

# Comparison between distance and near visual acuity in amblyopes

Heejeong Chun, MD, Young Chun Lee, MD, PhD\* 

## Abstract

To compare distant visual acuity (DVA) and near visual acuity (NVA) in amblyopia and evaluate if NVA can be used to diagnose amblyopia.

A retrospective study was performed on 73 patients diagnosed with amblyopia based on DVA, by measuring their NVA and comparing the DVA and NVA. The NVA was measured by Snellen chart at 30 cm and the DVA was measured by Dr Hahn vision test chart at 5m. The patients' age, type of amblyopia, spherical equivalent, the difference between spherical equivalent and the fellow eye spherical equivalent spherical, and prism diopter (PD) were evaluated and their relationship with the difference between the DVA and NVA was analyzed.

The NVA was significantly better than the DVA in amblyopia ( $P = .000$ ). The difference between the DVA and NVA was not significantly related to the type of amblyopia ( $P = .600$ ) or the patients' age ( $P = .351$ ). Also, the difference between the DVA and NVA was not significantly affected by the spherical equivalent ( $P = .425$ ) or the difference between spherical equivalent and the fellow eye spherical equivalent ( $P = .212$ ) in anisometropia amblyopia, and also not by the PD ( $P = .882$ ) in strabismus amblyopia.

In amblyopes, the NVA was better than the DVA before amblyopia treatment. The difference between the DVA and NVA was not affected by age, type of amblyopia, spherical equivalent, the difference between spherical equivalent and the fellow eye spherical equivalent spherical, or PD. Therefore, it should be taken into consideration that NVA could underestimate the severity of amblyopia and affect the accuracy at diagnosing amblyopia.

**Abbreviations:** D = diopter, DVA = distant visual acuity, NVA = near visual acuity, PD = prism diopter, SE = spherical equivalent, VA = visual acuity.

**Keywords:** amblyopia, distance visual acuity, near visual acuity

## 1. Introduction

Amblyopia is the most common cause of decreased vision in a single eye among children. It causes decreased best corrected vision in 1 or both eyes and decreased stereoscopic vision without structural abnormality in the eye. The prognosis of amblyopia is good if diagnosed and treated early, but it is difficult to treat if not found early. Therefore, early diagnosis is crucial for treating amblyopia in a timely manner.<sup>[1]</sup>

Currently the standard eyesight test performed in ophthalmic clinic measures distant visual acuity (DVA), and amblyopia is

diagnosed based on this DVA. There are opposing study results about the difference between DVA and near visual acuity (NVA) among ophthalmic diseases and even in the same disease. For example, best corrected NVA was better than best corrected DVA in eyes with cataract, but they did not show a significant difference in eyes with age related macular degeneration.<sup>[2]</sup> Some studies<sup>[3,4]</sup> showed NVA was worse than DVA in amblyopic eyes, but there is also the opposing study result.<sup>[5]</sup> However, Christoff et al<sup>[6]</sup> and Wang et al<sup>[7]</sup> stated that there was no significant difference between DVA and NVA in anisometropia amblyopia and strabismus amblyopia. Jin and Chung<sup>[8]</sup> compared prognosis and improvement of visual acuity (VA) in treating amblyopic eyes based on NVA, but there are not many other studies that compared DVA and NVA in amblyopes, especially in Korean ethnicity. Therefore, more studies in this area are needed.

An eyesight test that can evaluate patients' visual acuity precisely is necessary in order to diagnose amblyopia correctly. Jin et al<sup>[9]</sup> reported that DVA was more accurate for detecting high myopia but NVA was better for detecting high hyperopia and high astigmatism. But this was not a study subjected to amblyopes, and as mentioned above, the studies with amblyopes until today have not shown a consensus. In this study, we compared DVA and NVA to evaluate if NVA can be used in diagnosing amblyopia and to assess the factors that affect the difference between DVA and NVA.

## 2. Methods

Medical records of 73 patients diagnosed with amblyopia and 20 children with normal vision at Uijeongbu St. Mary's Hospital were reviewed retrospectively. Seventy-three amblyopic eyes

Editor: Rupsa Basu.

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Department of Ophthalmology, Uijeongbu St. Mary's Hospital, College of Medicine, The Catholic University of Korea, Kyungki-do, Republic of Korea.

