Original Research Article

Study on status of binocular vision in different occupations

Miru Khanal [1]*, Triptesh Raj Pandey [1], Sushil Kumar Sah[2], Shrban Sah[3]

[1]Dept. of Ophthalmology, Mech Netralaya Eye Hospital and Ophthalmic Research Centre, Mechinagar, Nepal
[2]Biratnagar Eye Hospital (BEH), Biratnagar, Nepal
[3]L V Prasad Eye Institue, Eye Institue, Telangana, India

ABSTRACT

Purpose: The study was to identify the various binocular vision dysfunctions in different occupations requiring near work. It affects their near work as well as their performance.

Materials and Methods: The cross-sectional study was conducted among 105 participants. Eye examination included visual acuity assessment, objective and subjective refraction, and details of orthoptic evaluation were done. Data was taken in an Excel sheet and analysis was made using the statistical software IBM SPSS Statistics 22.

Results: Of the total (105) participants, 20-20% were equally drawn from each occupation. the mean value of the positive fusional vergence: recovery (near) was noticed low 7.2 ± 3.5 among the teachers compared to 8.5 ± 4.0 among the tailors, 9.4 ± 3.9 among the bankers and higher 11.7 ± 5.4 among the health workers ($F = 3.38$, $p < 0.05$). The mean of the accommodative facility left eye was high 4.9 ± 2.5 among the health workers compared to 3.6 ± 1.8 among the teachers, 2.7 ± 1.3 among the tailors, and 2.6 ± 1.2 among the bankers ($F = 5.11$, $p < 0.01$).

Conclusions: Near work for 8 hrs can lead to binocular abnormalities' despite of occupation. The majority of the groups were affected by accommodative insufficiency and convergence insufficiency. They need to be provided with therapy according to their condition for better symptom relief.

1. Introduction

Binocular vision dysfunction can cause a wide variety of symptoms including blurriness, diplopia, headache, motion sickness, and poor concentration. In today's society, in which the emphasis on vision is associated with tasks requiring near vision, the visual system may be unable to perform this type of activity efficiently, leading to visual discomfort, fatigue or asthenopia, and impaired visual performance.[1] Convergence insufficiency/excess and divergence insufficiency/excess are the most common binocular vision disorders. Accurate and ineffective pursuits and saccades are indicators of oculomotor dysfunction. Focusing issues typically include accommodating insufficiency, excess/spasm, instability, infacility, and poorly maintained accommodation which leads to asthenopia.[2] In children, the lack of binocular vision is a serious vision impairment that deserves more attention. Mostly eye strain-related problems occur in near vision-demanding jobs and cause symptoms such as headache, strain, fatigue, eye irritation, double vision, and neck pain which results in the inability to focus comfortably near work and decreases quality of life as well as life choices. Parents and patients need to be informed about early detection of these conditions as well as the full range of treatment options. In a study on motorists, it was found

* Corresponding author.
  E-mail address: sushilsahoptom24@gmail.com (M. Khanal).

