Original Article

# Binocular vision parameters in chronic heavy alcoholics: Short-term outcomes of alcohol detoxification

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## ABSTRACT

**Background:** Alcohol consumption is rising in developing countries such as India, and alcohol addiction has systemic and ocular impacts. This study aimed to investigate the binocular functions of chronic heavy alcoholics before and after alcohol detoxification.

**Methods:** A prospective before–after study was designed and conducted at Treda De-Addiction Centre, Bengaluru, India. Males in the age range of 30–40 years who had been alcohol addicts for more than six years and met the inclusion criteria were recruited. We performed a routine optometric examination followed by detailed binocular vision assessment, including accommodative, vergence, and oculomotor tests on the first day of rehabilitation and one month after initiation of rehabilitation.

**Results:** Twenty-five males with of the age (mean ± standard deviation [SD]) 36.24 ± 4.33 years were evaluated. The pre- and post-detoxification mean ± SD of the monocular (right eye: 5.98 ± 3.50, 6.60 ± 3.49; left eye: 6.18 ± 3.69, 7.10 ± 3.78) and binocular accommodative facility (7.10 ± 3.93, 7.40 ± 4.51) did not change significantly (all $P > 0.05$). Eighteen (72%) of the participants had non-strabismic binocular vision anomalies (NSBVA), among whom the accommodative infacility and convergence insufficiency were higher in frequency and remained constant after alcohol detoxification. Furthermore, the binocular vision parameters showed no statistically significant difference between the pre- and post-detoxification values (all $P > 0.05$).

**Conclusions:** The binocular vision parameters did not change significantly after one month of alcohol detoxification in the chronic heavy drinkers. Most long-term alcoholics had NSBVA with no change after rehabilitation, indicating that short-term alcohol detoxification may not aid in the recovery of binocular parameters. However, further validation is required. Assessing the impact of vision therapy in addition to a longer period of abstinence can confirm or refute the persistence of observed effects of chronic alcohol consumption on binocular functions and NSBVA in this population.

## KEYWORDS

alcohol, heavy alcoholic, non-strabismus binocular vision anomalies, alcohol detoxification, binocular vision, accommodation, convergence

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## INTRODUCTION

Binocular single vision is an important aspect of vision and is enabled by aligning the eyes through precise muscle force regulation by the oculomotor system, which is controlled by the brain [1]. Compromised ocular muscle coordination can degrade binocular single vision [1]. Alcohol abuse affects 8.5% of the American population and is widespread in India. Alcohol dependence or alcohol abuse impairs brain structure, physiology, and functions. Ethanol-induced brain lesions in neuroimaging studies may explain ensuing cognitive and motor impairments [2-4]. However, the prevalence of alcohol consumption in different regions of India varies widely, ranging from 3.8 to 65.8% [5].

Alcohol consumption alters most visual functions although not to the same degree. Alcohol intake is associated with a broad spectrum of ocular disorders, such as permanent scotoma or vision loss, sluggish pupils, impaired contrast sensitivity, abnormal eye movements, impaired color perception, acute methanol optic neuropathy, optic disc edema, retinal ganglion cell damages, permanent scotoma or vision loss, cataract, dry eye syndrome, corneal epitheliopathy, altered intraocular pressure, age-related macular degeneration, diabetic retinopathy, retinal vein occlusion, central serous chorioretinopathy, functional retinal disease, and asteroid hyalosis [6-8].

Alcohol consumption negatively impacts the accommodative function and vergence system, and potentially leading to the deterioration of stereoacuity. Near stereopsis, distance stereopsis, and contrast sensitivity are deteriorated and retinal image quality is adversely affected by alcohol intake. Negative impacts on accommodation dynamics, such as deterioration of the mean velocity, velocity peak, response time, accommodative microfluctuations, and impaired accommodative facility were reported following alcohol consumption [9-11]. However, to date, the effects of long-term consumption of alcohol on binocular functions have been understudied.

Here, we aimed to compare binocular vision parameters in chronic heavy alcoholics before and after supervised abstinence from alcohol ingestion.

## METHODS

A prospective before–after study was designed and conducted at the Treda Alcohol De-Addiction Rehabilitation Centre, Bangalore, Karnataka, India between August 2018 and January 2019 using a nonprobability consecutive sampling technique. The study was approved by the Institutional Human Ethical Committee of Chitkara University, Punjab, India. The purpose of the study and procedures used were explained to potential participants and written informed consent obtained from each participant prior to their recruitment.

Individuals with a history of diabetes and/or hypertension, ocular diseases which affected the binocular functions, strabismus or history of surgery to correct strabismus, amblyopia, nystagmus, vertical deviation of more than 1 prism diopter, best-corrected visual acuity not equal to 20/20 in each eye, significant refractive error, contact lens use, history of vision therapy, and/or those who were unwilling to participate were excluded. Finally, twenty-five male patients aged 30–40 years who had been alcohol addicts for more than six years, fulfilled the inclusion criteria.

All participants were heavy drinkers. The Substance Abuse and Mental Health Services Administration defined heavy drinking as binge drinking for more than 5 days in the past 30 days (binge drinking is defined as drinking more than four drinks on the same occasion on at least 1 day in the past 30 days) [12]. The definition of one standard drink is a drink with 14 g (0.6 fl oz) of pure alcohol. This is found in 12 ounces of regular beer, 5 ounces of wine, and 1.5 ounces of distilled spirits, which usually have alcohol concentrations of approximately 5, 12, and 40%, respectively [13].

