(11)

Is binocular vision worth considering in people with low vision?

Czy warto uwzględniać widzenie obuoczne u osób słabowidzących?

Marta Uzdrowska[1], Michael Crossland[2], Anna Broniarczyk-Loba[1]

[1] Department of Binocular Vision Pathophysiology and Strabismus, University Hospital No.1, Medical University of Lodz, Poland
Head: Professor Anna Broniarczyk-Loba, MD, PhD
[2] Moorfields Eye Hospital, London, UK

Summary: In someone with good vision, binocular vision provides benefits which could not be obtained by monocular viewing only. People with visual impairment often have abnormal binocularity. However, they often use both eyes simultaneously in their everyday activities. Much remains to be known about binocular vision in people with visual impairment. As the binocular status of people with low vision strongly influences their treatment and rehabilitation, it should be evaluated and considered before diagnosis and further recommendations.

Key words: low vision, visual impairment, binocular vision assessment, low vision assessment, low vision rehabilitation.

Streszczenie: Widzenie jednooczne nigdy nie zastąpi widzenia obuocznego. U osób słabowidzących widzenie obuoczne często jest zaburzone. Jednakże jest ono często potrzebne tym pacjentom podczas wykonywania codziennych czynności. Wiele aspektów widzenia obuocznego u osób niepełnosprawnych wzrokowo pozostaje wciąż niezbadanych. Ze względu na to, że jakość widzenia obuocznego u osób słabowidzących ma znaczący wpływ na proces ich leczenia i rehabilitacji, powinno ono być badane, zanim zostanie postawiona diagnoza i zostaną ustalone dalsze zalecenia.

Słowa kluczowe: słabowidzenie, niepełnosprawność wzrokowa, ocena widzenia obuocznego, badanie słabowidzących, rehabilitacja słabo widzących.

Introduction

A detailed binocular vision assessment is often omitted in the examination of people with visual impairment. Two reasons for that seem most probable. First, it is often assumed that the pathology causing low vision is the major cause of the visual problems. Second, evaluation of binocular vision may be perceived as difficult and time consuming in people with visual impairment, especially those with central vision loss. It seems obvious that different methods of assessment are needed for this group of people. The aim of this paper is to review the literature on the assessment of binocular vision in people with visual impairment and to provide some basic information about the meaning of binocularity in low vision.

Binocular vision in people with good vision

Binocular vision is commonly described as having three levels: simultaneous perception, fusion and stereopsis (e.g. 1–4). The simplest level – simultaneous perception – means the ability to see two images at the same time, one of which is formed at the retina of the right eye and the other one at the retina of the left eye. For normal binocular vision, each image has to be formed simultaneously at the fovea of the corresponding retina and both images must be superimposed (simultaneus foveal perception). Thanks to the more advanced level of binocular vision called fusion such two images can be blended as one in the brain, provided they are similar enough. Usually two types of fusion are distinguished, namely sensory and motor fusion. Practically, sensory fusion means blending of simultaneously perceived images from both retinas in visual cortex. The eye movement which enables this is called motor fusion. The basis of stereopsis, the most refined level of binocular vision, is a phenomenon named binocular parallax. Because of the interpupillary distance, each eye observes objects from a slightly different perspective. Fusion of such two images results in perception of depth.

Efficient binocular vision comprising simultaneous perception, sensory-motor fusion and stereopsis provides numerous benefits which could not be obtained by monocular viewing only (3–6). Greater visual field in binocular vision, as compared to monocular viewing, facilitates orientation and mobility, and leads to blind spot compensation. Moreover, binocular summation of acuity and low light detection enables easier perception and recognition of stimuli in complex visual tasks. Binocular acuity and contrast summation occur regardless of age when monocular sensitivities are similar (7). In terms of spatial vision, binocularity allows stereopsis to occur. This ensures more precise evaluation of distances, size and position of body and other objects in space, as well as better detection of speed and motion of objects. Binocular clues in depth perception are then much more advanced and dependable than monocular ones, especially in unusual situations.