\* Correspondence: Young Chun Lee, Department of Ophthalmology, Uijeongbu St. Mary's Hospital, College of Medicine, The Catholic University of Korea, 271 Chunbo-ro, Geumoh-dong, Uijeongbu-si, Kyungki-do, Republic of Korea (e-mail: ycllee@cmcnu.or.kr).

Copyright © 2020 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial License 4.0 (CCBY-NC), where it is permissible to download, share, remix, transform, and buildup the work provided it is properly cited. The work cannot be used commercially without permission from the journal.

How to cite this article: Chun H, Lee YC. Comparison between distance and near visual acuity in amblyopes. *Medicine* 2020;99:46(e23111).

Received: 3 July 2020 / Received in final form: 6 October 2020 / Accepted: 9 October 2020

<http://dx.doi.org/10.1097/MD.0000000000002311>

from the reviewed patients and 40 normal eyes from the children with normal vision were chosen to be the study subjects. The study only included the eyes which had records of both DVA and NVA at their first checkup before any treatment. The NVA was measured by Snellen eye chart at 30 cm, and DVA was measured by Dr.Han light-emitting diode electronic eye chart at 5m. The VA used in the study was the best corrected VA and converted to logarithm of the minimum angle of resolution (logMAR) VA. This study was conducted according to the tenets of the Declaration of Helsinki and was approved by the institutional review board of the Uijeongbu ST. Mary's Hospital. The requirement for obtaining informed patient consent was waived due to the retrospective nature of the study.

The types of amblyopia included in this study were anisometropic, strabismus, combined, and ametropic amblyopia. Anisometropic, strabismus, and combined amblyopia were monocular amblyopia defined as an interocular difference of 2 lines or more in DVA on Snellen eye chart. Ametropic amblyopia was binocular amblyopia with DVA of better eye less than 0.30, and the eye with worse DVA was included as a study subject. Normal eyes from normal children were included in the study only if DVA was 0.0.

Anisometropic amblyopia was defined when there was interocular difference of 1.0 diopter (D) or more in spherical equivalent (SE), or 1.5 D or more in astigmatism using cycloplegic refraction, and not coincide with the definition of strabismus amblyopia. Strabismus amblyopia was defined when there was strabismus of 10 prism diopter (PD) or more in either far or near distance by prism and alternate cover test (PACT), and not coincide with the definition of anisometropic amblyopia. If the amblyopia was included in criteria of both anisometropic and strabismus amblyopia, it was categorized as combined amblyopia. Ametropic amblyopia was classified as amblyopia with hyperopia of +5D or more, myopia of -10D or more, or astigmatism of -2.5D or more which did not fall into anisometropic or strabismus amblyopia category.

Statistical analysis was performed using IBM SPSS Statistics for Windows (version 22.0, IBM Corp., Armonk, NY). Data were expressed as mean  $\pm$  standard deviation. Paired t-test was used to compare DVA and NVA. One-way ANOVA and Pearson correlation were used to find a relationship the difference in DVA and NVA has with types of amblyopia or age. The relation the difference in DVA and NVA has with SE or interocular difference of SE was analyzed by Pearson correlation in anisometropic amblyopia. The difference in DVA and NVA was also analyzed to find a relation with PD by Spearman correlation in strabismus amblyopia. A *P* value  $< .05$  was considered to be statistically significant.

