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Stereoscopic Acuity in Children with Different Degrees of Visual Impairment

Original scientific paper

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Abstract

The aim of the research was to examine the state of stereoscopic visual acuity in children with different degrees of visual impairment. The study included 240 respondents, ranging in age from 3 to 18 years old. All respondents were examined in at the orthoptic-pleoptic department of the Clinic for Eye Diseases at the University Clinical Center in Tuzla. The respondents were divided into three age groups, from 3 to 6 years old, from 7 to 14 years old and third group from 15 to 18 years old. Groups were equal in terms of number of respondents, age and gender. For data processing, SPSS 17.0 for Windows was used, applying descriptive statistics, Mann-Whitney test, p-value and χ2 test. After data analysis, considering results of the research, it can be concluded that, for the degree of visual impairment variable, there is statistical significance across all age groups. The research emphasizes the importance of timely educational and rehabilitative treatment in the rehabilitation process of children with stereovision dysfunction at various degrees of visual impairment.

***Keywords*:** *stereoscopic acuity, degree of visual impairment, visually impaired children*

Vision is the most important sense for perceiving environment, space and navigating within it in humans and higher vertebrates. Early detection and monitoring of eye diseases are crucial for preventing futher vision loss and other vision-related problems that may occur Vukicevic i sar., 2013). Stereoscopic acuity is an indication of binocularity. If visual acuities are good and equal, stereoscopic acuity should also be good. Poor stereoscopic vision in patients with good visual acuity is an indication of poorly compensated ocular motor balance. (Jakovljevic, 2011). Stereoscopic vision or depth perception is the highest level of binocular function, present with orthophoria (normal eye alignment) and good visual acuity in both eyes (Fawcett et al, 2005). Stereovision declines with age despite healthy foveal function in both eyes (Kuang, 2005). Stereoscopic vision is the unique impression of depth, i.e. capability to see in three dimensions (Vishwanath, 2014). There are two different aspects of stereoscopic

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vision, coarse stereopsis and fine stereopsis, which provide depth information of varying degrees of spatial and temporal precision (Barry, 2012). Stereovision can be limited by the reduced visual acuity of the amblyopic eye. Individuals with relatively lower visual acuity may not be able to achieve stereovision (Craven et al., 2013). Fine stereopsis requires both eyes to have good visual acuity to detect small spatial differences (Narasimhani et al., 2012). Individuals with strabismus typically do not have stereoscopic visual acuity (Meier et al., 2014). The lack of stereovision can range from complete absence to varying degrees of impairment. Most common causes of impaired stereovision can be blindness in one eye, amblyopia and strabismus (Xi et al., 2014). Main function of stereovision is spatial orientation. If an individual loses depth perception of space, their life might be in danger. When reaching for an object, it is crucial to accurately assess the distance to that object. If our assessment is not correct, interaction becomes tense and diverts our attention from the main task (Arsenault and Ware, 2004). Children and adults with reduced stereovision scored worse on visuomotor tasks compared to their peers with normal stereovision. (O'Connor et al., 2010). Poor stereovision is characteristic of amblyopy and such deviations in development can be related to reduced motoric skills in children and adults (Weber, 2008).

Aim of the Research

Examine impact of visual impairment degree on stereoscopic visual acuity in relation to age of the respondents.

Methods

Sample of Respondents

The sample of respondents consisted of visually impaired children with different degrees of visual impairment (mild, moderate, and severe forms). A total of 240 respondents (N=240), aged 3 to 18 years, were examined at the orthoptic-pleoptic department of the Clinic for Eye Diseases at the University Clinical Center in Tuzla. The respondents were divided into three age groups: 3 to 6 years old, 7 to 14 years old, and 15 to 18 years old. Respondents were matched in terms of number, age, and gender. The criteria that participants needed to meet to be included in this study sample were: having a visual impairment, having preserved intellectual status, and being chronologically between 3 and 18 years of age.

Variable sample

Variables used in this study can be divided into two groups: anamnestic variables and variables for assessing stereoscopic visual acuity function.