Binocularity in people with low vision

Even after appropriate refractive correction and the prescription of low vision devices and other rehabilitative aids, people with visual impairment experience difficulties in visual tasks.

Current knowledge about binocular vision in people with visual impairment remains rather restricted (5, 8). Measurement of binocular visual functions in this group of people is often omitted during a routine eye examination, which may lead to ineffective recommendations causing frustration for both the patient and the specialist (9). An important reason for performing

binocular status assessment in people with low vision should be to differentiate between difficulty seeing caused by binocular anomalies and ocular pathology itself, as not all visual problems in these people are connected with the pathological cause of the low vision. Further, full consideration of binocular vision will improve interaction with the environment (5, 9).

As mentioned above, people with good vision benefit most from binocularity when their monocular sensitivities are similar. According to some specialists (5), people with low vision also benefit from binocularity, at least in case of certain visual functions, even when their eyes are affected unequally. Regardless of binocularity level in this group of people, it must be kept in mind that people with low vision often use both eyes in their everyday activities, even if their monocular performance is significantly better than binocular (10).

There are some reports of binocular vision in people with age-related macular degeneration (AMD). Tarita-Nistor and colleagues (5) report binocular contrast inhibition at low and medium spatial frequencies in such people, but simultaneously show that their binocular acuity gain is very similar to that of a control group. Moreover, the authors suspect that binocular acuity summation may be affected by age more than by the AMD itself. However, rivalry processes in their participants were severely disrupted by the disease. Reduced binocular contrast summation and binocular inhibition in a group of people with AMD was also reported by Valberg and Fosse (10). They speculated this was caused by unequal macular scotomas failing to provide adequate light stimulation of corresponding foveal points in both eyes. As a result, proper fixation and retinal correspondence were difficult to maintain, affecting acuity, contrast sensitivity and stereopsis. This translates into difficulty with binocular orientation and reading.

Similarly, Markowitz (11) suggests that tridimensional perception in people with visual impairment is affected by binocular deficiencies. However, he indicates that with reasonable orthophoria peripheral fusion and (as a result) peripheral stereopsis are possible. Good mobility and successful spatial orientation in people with low vision seem to confirm his approach.

In contrast, Rundström and Eperjesi (9) showed that binocular status in people with visual impairment is rather complex. They may experience common binocular vision anomalies such as heterophoria or heterotropia together with their pathology – in other words, muscle imbalance might be partially but not solely attributed to the disease. Consequences of ocular pathology can interfere with binocular vision anomalies, which the patient might have had before the disease occurred. For these reasons binocular vision assessment in low vision seems crucial to differentiate between pathology and binocular vision disorders, as management and rehabilitation techniques in both cases are different.

Evaluation of binocular vision in low vision

A few authors have made an attempt to suggest some methods of assessing binocular vision in people with poor vision. Rundström and Eperjesi (9) conducted their research in people with different ocular pathologies (most of the participants had AMD). Besides a detailed history and symptoms the authors assessed heterophoria and heterotropia at near (using cover test), ocular movements, convergence, retinal correspondence (with Bagolini glasses) and horizontal vergence reserves with prismatic measurement of any observed anomaly. All procedures were performed with a use of a pen torch.

Trauzettel-Klosinski (12) suggests evaluation of the corneal reflexes as a means of assessing fixation. Markowitz recommends using the Titmus Fly as a method for assessing gross stereopsis and the King-Devick test to assess oculomotor function (11). The Titmus Fly booklet consists of three stereoscopic tests (the fly, the animals and the Wirt rings) based on the vectographic technique. Nasally displaced polarised vectographs create an effect of images coming up off the page. Horizontal disparities in the test are progressively more difficult to follow (from 3.600 to 40 sec of arc, when presented at 40 cm). An observer should indicate which elements of the test are seen as elevated. The King-Devick test, developed in 1976, is an objective method of assessing saccadic eye movements and visual tracking. It consists of one demonstration card and three test cards. Each card contains a sequence of single digit numbers that become progressively more difficult to read because of spacing between them. An examined person is asked to read the numbers aloud from left to right on each card as quickly as possible without making any mistakes. The score is based on both number of errors and reading speed.