that stereopsis was more significant in accomplishing better driving performance.[3] More asthenopic symptoms occur on VDT (video display terminal) users as they result in many binocular vision dysfunctions such as accommodative infacility and vision-related problems such as fatigue, headache, eye strain, and blurring of vision.[4–6] In certain occupational populations, vision-related problems are not even known, which leaves inadequate visual performance.[7] Several types of binocular vision disorders, including constant or intermittent strabismus, disorders of maintaining horizontal eye alignment (convergence insufficiency, convergence excess, divergence insufficiency, divergence excess), and vertical heterophoria which results in person due to a lack the binocular qualities like tracking, stereopsis, fusion, convergence and visual motor integration.[1,8] There are certain activities that require binocular vision such as catching the ball, walking, sewing, stepping into stairs, performing surgery, etc.[9] Binocular vision plays a good role in a person's day-to-day tasks depending upon the person's occupation.[10] Due to these various reasons, the status of binocular vision in different occupations would unknowingly provide an overview of the problems that patients face in their workplace.
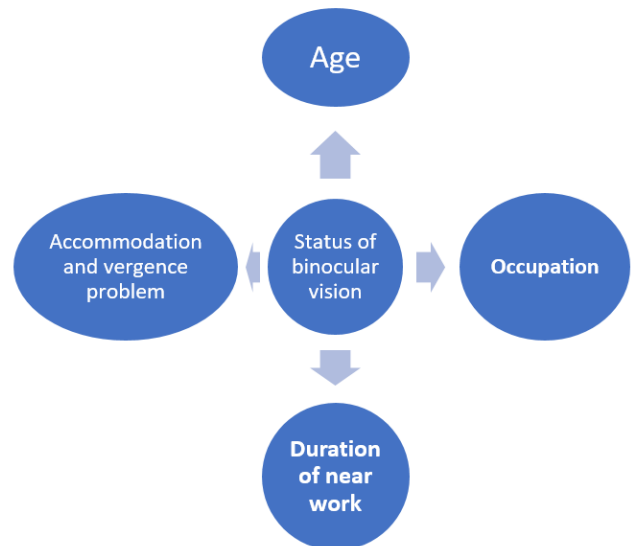
Binocular vision carries great significance in a variety of occupations for better performance of visual tasks in their respective fields, however, in some occupational populations the vision-related problems are not even known leaves to inadequate visual performance. In this study, we will mainly focus on binocular vision dysfunction in different occupations to initiate further plans in such fields.

2. Methods

This cross-sectional descriptive research was conducted among 105 participants of different occupations. The ethics committee of the Nepal Health Research Council (NHRC) approved this research. Those participants who were willing to participate and were satisfying the inclusion criteria were taken for the research. Informed written consent was taken from participants and data was collected in an assessment form (prepared Performa). An orthoptic assessment was done of the participants.

Assessment of refractive error: - Static retinoscopy would be performed target distant chart at 6 m. A subjective exam technique would be performed by means of a monocular fogging method with a cross-cylinder, followed by binocular balancing to a standard endpoint of maximum plus for best visual acuity (BVA). This BVA correction will be named in this work as the result of the subjective refractive exam. The assessment of accommodative and binocular tests would be done with the results of the subjective refractive exam in place. The tests involved the assessment of direction and the magnitude of the distance and the near horizontal and vertical phoria done with a cover test and prism bar, AC/A ratio measured

with gradient methods, positive and negative fusional vergence (smooth and step vergence)with prism bar method, positive and negative relative accommodation, objective and subjective near point of convergence, monocular and binocular accommodative facility with ^2.00 Dioptre lenses using a near card, monocular accommodative amplitude using both pushup and stereopsis measurement with the Titmus stereo test.

Figure 1: Occupational framework

2.1. Rationale/ justification

Binocular single vision carries great importance in order to accomplish certain tasks at one's workplace especially more at near work. Continuous work causes a variety of visual symptoms such as headache, eye strain, blurring of vision, nausea, and fatigue, which results in inadequate output in their respective workplace.[11] The problems of binocular vision dysfunction have increased in the past few years mostly in VDT users and students.[12] Various researches had been done earlier on the effects on binocular vision dysfunction in a few occupations but very few discussions have been made on the status of binocular vision dysfunction in different occupations.

The present study focused on the status of binocular vision dysfunction in different occupations related to near work. The binocular vision problems they face in their workplace would be the reason for inadequate outcomes. So, knowing the status of binocular vision problems would give us an idea of what needs to be done in the future to overcome such problems according to related occupations.

3. Results

This section presents data from the 105 eye participants representing different demographic and service-related data.