Research Procedure and Measurement Instrument

The research was conducted in the Orthoptic and Pleoptic Department of the Clinic for Eye Diseases at the University Clinical Center Tuzla, based on the implementation of clinical tests designed to detect stereovision dysfunction. The methods used within the study included anamnesis, visual acuity examination, refraction (subjective and objective methods), eye motility and extraocular muscle balance examination (ductio and versio in nine gaze directions, Cover-Uncover test), convergence assessment, measurement of objective deviation (using Synoptophore with alternating occlusion, prism and Cover test), and binocular vision assessment (retinal correspondence and binocular vision tests: Synoptophore, Filtris-Rosi-Bagolini, Worth test, Titmus test, Lang Stereo test (Lang I and Lang II), Bar-Reading test).

Statistical Data Processing

For the observed variables in each examination, for each age group formed, absolute and relative frequencies were calculated, followed by measures of central tendency and measures of dispersion. To test for differences in mean values between groups of participants formed according to specific criteria, non-parametric tests were used, given that the observed characteristics were nominal, and the numerical features did not follow a normal distribution, as determined by the Kolmogorov-Smirnov test. A contingency table and the chi-square test of independence were used to determine the interdependence between

modalities of qualitative variables. To determine the differences in mean values between two independent samples, the non-parametric Mann-Whitney test was used. For determining differences in means among three independent samples, the non-parametric Kruskal-Wallis test was used. For data processing software package SPSS 20.0. was used. All research was conducted at a significance level of 5% (0.05).

Results

In Table 1, the results of testing the influence of the degree of visual impairment on stereoscopic visual acuity are presented, considering the age of the participants. Upon reviewing Table 1, we can see that among children aged 3 to 6 years with moderate visual impairment, 63.33% do not have stereovision. It can also be seen that among children in this age group with severe visual impairment, 20% do not have stereovision, while among children with mild visual impairment in this age group, stereovision was not observed in 16.67% of cases. This means that in this age group of children, there is a significantly higher percentage of children without stereovision with moderate and severe visual impairment compared to children with stereovision. Stereovision was observed in as many as 60% of children aged 3 to 6 years with mild visual impairment. Children with moderate visual impairment had stereovision present in 35% of cases, while the lowest percentage was observed in children with severe visual impairment, with only 5% having stereovision. By reviewing the results of the chi-square test and its corresponding p-value ($P < 0.05$), we can see that there is a significant difference between stereoscopic visual acuity and the degree of visual impairment in children aged 3 to 6 years.

Table 1

Analysis of the influence of the degree of visual impairment on stereoscopic visual acuity in respondents aged 3 to 6 years

AGE	DEGREE OF VISUAL IMPAIRMENT	STEREOVISION					
		Does not exist		Exists		Total	
		F	%	F	%	f	%
3-6 years	Mild	10	16,67	12	60,00	22	27,50
	Moderate	38	63,33	7	35,00	45	56,25
	Severe	12	20,00	1	5,00	13	16,25
	TOTAL	60	100,00	20	100,00	80	100,00
χ^2=14,460; df=2; P=0,001							

Table 2 presents data on testing the influence of the degree of visual impairment on stereoscopic visual acuity in children aged 7 to 14 years. In this group, we can see that the highest percentage of stereovision was observed in children with mild visual impairment at 50%, followed by 15% in children with moderate visual impairment, and 35% in children with severe visual impairment. Regarding the absence of stereovision, the highest percentage was observed in children with severe visual impairment at 46.34%, followed by children with moderate visual impairment at 34.15%, and children with mild visual impairment had the lowest percentage at 19.51%. Therefore, in this group of children with mild visual impairment, a significantly higher percentage of children have stereovision compared to those who do not. Therefore, based on the results of the chi-square test and its corresponding p-value ($P < 0.05$), we can conclude that there is a significant difference between stereoscopic visual acuity and the degree of visual impairment in children aged 7 to 14 years.

Table 2
Analysis of the influence of the degree of visual impairment on stereoscopic visual acuity respondents aged 7 to 14 years

AGE	DEGREE OF VISUAL IMPAIRMENT	STEREOVISION					
		Does not exist		Exists		Total	
		F	%	f	%	f	%
7-14 years	Mild	8	19,51	20	50,00	28	34,57
	Moderate	14	34,15	6	15,00	20	24,69
	Severe	19	46,34	14	35,00	33	40,74
	TOTAL	41	100,00	40	100,00	81	100,00
χ^2=9,089; df=2; P=0,011							