Rubin and colleagues (7) suggest that monocular and binocular acuity can be an efficient predictor of reading speed in people with visual disability.

Influence of binocular anomalies on low vision rehabilitation

Despite effective methods of treatment and surgery, for many people rehabilitation remains the only possible means of improving visual function (12). Rehabilitation in low vision comprises visual procedures (proper refractive correction, low vision aids, exercises and visual techniques), everyday activities, spatial orientation and special care provided by ophthalmologists, psychologists, social workers and others.

Kabanarou and colleagues (8) reported that people with AMD tend to demonstrate monocular preferred retinal loci (PRLs) on non-corresponding areas of retina in both eyes. Moreover, they often use different retinal locations while viewing a target binocularly and monocularly. Because of this, gaze position is shifted in one or both eyes under binocular compared to monocular viewing conditions. The authors showed that this shift is significantly correlated with the worse eye. These facts may affect binocular behaviour of people with AMD and influence their rehabilitation, particularly for the development or training of eccentric viewing strategies.

According to Rundström and Eperjesi (9), the presence of binocular anomalies makes it difficult, or even impossible, to use potentially useful visual aids. As a result, the patient is often reviewed for further assessment, which may result in monocular occlusion or in use of rule-of-thumb procedures. This is confirmed by Trauzettel-Klosinski (12), who reports that negative effects of improper correction are enhanced while using magnifying aids.

Analysis of many studies (e.g. 13–16) suggests that the most frequently prescribed low vision (LV) aids are magnifying glasses of various kinds and monoculars. A possible reason for that might be that these types of LV devices are easily available and quite easy to use (especially hand magnifiers). However, it does not mean that binocular vision aids cannot be used

ISSN 0023-2157 Index 362646

successfully by people with visual impairment. Despite being prescribed rarely, binocular aids were also dispensed in the studies mentioned above. Moreover, as shown by Fonda in 1970 (17), success rates for binocular vision aids can be quite high. In his research with binocular reading additions with prisms, 56 out of 65 people (88%) judged the corrections to be successful.

Anecdotal reports suggest that some low vision specialists recommend binocular low vision devices quite often, whereas others express their reluctance due to a high failure rate observed in their patients. Overlooking binocular status may be one reason for this poor rate of success. Assuming that binocular low vision aids can influence a user's binocularity, it seems probable that individuals with poor binocularity can experience discomfort using binocular LV devices. For instance, the amount of prisms incorporated in binocular 'high adds' used for reading – regardless of the method of calculation (17–20) – may not entirely compensate for the convergence demand correlated with a short observation distance caused by the power of the glasses. Moreover, the glasses disrupt a physiological relation between accommodation and convergence in user's visual system and thus, can cause heterophoria (20). It seems intuitive that the induced heterophoria superimposes with patient's own binocular status and – depending on its direction – might amplify or reduce subjective symptoms in a user. In addition, as mentioned above, magnification is another factor able to intensify existing visual difficulties and discomfort in people using low vision aids. However, since influence of low vision devices on binocularity in people with visual impairment is rarely considered in both routine examinations and research work, these speculations need further investigation and confirmation.

Conclusion

Although rarely conducted, binocular vision assessment in low vision is extremely important. It can help specialists differentiate between pathology and binocular vision disorders, which may overlap in people with visual impairment. Advantages of such an approach may include properly adjusted treatment and rehabilitation, satisfaction and efficient cooperation of the specialist and the patient. It must be kept in mind that even a small improvement in visual system of people suffering from low vision means a practical change in their quality of life. This is especially valuable for those who cannot be treated effectively and in whom rehabilitation remains the only possible option.