Table 1: Background characteristics of participants

Variables	Category	Total N	Total %
Occupation of participants	Tailors	21	20.0
	Teachers	21	20.0
	Bankers	21	20.0
	Health workers	21	20.0
	Others	21	20.0
Age of participants	Up to 24 years	28	26.7
	25 to 29 years	58	55.2
	More than 29 years	19	18.1
Sex of participants	Female	72	68.6
	Male	33	31.4
Complain*	Asthenopia	42	40.0
	Headache	83	79.0
	Blurred vision	33	31.4
Working hour	Up to 8 hours	70	66.7
	More than 8 hours	35	33.3

* Multiple responses

Of the total (105) participants, 20-20% were equally drawn from each occupation group- tailors, teachers, bankers, health workers, and other occupations. The mean age and mode of the participants were 26.4±3.1 and 27 years, respectively, and more than the half (55.2%) were from the age group 25 to 39 years. More than two-thirds (68.6%) of the participants were female 79% having a headache, 40% had asthenopia, and 31% had complaints of blurred vision. The average hour of work of the participants was 8.2±1.5 hours and two-thirds (66.7%) of the respondents' working hours were up to 8 hours.

All the participants were non-user of spectacles, and the majority (62.9%) had no acceptance for right and left eyes. The average stereopsis was 68.3±62.4, and almost half (48.6%) had 40.0. Almost all had worth four dot tests at a distance and near fusion. Similarly, 100% of participants were observed with full extraocular motility at right and left.

Table 2, shows that the accommodative parameters in health workers are comparable to normative value except for the AC/A ratio which is significantly less in all age groups. Bankers have significantly reduced the Amplitude of accommodation while PRA is less in teacher, tailor, and Bankers compared with normative value.

NFV for distance is comparable to Normative value, however, NFV for Near, PFV for both distance and near and vergence facility is significantly less than the normative value in all the groups.

Table 2: Ocular status of the participants

Variables	Unit	Total N	Total %
Ocular history	Non-spectacle user	105	100.0
Acceptance right	0	66	62.9
	0.25	38	36.2
	0.5	1	1.0
Acceptance left	0	66	62.9
	0.25	39	37.1
Stereopsis	40.0	51	48.6
	50.0	6	5.7
	60.0	19	18.1
	70.0	1	1.0
	80.0	12	11.4
	100.0	8	7.6
	140.0	4	3.8
	200.0	2	1.9
	400.0	1	1.0
	500.0	1	1.0
Worth four dot test: distance	Fusion	105	100.0
Worth four dot test: near	Fusion	105	100.0
Extraocular motility: right	Full	105	100.0
Extraocular motility: left	Full	105	100.0

Table 3: Normative data according to subject methods

Methods	Normative finding
Near point of accommodation (NPA)	+8.75
Negative relative accommodation (NRA)	+2.00±0.50
Positive relative accommodation (PRA)	-2.37±1.00
Negative fusional vergence (Distance)	7.0±3.0 (Break) 4±2 (Recovery)
Negative fusional vergence (Near)	13±4 (Blur) 21±4 (Break) 13±5 (Recovery)
Positive fusional vergence (Distance)	9±4 (Blur) 19±8 (Break) 10±4 (Recovery)
Positive fusional vergence (Near)	17±5 21±6 11±7
Accommodative convergence/Accommodation (AC/A)	4:1 ± 2.0
Vergence facility (VF)	(15.0±3.0) cpm
Accommodative facility (AF)	(11.0±5.0) cpm

Table 4: Different types of binocular single-vision anomalies (n=105)