In Table 3 that follows, the results of testing the influence of the degree of visual impairment on stereoscopic visual acuity in children aged 15 to 18 years are presented. From the results, we can see that that children in this group with the highest percentage of stereovision are those with mild visual impairment, reaching as high as 69.44%. The presence of stereovision in children in this age group, with moderate visual impairment, was at 16.67%, and with severe visual impairment, it was 13.89%. The absence of stereovision was most prevalent in children with severe visual impairment, at 46.51%. This was followed by 32.56% of participants who did not have stereovision among children with mild visual impairment. Among children with moderate visual impairment, the absence of stereovision was observed in 20.93% of cases. Therefore, in this group of children, similar to the previous two groups (aged 3 to 6 years and 7 to 14 years), there is a significantly higher percentage of children with moderate and severe visual impairment who do not have stereovision. Conversely, the situation is completely reversed for children with mild visual impairment, where a higher percentage have stereovision. According to the results of the chi-square test and its corresponding p-value ($P < 0.05$), we can conclude that there is a significant difference between stereoscopic visual acuity and the degree of visual impairment in children aged 15 to 18 years.

Table 3
Analysis of the influence of the degree of visual impairment on stereoscopic visual acuity respondents aged 15 to 18 years

AGE GROUP	VISUAL IMPAIRMENT DEGREE	STEREOVISION					
		Does not exist		Exists		Total	
		F	%	f	%	f	%
15-18 years	Mild	14	32,56	25	69,44	39	49,37
	Moderate	9	20,93	6	16,67	15	18,99
	Severe	20	46,51	5	13,89	25	31,65
	TOTAL	43	100,00	36	100,00	79	100,00
χ^2=12,178; df=2; P=0,002							

Discussion

"Stereovision" is a term commonly used to refer to depth perception and the three-dimensional structure derived from visual information resulting from viewing with two eyes of an individual with normally developed binocular vision (*Howard and Rogers, 1995).* Poor stereovision is a characteristic of amblyopia and may be associated with reduced motor skills in children and adults (Greenwood at al., 2015). The aim of this paper was to examine the contribution of stereovision in learning new skills for intercepting/catching in natural environment. Research results have shown that development and utilization of compensatory traces for debt perception is not enough for successful execution of tasks of interception and catching under time constraint and that is because of reduced level of stereovision (Mazyn et al., 2007). A similar study assessing fine motor skills in children with amblyopia showed that children with amblyopia performed significantly worse than their peers without amblyopia on 15 out of 16 fine motor tasks requiring motor skills essential for practical daily tasks. It was concluded that stereovision was significantly reduced in children with amblyopia in comparison to control group of children. The underlying etiology of amblyopia and the level of stereovision development significantly influenced the fine motor skills of the participants. (Webber et al., 2006). Performing motor skills is associated with reduced stereovision, supporting the need for therapy that could facilitate stereovision development. Furthermore, adequate levels of motor skill proficiency can greatly enhance long-term enjoyment of physical activities, participation in sports, and healthy way of life overall (Vujik at al., 2010). Additionally, a study examining stereoscopic visual acuity in children with amblyopia found that over 57.8% of participants had strabismic amblyopia, while 35% had ametropic-refractive amblyopia (Dorn and Petrinovic-Doresic, 2007). Similar research aimed to examine which degree of visual impairment was most prevalent. The results showed that moderate-severe visual impairment was the most common for before orthoptic treatment, observed in 1.73% of participants, while moderate visual impairment was recorded in 2.32% of respondents. (Stanek-Tanaskovic (1991). While research that aimed to examine the impact of anisometropia on stereoscopic visual acuity involved total of 30 healthy adults aged between 18 and 35 years. After analyzing results, all respondents showed a decrease in stereoscopic visual acuity with increasing levels of anisometropia. There was also a significant increase of foveal suppression. Stereoscopic visual acuity decreased proportionally with the degree of anisometropia. The authors concluded that increasing anisometropia caused a significant reduction in stereoscopic visual acuity in all participants (Amiteva et al., 2014)

Conclusion

Based on the results of conducted research, it can be concluded that there is a statistical significance between stereoscopic visual acuity and degree of visual impairment in children aged between 3 and 6 years. Statistically significant difference was observed between stereoscopic visual acuity and degree of visual impairment in children from 7 to 14 years of age. The results of testing the differences in the influence of the degree of visual impairment on stereoscopic visual acuity in children aged 15 to 18 years showed a statistically significant difference. Considering these results, it can be concluded that, no matter the age of the respondents, stereoscopic visual acuity was dependent on degree of visual impairment.