### 3. Results

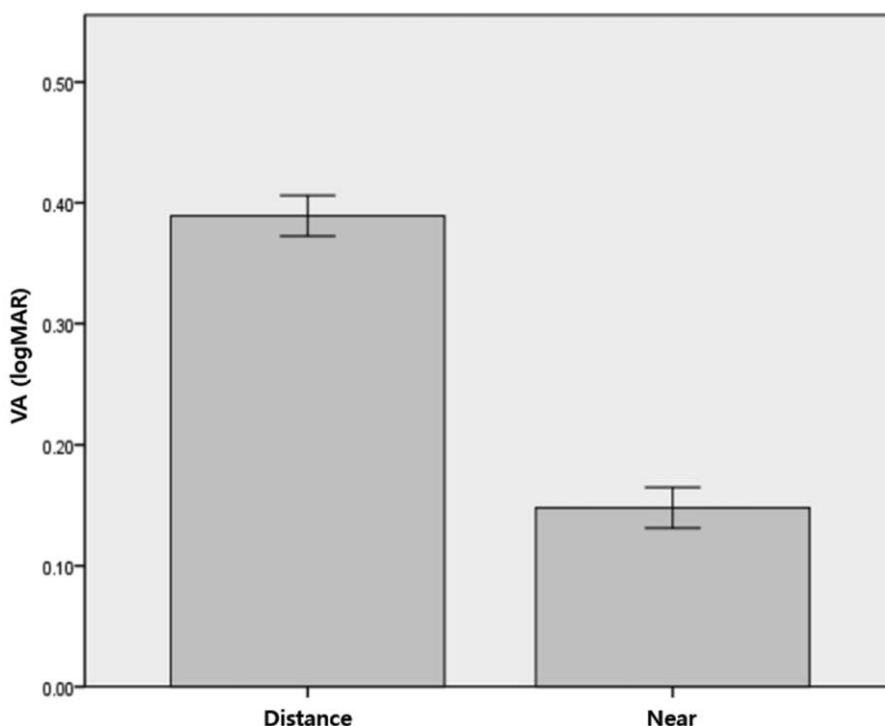
The 20 normal study patients included 8 males and 12 females with mean age of  $6.6 \pm 3.6$  years. They all had both DVA and NVA of 0.0 logMAR. Amblyopic study patients included 38 males and 35 females with mean age of  $8.8 \pm 5.5$  years. Their mean DVA was  $0.39 \pm 0.21$  logMAR and the mean NVA was  $0.15 \pm 0.21$  logMAR, and the mean difference between DVA and NVA was  $0.24 \pm 0.14$  (Table 1).

The amblyopic eyes were classified into 35 anisometropic amblyopia, 14 strabismus amblyopia, 10 combined amblyopia, and 14 ametropic amblyopia. In anisometropic amblyopia, the mean SE of amblyopic eyes was  $2.49 \pm 3.56$  D and the mean interocular difference of SE was  $2.85 \pm 1.97$  D. In combined amblyopia, the mean SE of amblyopic eyes was  $-1.95 \pm 5.80$  D and the mean interocular difference of SE was  $3.00 \pm 2.04$  D. The mean SE of ametropic amblyopia was  $1.11 \pm 5.20$  D. Among the 14 strabismus amblyopia, 8 were exotropia and 6 were esotropia. Exotropia had a mean PD of  $15.13 \pm 5.49$  and esotropia had a mean PD of  $13.5 \pm 6.12$ . Combined amblyopia included 8 exotropia and 2 esotropia, with mean PD of  $24.50 \pm 10.27$  for exotropia and  $13.00 \pm 4.24$  for esotropia (Table 1).

**Table 1**  
Baseline characteristics of study patients.

	Type of amblyopia				
	Overall (n=73)	Anisometropia (n=35)	Strabismus (n=14)	Combined (n=10)	Ametropic (n=14)
Age (yr old)	$8.8 \pm 5.5$ (4–30)	$8.9 \pm 5.4$ (4–30)	$7.9 \pm 4.2$ (4–20)	$11.3 \pm 6.7$ (6–27)	$7.8 \pm 6.0$ (4–20)
Male/female (n)	38/35	22/13	6/8	3/7	7/7
VA (log MAR)					
Distance	$0.39 \pm 0.21$ (0.15–1.00)	$0.38 \pm 0.20$ (0.15–0.82)	$0.33 \pm 0.22$ (0.15–1.00)	$0.53 \pm 0.27$ (0.22–1.00)	$0.37 \pm 0.19$ (0.22–0.82)
Age $\leq$ 6 (n=34)	$0.34 \pm 0.17$ (0.15–1.00)				
Age $>$ 6 (n=39)	$0.44 \pm 0.24$ (0.15–1.00)				
Near	$0.15 \pm 0.21$ (0.00–1.00)	$0.14 \pm 0.18$ (0.00–0.70)	$0.07 \pm 0.09$ (0.00–0.30)	$0.26 \pm 0.36$ (0.00–1.00)	$0.17 \pm 0.20$ (0.00–0.70)
Age $\leq$ 6 (n=34)	$0.10 \pm 0.11$ (0.00–0.40)				
Age $>$ 6 (n=39)	$0.19 \pm 0.26$ (0.00–1.00)				
D-N VA (log MAR)	$0.24 \pm 0.14$	$0.24 \pm 0.14$	$0.26 \pm 0.16$	$0.27 \pm 0.21$	$0.20 \pm 0.10$
Age $\leq$ 6 (n=34)	$0.24 \pm 0.14$				
Age $>$ 6 (n=39)	$0.25 \pm 0.15$				
SE		$2.49 \pm 3.56$ (-7.38–8.00)		$-1.95 \pm 5.80$ (-11.75–7.63)	$1.11 \pm 5.20$ (-7.88–7.75)
SE-FESE		$2.85 \pm 1.97$ (1.00–8.00)		$3.00 \pm 2.04$ (1.00–7.63)	
Type of strabismus					
Exotropia			8	8	
Esotropia			6	2	
Prism diopter (PD)			$14.43 \pm 5.60$ (10–25)	$22.20 \pm 10.34$ (10–45)	
Exotropia			$15.13 \pm 5.49$ (10–25)	$24.50 \pm 10.27$ (12–45)	
Esotropia			$13.5 \pm 6.12$ (10–25)	$13.00 \pm 4.24$ (10–16)	