Profession	Health worker	Teacher's	Tailor	Bankers	F	P
NPA	8.9	7.5	7.4	6.6	2.39	0.06
NRA	1.8±0.8	1.7±0.7	1.7±0.7	1.7±0.7	0.19	0.89
PRA	-2.0±0.9	-1.9±1.0	-1.4±0.8	-1.5±0.9	1.99	0.10
NFV						
Blur(D)	0.0	0.0	0.0	0.0		
Break(D)	8.6±1.8	7.6±2.3	7.4±2.7	7.2±2.3	0.92	0.46
Recovery D	6.2±1.8	5.2±2.0	4.3±1.9	4.8±2.0	2.14	0.08
NFV(N)						
Blur	11.9±2.4	9.0±1.5	9.8±1.5	18.8±39.3	1.09	0.37
Break	14.6±2.3	12.3±3.1	13.7±1.7	13.0±2.7	2.10	0.09
Recovery	4±2.2	7.7±2.8	9.1±2.6	8.5±2.6	1.99	0.10
PVF(D)						
Blur	8.0±3.8	6.7±2.5	7.4±3.6	7.9±3.8	0.45	0.77
Break	10.8±3.9	9.7±3.7	9.9±4.2	11.4±6.0	0.72	0.58
Recovery	6.1±3.6	4.7±2.3	5.7±3.2	5.7±3.8	0.46	0.76
PVF(N)						
Blur	14.5±5.5	9.4±3.5	10.2±3.6	11.6±4.2	4.42	<0.01
Break	16.7±5.5	12.5±4.2	14.7±4.6	15.1±5.1	2.06	0.09
Recovery	11.7±5.4	7.2±3.5	8.5±4.0	9.4±3.9	3.38	<0.05
NPC	17.6±7.9	17.4±6.6	16.8±9.1	13.4±5.6	1.10	0.36
AC/A	1.9±0.8	2.3±0.8	1.7±1.2	1.9±0.8	1.10	0.36
VF	8.1±2.3	6.6±2.1	6.3±1.8	6.3±2.6	2.28	0.07
AF	3.3±2.6	1.7±0.7	1.6±0.5	1.7±0.9	3.97	<0.01

4. Discussion

In this study, we analyzed the binocular vision assessment on subjects who had different occupations but all were related to the similar working style that is more focused on near/ intermediate tasks. We observed the binocular vision abnormalities of all the subjects as we included only emmetropes in the study methodology. We observed accommodations and convergence problems in all occupations despite age and gender. However, there was no significant result showing any abnormalities in stereopsis and binocularity (fusion) in any occupation. There was statistically significant abnormalities in accommodations and vergences due to their near task for 8 hours or more in continuity. We found that the mean values of the accommodative range, accommodative amplitude, accommodative facility, and MEM showed lower value than normal ranges that was statistically significant (p<0.05) with difficulty plus lenses. In the vergences test, the majority of the cases showed convergence insufficiency (CI) and accommodative excess (AE) as we found more exophoria in the near than in the distance and low PFV in near than distance in most of the cases.

4.1. Sensory parameters

In this study, we found that all the subjects of different occupations had binocularity (fusion) present as evaluated with the Worth Four Dot Test (WFDT). The stereopsis test showed good stereopsis in all the subjects. We included only emmetropes excluding manifest strabismus/amblyopia in subjects that may be the reason for having good stereopsis and fusion in subjects. A similar study done by Costantino Schiavi et al. showed that good stereopsis and fusion are required to balance binocular single vision as any of the factors get affect the binocular abnormalities can be converted to manifest strabismus. [13]

4.2. Accommodation Parameters

In this study, we found that accommodative amplitude and range were statistically not significant in all the groups according to gender, or work hours. This may be most likely due to the vigorous accommodative work seen in symptomatic adults, as seen in our sample group. However, some studies did observe a reduction in the amplitude of accommodation after near-work exposure for a long period. This could probably be due to the tonic accommodation caused due to prolonged work. We didn't find significant changes in both NRA and PRA. Seo et al., reported a decrease in both NRA and PRA following the use of computers as a visual task in the adult population. On the other hand, Kwon et al., studies in the age group of 36-50 years found a reduction in the ability to relax and stimulate accommodation as the age factor became a major component for such a decline. However, if we were at the facility of accommodations, we found it statistically significant (p<0.01); the MAF and BAF were lower than the normal range. [14]