References

Amitava, A.K., Jagriti, R., Waris, A., Akhtar, N., Malakar, M. (2014). The association between anisometropia and binocular visual function. *Institute of ophthalmology, A.M.U. Aligarh, 3 (1):* 211-214.

Arsenault, R., Ware, C. (2004). The importance of stereo and eye-coupled perspective for eye-hand coordination in fish tank VR, *Presence, 13* (5): 549-559.

Bradley, A., Brendan, T., Kathryn, J. (2014). Linking binocular vision neuroscience with clinical practice. *Ophthalmic & Physiological Optics. 34 (2): 125–128.*

Barry, S. (2012). Beyond the critical period. Acquiring stereopsis in adulthood. *Cambridge University Press.*

Craven, A., Tran, T., Gustafson, K., Wu, T., So, K., Levi, D., Li, R. (2013). Interocular acuity differences alter the spatial frequency tuning of stereopsis, *Invest Ophthalmol Vis Sci.*

Celic, M., Dorn, V. (2004). Strabismus and Nystagmus. Zagreb: *Medicinska naklada*

Dorn, Lj., Petrinovic- Doresic, J. (2007). Stereoscopic visual acuity in strabismic and ametropic/ refractive amblyopia. *Ophthalmol Croat. 16* (1): 101.

Fawcett, S.L., Wang, Y.Z., Birch, E. (2005). The critical period for susceptibility of human stereopsis. *IOVS, 46* (2): 521-525.

Greenwood, J., Vijay, T., Bunce, C. (2015). Binocular versus standard occlusion or blurring treatment for unilateral amblyopia in children aged three to eight years, *Cochraine database of systematic reviews, 52*(10)*:*195–204.

Howard, I. P., Rogers, B. J. (1995). Binocular vision and stereopsis. New York: *Oxford University Press*.

Kuang, T.M. (2005). Impact of stereopsis on quality of life. *Eye, (19)*: 540-545.

Jakovljevic, M. (2011). Protocol of optometric examination. Novi Sad, *University of Novi Sad.*

Meier, K., Qiao, G., Wilcox, L.M., Giaschi, D. (2014). Coarse stereopsis reveals residual binocular function in children with strabismus*. Journal of Vision. 14* (10): 698–698.

Mazyn, L.I.N., Lenoir, M., Montagne, G. (2007). Stereo vision enhances the learning of a catching skill, *Exp Brain Res,* (1799: 723-726.

Narasimhan, S., Wilcox, L., Solski, A., Harrison, E., Giaschi, D. (2012). Fine and coarse stereopsis follow different developmental trajectories in children. *Journal of Vision. 12 (9): 219.*

O'Connor, A., Birch, E., Anderson, S., Draper, H. (2010). The functional significance of stereopsis. *IOVS, 51* (4): 2019-2023.

Stanek-Tanaskovic, K. (1991). Kongenitalne anomalije i oboljenja oka u djece kao uzrok ambliopije. Sarajevo: Jugoslovenski oftalmoloski arhiv.

Vishwanath, D. (2014). Toward a new theory of stereopsis*. Psychological Review. 121 (2): 151–178.*

Vukicevic, M., Koklanis, K., Giribaldi, M. (2013). Orthoptics: Evolving to meet increasing demand for eye service. *Sydney: In Insight news.*

Vuijk, P.J., Hartman, E., Scherder, E., Visscher, C. (2010). Motor perfomance on children with mild intellectual disability and borderline intellectual functioning, *Journal of intellectual disability research, 54 (11):* 955-964.

Webber, A.L., Wood, J.M., Gole, G.A., Brown, B. (2008). The effect of amblyopia on fine motor skills in children. *IOVS, 49 (2)*: 594-603.

Webber, A.L., Wood, J.M., Gole, G., Brown, B. (2006). The effect of amblyopia on motor and psychosocial skills in children, *Clin Exp Optom, 89 (2)*: 104-117.

Xi, J., Jia, W.L., Feng, L.X., Lu, Z.L., Huang, C.B. (2014). Perceptual learning improves stereoacuity in amblyopia. *Investigative Ophthalmology and Visual Science 55 (4): 2384–2391.*