D-N VA = difference between distance visual acuity and near visual acuity, SE = spherical equivalent, SE-FESE = difference between spherical equivalent and the fellow eye spherical equivalent, VA = visual acuity.



**Figure 1.** Comparison between distance and near best corrected visual acuity in amblyopic eyes. The near visual acuity was significantly better than the distance visual acuity in amblyopia ( $P=.000$ ). VA=visual acuity. logMAR=logarithm of the minimum angle of resolution.

In amblyopic eyes, NVA was significantly better than DVA ( $P=.000$ ) (Fig. 1) (Table 2), and only 26 patients (36%) among the 73 patients diagnosed with amblyopia based on DVA also showed amblyopia with NVA. The difference between DVA and NVA was not significantly related with types of amblyopia ( $P=.600$ ) or age ( $P=.351$ ) (Table 2). In anisometropic amblyopia, the difference between DVA and NVA did not show significant relation with SE of amblyopic eye ( $P=.425$ ) or interocular difference of SE ( $P=.212$ ) (Table 2). Also, the difference of DVA and NVA was not significantly related with the amount of PD ( $P=.882$ ) in strabismus amblyopia (Table 2).

**4. Discussion**

Amblyopia is one of the most important disease in pediatric ophthalmology and it has a good prognosis when diagnosed and treated early. In today’s ophthalmic clinics, amblyopia is diagnosed using DVA, but it is necessary to verify if NVA could be used to diagnose amblyopia as well. Bušić M et al<sup>[10]</sup> showed that testing NVA along with DVA could increase the sensitivity and specificity of amblyopia screening, and Huang et al<sup>[11]</sup> stated the importance of accurately checking NVA for diagnosing amblyopia, especially in children. However, there are not many studies comparing DVA and NVA in patients with amblyopia, and they have not yet reached a consensus on the results. Our

**Table 2**  
**Comparison between distance and near visual acuity and the effect of other factors.**

	Value	VA		D-N VA	P-value
		Distance	Near		
Overall		0.39±0.21	0.15±0.21		.000*
Age (yr old)	8.8±5.5			0.24±0.14	.351†
Type of amblyopia				0.24±0.14	.600‡
Anisometropia				0.24±0.14	
SE	2.49±3.56				.425¥
SE-FESE	2.85±1.97				.212§
Strabismus				0.26±0.16	
PD	14.43±5.60				.882£
Combined				0.27±0.21	
Ametropic				0.20±0.10	

D-N VA = difference between distance visual acuity and near visual acuity, PD = prism dioptre, SE = spherical equivalent, SE-FESE = spherical equivalent and the fellow eye spherical equivalent, VA = visual acuity. \*Paired t-test for distance and near VA; †Pearson correlation test for relation between age and D-N VA; ‡1-way analysis of variance (ANOVA) for the D-N VA among types of amblyopia; ¥Pearson correlation test for relation between SE and D-N VA in anisometropia amblyopia; §Pearson correlation test for relation between SE-FESE and D-N VA in anisometropia amblyopia; £Spearman correlation test for relation between PD and D-N VA in strabismus amblyopia.

study evaluated if NVA could be used as a substitute for DVA in diagnosing amblyopia by comparing DVA and NVA.

In this study, there was not a single normal eye that had worse NVA than DVA, but NVA was significantly better than DVA in amblyopic eyes. However, this difference between DVA and NVA did not show any significant relations with other factors, such as types of amblyopia, age, SE of amblyopic eyes, interocular difference of SE, or PD.