In the study, the MEM of the subjects in groups was found to lead, lag, and normal accommodations in all groups but the bankers showed more lead and lag of accommodations. A similar study done by Moulakkai et al., the accommodative response change was found to be associated with age and amplitude of accommodation and not just based on handheld electronic devices.[15] The binocular AF was significantly reduced in our study. It was in association with past reference in young adults, by Park et al.,[16] and in middle-aged subjects by Kwon et al, where watching movies was given as a visual task for the subjects using a smartphone.[14] The AC/A ratio showed a significantly low value compared to the normal range. This explained that the AC/A ratio was dependent on accommodation and convergence, which is active in young adults but due to prolonged near-work tasks, it is hampered. A study conducted by Mark et al., found myopic progression in adults and a high AC/A ratio by performing the task at a close distance when using desktop computers.[15]

4.3. Vergence parameters

In this study, we found that the cover and prism cover tests showed more near-exo and distance- Ortho in all occupations compared to normal ranges of vergences. All the occupations showed low PFV and normal NFV in the near. Vergence facility was significantly low with difficulty in BO in all the occupations. According to a study done by London R et al., a decrease in NPC may lead to visual and ocular distress while performing near-visual tasks or in occupations related to near work.[17] This study noted significant changes in the NPC (break). Both NFV and PFV showed significant changes for near concerning breakpoint, which indicated a decline of fusional and accommodative vergence. Therefore, an adequate reserve of both these systems was required for the subject to re-establish binocularity. In a study done by Park et al., a significant decrease in NFV in both presbyopic and non-presbyopic groups was noted.[16] A similar study was done on assessment showed the NPA and fusional vergence declined following continuous text reading at 50 centimeters for 20 mins on an iPad. With regards to desktop computers, past investigations had reported inconsequential vergence changes with more effect in NFV compared to PFV but our study showed significant changes in PFV compared to NFV in the near.[14] The VF measurements showed a significant decline. These results suggested that subjects were not able to tolerate rapid changes in vergence dynamics after long working hours for near. Over a period, this might be because of poor binocular vision and asthenopic symptoms in adults which was similar to our study as our subjects also showed asthenopic symptoms.

4.4. Binocular vision abnormalities (BVA)

A long period of near work leads to convergences and accommodation problems in any occupation. In this study,

bankers showed more convergences insufficiency with accommodative excess compared to other occupations despite age, gender, or working hours. According to genders, males had more accommodative and vergences problems compared to women. Working hours didn't show any statistically significant result in binocular vision abnormalities. In this study, we found that the tailors and bankers were having more accommodative problems compared to the other occupations. Tailors and Bankers had more accommodative insufficiency. Banker had Accommodative Excess (AE) too. Convergences insufficiency is more in Health workers and Bankers. In a study done by Francisco Lara et al.[18] Accommodation excess was the most common anomaly for subjects with purely accommodative dysfunction.

In our study, basic Exophoria was more common in teachers and others whereas Convergences Excess (CE) was more in tailors. A similar study done by cacho-martínez P et al., showed that Exophoria was common in university clinic examinations (Students and professors).[19] Basic Exophoria and Convergence Insufficiency (CI) were more common in all the occupations and a few of them had CE also. In a study done by Francisco Lara et al., convergence excess and convergence insufficiency were common.[18] In another study done by Angel Gracia et al., showed convergence insufficiency and accommodative insufficiency was common in occupations related to near task.[20]

5. Conclusion

Rigorous near work for 8 hrs can lead to binocular abnormalities despite of occupation. The majority of the groups were affected by accommodative insufficiency and convergence insufficiency. They need to be provided with therapy according to their condition for better symptom relief.

6. Limitation of Study

This study is a single hospital-based study. Multicenter or community-based studies my further validate the results of the study.

7. Source of Funding

None.

8. Conflict of Interest

None.

References

1. García-Muñoz A, Carbonell-Bonete S, Cacho-Martínez P. Symptomatology associated with accommodative and binocular

vision anomalies. *J Optom*. 2014;7(4):178–92.

2. Marran LF, Land PND, Nguyen AL. Accommodative insufficiency is the primary source of symptoms in children diagnosed with convergence insufficiency. *Optom Vis Sci*. 2006;83(5):281–9.

3. Bauer A, Dietz K, Kolling G, Hart W, &schiefer U. The relevance of stereopsis for motorists: a pilot study. *Graefes Arch Clin Exp Ophthalmol*. 2001;239(6):400–6.

