1.57	2.80±0.63	0.477	0.965	0.659	0.362
Intensity	20.63±15.31	18.88±12.49	17.89±13.28	18.23±12.95	17.68±12.19	0.060	0.868	0.629	0.463

by convergence, some other studies reported that this increase can only be due to accommodation[20]. Therefore, the measured visual acuity usually does not depend on moment-to-moment changes in the patient's nystagmus parameters but rather depends on sensory or neurological limitations[21]. The exact mechanism of the above finding is not yet known.

In this study, contrast sensitivity has been investigated at three spatial frequencies 1.5, 3, and 6. Although contrast sensitivity is significantly reduced in people with albinism, optical correction can significantly improve it at all three spatial frequencies[16]. The adding base-out prisms showed a significant improvement in all spatial frequencies compared to the optical correction mode. However, no noticeable difference was found between different amounts of prism. Increasing the amount of prism and convergence did not improve the contrast sensitivity. In another study, it was found that the contrast sensitivity in horizontal gratings was higher than in vertical gratings. The main reason for this finding was the nystagmus movements among these people[22]. However, in this study, there was no difference in sensitivity between horizontal and vertical gratings, also it was more difficult to distinguish oblique gratings in these people.

The study also investigated the characteristics of nystagmus in individuals with albinism, including amplitude, frequency, and intensity, using videonystagmography. The study found no significant difference in any of the investigated parameters of characteristic of nystagmus with and without optical correction. It appears that the increase in visual acuity with optical correction is primarily due to the correction of refractive errors and not due to its effect on nystagmus parameters. However, this study only examined the amplitude, frequency, and intensity of the nystagmus, while previous studies have shown that the quality of foveation periods directly affects visual performance[23]. Reducing the amplitude and intensity of nystagmus can also be effective in terms of aesthetics. Although adding base-out prisms and convergence generally did not show a statistically significant effect on the characteristics of the nystagmus, the study showed a significant decrease in the range parameter in six cases (31.57%) of the studied individuals, as well as significant increase in this parameter (26.31%) was observed in five cases. The difference in the effectiveness of convergence at a distance can be due to the differences in the level of fusion and binocular vision, accuracy in fixation during the videonystagmography test, and even the duration of foveation in these individuals. Wang *et al*'s[24] study was able to show a significant effect in reducing the frequency and intensity of nystagmus, this difference with the present study can be due to the difference in the characteristics of the studied population, including the range of fusion the participants and the causes of nystagmus. Nystagmus is a complication that affects people with albinism, and it has multiple causes. Due to incorrect routing of chiasmatic nerves and other pathological factors, controlling and creating nystagmus can be a complex process. In a study conducted by Serra *et al*[25], they explored the impact of creating convergence at a distance through two methods: base-out prisms and surgery. They found that when looking closely, the duration of foveation increases while the amplitude of the nystagmus remains unchanged. It should be noted that this study only investigated the short-term effect of a prism with the base facing outwards on nystagmus characteristics. Further research is necessary to explore the long-term effects of convergence at a distance.

Finally, this study showed that optical correction with base-out prisms can improve near and far visual acuity, as well as contrast sensitivity, in the patients with albinism and nystagmus. However, no definite positive changes were observed in the improvement of their eye movements.

ACKNOWLEDGEMENTS

Conflicts of Interest: Dashti M, None; **Riazi A,** None; **Ashrafi M,** None; **Rahmani S,** None; **Tabatabaei SM,** None.

REFERENCES

1 Yahalom C, Navarrete A, Juster A, Galbinur A, Blumenfeld A, Hendler K. Visual acuity improvement in children with albinism beyond the first decade of life. *PLoS One* 2024;19(1):e0296744.

2 Nash DL, Diehl NN, Mohney BG. Incidence and types of pediatric nystagmus. *Am J Ophthalmol* 2017;182:31-34.

3 Sayed KM, Mahmoud Abdellah M, Gad Kamel A. Analysis of the refractive profile of children with oculocutaneous albinism versus an age-matched non-albino group. *Clin Ophthalmol* 2021;15:73-78.

4 Moreno-Artero E, Morice-Picard F, Bremond-Gignac D, Drumare-Bouvet I, Duncombe-Poulet C, Leclerc-Mercier S, Dufresne H, Kaplan J, Jouanne B, Arveiler B, Taieb A, Hadj-Rabia S. Management

of albinism: French guidelines for diagnosis and care. *J Eur Acad Dermatol Venereol* 2021;35(7):1449-1459.