References:

1. Smith G, Atchison DA: *The Eye and Visual Optical Instruments*. Chapter 32 *Binocular vision testing instruments*, pp. 595–598, Cambridge University Press 1997.
2. Howard IP, Rogers BJ: *Seeing in depth*. Vol. 1: *Basic Mechanisms*, Vol. 2: *Stereoscopic vision*, Oxford University Press, Inc., New York 2012.
3. Bhola R: *Binocular Vision*. EyeRounds.org, University of Iowa Health Care, Ophthalmology and Visual Sciences, posted Jan. 18, 2006, updated Jan. 23, 2006
4. Steinman SB, Steinman BA, Garzia RP: *Foundations of Binocular Vision. A clinical perspective*. Chapter 1: *Introduction to Binocular Vision: Why Do We Have Two Eyes?* The McGraw-Hills Companies, USA 2000, pp. 1–8.
5. Tarita-Nistor L, González EG, Markowitz SN, Steinbach MJ: *Binocular function in people with age-related macular degeneration: a review*. Can J Ophthalmol. 2006; 41: 327–332.
6. Sheedy JE, Bailey IL, Buri M, Bass E: *Binocular vs. monocular task performance.* Am J Optom Physiol Opt. 11/ 1986; 63(10): 839–846.
7. Rubin GS, Muñoz B, Bandeen-Roche K, West SK: *Monocular versus binocular visual acuity as measures of vision impairment and predictors of visual disability*. Invest Ophthalmol Vis Sci. 2000; Vol. 41: No. 11.
8. Kabanarou SA, Crossland MD, Bellmann C, Rees A, Culham LE, Rubin GS: *Gaze changes with binocular versus monocular viewing in age-related macular degeneration*. Ophthalmology. 2006; 113(12): 2251–2258.
9. Rundström MM, Eperjesi F: *Is there a need for binocular vision evaluation in low vision?* Ophthal Physiol Opt 1995; Vol. 15, No. 5: pp. 525–528.
10. Valberg A, Fosse P: *Binocular contrast inhibition in subjects with age related macular degeneration.* J Opt Soc Am. 2002; Vol. 19, No. 1: pp. 223–-228
11. Markowitz SN: *Principles of modern low vision rehabilitation*. Can J Ophthalmol. 2006; 41: 289–312.
12. Trauzettel-Klosinski S: Chapter 10: *Rehabilitative techniques, in Handbook of clinical Neurology*, Vol. 102 (3rd series), *Neuro-ophthalmology.* Elsevier, Amsterdam 2011; 102; 263–278.
13. Palmer S: *Factors which influence the use of low vision aids.* Visibility, Glasgow 2005, p. 22.
14. de Carvalho KM, Minguini N, Moreira Filho DC, Kara-José N: *Characteristics of a pediatric low-vision population*. J Pediatr Ophthalmol Strabismus. 1998; 35(3): 162–165.
15. Shuttleworth GN, Dunlop A, Collins JK, James CRH: *How effective is an integrated approach to low vision rehabilitation? Two year follow up results from south Devon*. Br J Ophthalmol. 1995; 79: 719–723.
16. Haddad MA, Lobato FJ, Sampaio MW, Kara-José N: *Pediatric and adolescent population with visual impairment: study of 385 cases*. Clinics 2006; 61(3): 239–246.
17. Fonda GE: *Binocular Reading Additions for Low Vision*. Arch Ophthalmol. 1970; 83(3): 294–299.
18. Fonda GE: *Designing Half-eye Binocular Spectacle Magnifiers*. Surv Ophthalmol. 1991; 36(2): 149–154.
19. Farrall H: *Optometric Management of Visual Handicap*. Blackwell Scientific; St. Louis, Mo.: Distributor, USA, Mosby-Year Book, 1991; pp. 113–116.
20. Katz M: *Convergence Demands by Spectacle magnifiers*. Optom Vis Sci. 1996; 73(8): 540–545.

The study was originally received 20.10.2013 (889925)/
Praca wpłynęła do Redakcji 20.10.2013 r. (889925)
Accepted for publication 09.02.2014/
Zakwalifikowano do druku 09.02.2014 r.

Reprint requests to (Adres do korespondencji):
mgr Marta Uzdrowska
Zakład Patofizjologii Widzenia Obuocznego i Leczenia Zeza
Szpital Kliniczny Nr 1, Uniwersytet Medyczny w Łodzi
ul. Kopcińskiego 22
90-150 Łódź
e-mail: mw.uzdrowska@gmail.com