4. Shrestha GS, Mohamed FN, Shah DN. Visual problems among video display terminal (VDT) users in Nepal. *J Optom*. 2011;4(2):56–62.

5. Dainoff MJ, Happ A, Crane P. Visual fatigue and occupational stress in VDT operators. *Hum Factors*. 1981;23(4):421–37.

6. Blehm C, Vishnu S, Khattak A, Mitra S, Yee RW. Computer vision syndrome: a review. *Surv Ophthalmol*. 2005;50(3):253–62.

7. Untimanon O, Pacharatrakul W, Boonmeepong K, Thammagarun L, Laemun N, Taptagaporn S, et al. Visual problems among electronic and jewelry workers in Thailand. *J Occup Health*. 2006;48(5):407–12.

8. Purcell LR, Nuffer JS, Clements SD, Clausen LR, Schuman DO, Yolton RL. The cost effectiveness of selected optometric procedures. *J Am Optom Assoc*. 1983;54(7):643–7.

9. Abdul-Kabir M, Kumah DB, Koomson NY, Afari C. Prevalence of accommodative insufficiency and accommodative infacility among junior high school students in a Ghanaian town. *J Sci Technol*. 2014;34(2):60–4.

10. Montés-Micó R. Prevalence of general dysfunctions in binocular vision. *Ann Ophthalmol*. 2001;33(3):205–8.

11. Hashemi H, Khabazkhoob M, Nabovati P, Shahraki FA, Ostadimoghaddam H, Faghihi M, et al. Accommodative insufficiency in a student population in Iran. *J Optom*. 2019;12(3):161–7.

12. Porcar E, Martinez-Palomera A. Prevalence of general binocular dysfunctions in a population of university students. Optometry and vision science: official publication of the American Academy of. *Optometry*. 1997;74(2):111–3.

13. Schiavi C, Croce D, Primavera V, Tassi L, Convergence F. Accommodation, Fusion, and Stereopsis: What Keeps the Eyes Aligned in Intermittent Exotropia? *Scientifica*. 2018;2018:9546979.

14. Kwon KI, Kim HJ, Park M, Kim SR. The Functional Change of Accommodation and Convergence in the Mid-Forties by Using Smartphone. *J Korean Ophthal Opt Soc*. 2016;21(2):127–35.

15. Moulakaki AI, Recchioni A, Águila Carrasco AJ, Esteve-Taboada JJ, Montés-Micó R. Assessing the accommodation response after near visual tasks using different handheld electronic devices. *Arq Bras Oftalmol*. 2017;80(1):9–13.

16. Changes in Near Lateral Phoria and Near Point of Convergence After Viewing Smartphones. *J Korean Ophthalmic Opt Soc*. 2012;17(2).

17. Nishanth S, Padavettan C, Vidhyalakshmi S, Madhivanan N, Madhivanan N. Changes in vergence and accommodation parameters after smartphone use in healthy adults. *Indian J Ophthalmol*. 2021;69(6):1487–90.

18. Lara F, Cacho P, García A, Megías R. General binocular disorders: prevalence in a clinic population. *Ophthalmic Physiol Opt*. 2001;21(1):70–4.

19. Cacho-Martínez P, García-Muñoz A, Ruiz-Cantero MT. Diagnostic Validity of Clinical Signs Associated with a Large Exophoria at Near. *J Ophthalmol*. 2013;2013:549435. doi:10.1155/2013/549435.

20. García-Muñoz A, Carbonell-Bonete S, Cacho-Martínez P. Symptomatology associated with accommodative and binocular vision anomalies. *J Optom*. 2014;7(4):178–92.

Author biography

Miru Khanal, Master in Optometrist ⬤ https://orcid.org/0009-0009-6275-1209

Triptesh Raj Pandey, - ⬤ https://orcid.org/0000-0002-1587-6481

Sushil Kumar Sah, Master in Optometrist

Shrban Sah, Master in Optometrist