5 Liu SY, Kuht HJ, Moon EH, Maconachie GDE, Thomas MG. Current and emerging treatments for albinism. *Surv Ophthalmol* 2021;66(2):362-377.

6 Huang ZJ, Huang DG, Chen WQ. Surgical treatment for proliferative diabetic retinopathy with ocular albinism. *Int J Ophthalmol* 2023;16(3):479-482.

7 Dell'Osso LF. Development of new treatments for congenital nystagmus. *Ann N Y Acad Sci* 2002;956:361-379.

8 Wolf AB, Rubin SE, Kodsi SR. Comparison of clinical findings in pediatric patients with albinism and different amplitudes of nystagmus. *J Am Assoc Pediatr Ophthalmol Strabismus* 2005;9(4):363-368.

9 Papageorgiou E, Lazari K, Gottlob I. The challenges faced by clinicians diagnosing and treating infantile nystagmus Part II: treatment. *Expert Rev Ophthalmol* 2021;16(6):449-465.

10 McLean RJ, Windridge KC, Gottlob I. Living with nystagmus: a qualitative study. *Br J Ophthalmol* 2012;96(7):981-986.

11 Ganança MM, Caovilla HH, Ganança FF. Electronystagmography versus videonystagmography. *Braz J Otorhinolaryngol* 2010;76(3):399-403.

12 Abel LA. Infantile nystagmus: current concepts in diagnosis and management. *Clin Exp Optom* 2006;89(2):57-65.

13 Self JE, Dunn MJ, Erichsen JT, Gottlob I, Griffiths HJ, Harris C, Lee H, Owen J, Sanders J, Shawkat F, Theodorou M, Whittle JP, Nystagmus UK Eye research group (NUKE). Management of nystagmus in children: a review of the literature and current practice in UK specialist services. *Eye* (*Lond*) 2020;34(9):1515-1534.

14 Hassan S, Habib SG, Ebisike PI, *et al*. Pattern of refractive errors in persons with albinism in two states of North-Western Nigeria. *African Journal of Medical and Health Sciences* 2021;20(10):138-144.

15 Yahalom C, Tzur V, Blumenfeld A, Greifner G, Eli, Rosenmann A, Glanzer S, Anteby I. Refractive profile in oculocutaneous albinism and its correlation with final visual outcome. *Br J Ophthalmol* 2012;96(4):537-539.

16 Jhetam S, Mashige KP. Ocular findings and vision status of learners with oculocutaneous albinism. *Afr Vis Eye Health* 2019;78(1):a466.

17 Verkicharla P, Thakur S, Kammari P, Dhakal R, Das AV. Refractive development in individuals with ocular and oculocutaneous albinism. *Int Ophthalmol* 2022;42(7):2007-2015.

18 Jhetam S, Mashige KP. Effects of spectacles and telescopes on visual function in students with oculocutaneous albinism. *Afr Health Sci* 2020;20(2):758-767.

19 Schulze Schwering M, Kumar N, Bohrmann D, Msukwa G, Kalua K, Kayange P, Spitzer MS. Refractive errors, visual impairment, and the use of low-vision devices in albinism in Malawi. *Graefes Arch Clin Exp Ophthalmol* 2015;253(4):655-661.

20 Wybar K. Diagnostic and therapeutic problems in nystagmus. *Br J Ophthalmol* 1969;53(4):224-229.

21 Hanson KS, Bedell HE, White JM, Ukwade MT. Distance and near visual acuity in infantile nystagmus. *Optom Vis Sci* 2006;83(11):823-829.

22 Loshin DS, Browning RA. Contrast sensitivity in albinotic patients. *Am J Optom Physiol Opt* 1983;60(3):158-166.

23 Wang ZI, Dell'Osso LF. Eye-movement-based assessment of visual function in patients with infantile nystagmus syndrome. *Optom Vis Sci* 2009;86(8):988-995.

24 Wang Y, Wu Q, Bai DY, Cao WH, Cui YH, Fan YW, Hu SL, Yu G. Efficacy of surgery on congenital nystagmus with convergence damping. *Zhonghua Yan Ke Za Zhi* 2015;51(11):844-849.

25 Serra A, Dell'Osso LF, Jacobs JB, Burnstine RA. Combined gaze-angle and vergence variation in infantile nystagmus: two therapies that improve the high-visual-acuity field and methods to measure it. *Invest Ophthalmol Vis Sci* 2006;47(6):2451-2460.