Jin et al<sup>[9]</sup> showed that DVA was more sensitive in checking high myopia and NVA was more sensitive in checking high hyperopia or high astigmatism. O'Donoghue et al<sup>[12]</sup> and Leone et al<sup>[13]</sup> also stated that DVA was not enough for screening refractive errors. In this study, every patient with amblyopia showed significantly better NVA than DVA. And only 26 patients (36%) among the 73 patients diagnosed with amblyopia using DVA also showed amblyopia based on NVA, which showed that NVA alone was not accurate enough to diagnose amblyopia.

It is possible to suggest that unlike adults, children do not cooperate well when measuring DVA, whereas measuring NVA is more favorable to have their attention, leading to better NVA. But according to our study results, the difference between DVA and NVA was not significantly related to age, therefore it can be considered that NVA is not accurate when diagnosing amblyopia in both adults and children.

Also, Jin and Chung<sup>[8]</sup> stated that the VA improvement rate was faster at distance than at near in patients with amblyopia and that it was favorable to measure NVA along with DVA when treating them. However, our study results showed that NVA was not suitable for diagnosing amblyopia in most study patients, therefore checking improvement of amblyopia with NVA would not be as helpful as their study<sup>[8]</sup> suggested.

Our study has some limitations. The study sample was not large enough and it only included patients with Korean ethnicity, which could have led to different results from previous studies with different ethnicities. Also, the eye charts used at distance and near were different which could have caused the difference in VA. Finally, because most patients with amblyopia first visit ophthalmic clinics at younger age, the mean study patients age can be younger and the measurement of VA may be less accurate.

In conclusion, NVA was significantly better than DVA in amblyopic eyes and this difference between DVA and NVA was

not affected by other factors, such as types of amblyopia, age, SE of amblyopic eyes, interocular difference of SE, or PD. Therefore, NVA is not helpful in diagnosing amblyopia since it can underestimate the severity of amblyopia.

### Author contributions

**Writing – original draft:** Heejeong Chun.

**Writing – review & editing:** Heejeong Chun, Young Chun Lee.

### References

- [1] De Santis D. Amblyopia. *Pediatr Clin North Am* 2014;61:505–18.
- [2] Mercado CL, Doroslovacki P, Wang J, et al. Comparison of distance and near visual acuity in patients with vision loss due to cataract. *Int Ophthalmol* 2017;37:169–72.
- [3] Catford GV. Amblyopia: a comparison between distance and near vision. *Br J Ophthalmol* 1956;40:633–5.
- [4] Lennarson L, France T, Portnoy J, Ravault AP, Lent M, et al. A comparison of distance and near vision in amblyopia. *Transactions of the Fifth International Orthoptic Congress Lyon, France: LIPS; 1984; 329–36.*
- [5] Von Noorden GK, Helveston EM. Influence of eye position on fixation behavior and visual acuity. *Am J Ophthalmol* 1970;70:199–204.
- [6] Christoff A, Repka MX, Kaminski BM, et al. Distance versus near visual acuity in amblyopia. *J AAPOS* 2011;15:342–4.
- [7] Wang L, Lu W, Fu T, et al. Clinical observation of near visual acuity and distance visual acuity in amblyopia children. *Ophthalmol China* 2013;22:266–8.
- [8] Jin H, Chung SA. Comparison of improvement rates between distance and near visual acuity in children with unilateral amblyopia. *J Korean Ophthalmol Soc* 2015;56:1432–8.
- [9] Jin P, Zhu J, Zou H, et al. Screening for significant refractive error using a combination of distance visual acuity and near visual acuity. *PloS One* 2015;10:e0117399.
- [10] Basic M, Bjelos M, Petrovecki M, et al. Zagreb amblyopia preschool screening study: near and distance visual acuity testing increase the diagnostic accuracy of screening for amblyopia. *Croat Med J* 2016; 57:29–41.
- [11] Huang YQ, Huang H, Huang RZ. A near-vision chart for children aged 3–5 years old: new designs and clinical applications. *Int J Ophthalmol* 2014;7:457–62.
- [12] O'Donoghue L, Rudnicka AR, McClelland JF, et al. Visual acuity measures do not reliably detect childhood refractive error—an epidemiological study. *PloS One* 2012;7:e34441.
- [13] Leone JF, Mitchell P, Morgan IG, et al. Use of visual acuity to screen for significant refractive errors in adolescents: is it reliable? *Arch Ophthalmol* 2010;128:894–9.