The participants were asked to report the presence of any of the following symptoms of non-strabismic binocular vision anomalies (NSBVA): blurred vision, headache, ocular discomfort, ocular or systemic fatigue, double vision, motion sickness, and inability to concentrate during task performance [14, 15]. Moreover, we investigated for the presence of any accommodative anomalies (accommodative excess [AE], accommodative insufficiency [AI], accommodative insufficiency secondary convergence excess [AICE], and accommodative infacility [AIF]), vergence anomalies (convergence insufficiency [CI], convergence insufficiency secondary to accommodative insufficiency (CIAI), and psuedoconvergence insufficiency [PCI]), basic exophoria, basic esophoria, and vertical phoria, in the pre- and post-rehabilitation assessment. The mean values of collected data were compared with the normative values [16-18], and NSBVA was diagnosed accordingly.

The participants underwent anterior and posterior segment examinations by an expert optometrist (K.N.). Binocular vision functions were assessed in the following sequence: Snellen visual acuity chart, Reduced Snellen near vision chart (N-notation), Titmus fly (Titmus stereo fly; Bernell Co., Mishawaka, IN, USA), torchlight, retinoscope (Welch Allyn, Auburn, NY, USA) and direct ophthalmoscope (Welch Allyn), Bernell prism bar (Bernell Co.), stopwatch, accommodative flippers, Vergence flippers (12 prism base out and 3 prism base in), Modified Thorington chart for distance and near phoria measurement (Bernell Co.). All binocular functions were assessed on the day of admission to the rehabilitation center. The rehabilitation interventions included yoga, prayer, relaxation therapy, recreational activities, psychotherapy, group therapy, and grief therapy. On the thirty-first day after rehabilitation, the same binocular vision parameters were measured under the same environmental conditions and time of day as in the initial assessment. The mean values of collected data were compared with the normative values.

The data were entered into a Microsoft Excel spreadsheet and imported into IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA) for further statistical analysis. The data was normally distributed; thus, pre- and post-rehabilitation results were compared using a paired *t*-test. Data were presented as frequencies (number and percentage) or mean (standard deviation[SD]). The significance level was set at $P < 0.05$.

## RESULTS

Twenty-five individuals with an age mean ± SD of 36.24 ± 4.33 years were evaluated. The mean ± SD of the duration of alcohol consumption was 12.56 ± 6.00 years. Of the 25 participants, 14 (56%) had emmetropia, 4 (16%) had myopia, 2 (8%) had astigmatism, and 5 (20%) had presbyopia. During the sensory evaluation, fusion was maintained for both distance and nearness. The mean (median) near stereoacuity with the Titmus fly test was 148.13 seconds of arc (120 seconds of arc). Figure 1 shows the frequency of eye deviation for distance and nearness detected during cover-uncover testing in pre- and post-alcohol rehabilitation assessments. Ocular alignment in the majority of participants was found to be orthotropic both in distance and nearness and was comparable in the pre- and post-rehabilitation assessment.

Table 1 compares the accommodative functions in the pre and post-alcohol rehabilitation assessments. The positive relative accommodation (PRA) was found to be a little less and the binocular accommodative facility (AF) was greater than normal mean values [16]. As shown in Table 1, the mean values of accommodative functions did not change significantly 31 days after the rehabilitation (all $P > 0.05$).

Figure 2 compares the AF before and after alcohol detoxification for the right, left, and both eyes. The pre- and post-detoxification mean ± SD of the monocular (right eye: 5.98 ± 3.50, 6.60 ± 3.49; left eye: 6.18 ± 3.69, 7.10 ± 3.78) and binocular AF (both eyes: 7.10 ± 3.93, 7.40 ± 4.51) did not change significantly (all $P > 0.05$). Likewise, Table 2 shows that the vergence functions remain unchanged before and after detoxification assessments (all $P > 0.05$), and the near point of convergence (NPC) before and after detoxification assessments is clinically greater than previously reported average range [16].

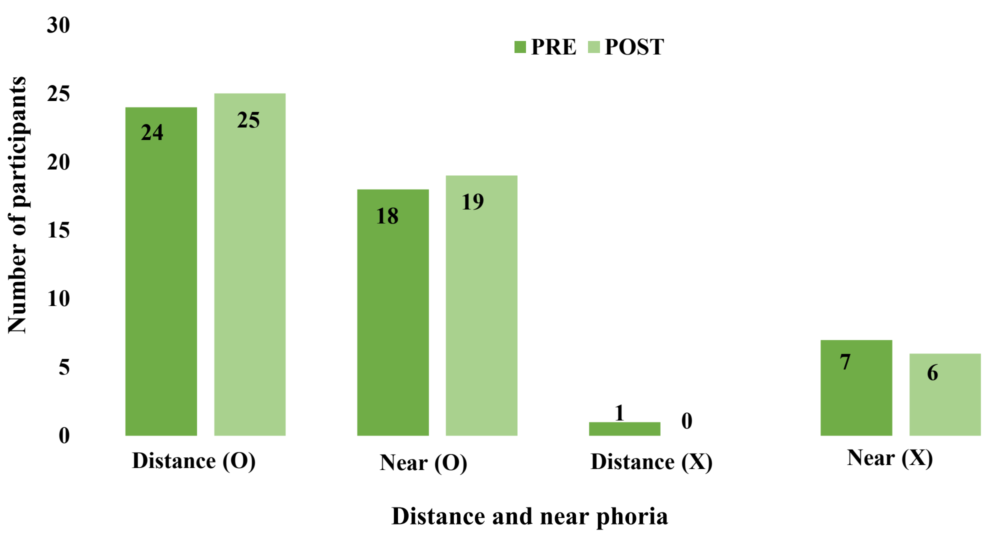


**Figure 1. Frequency of eye deviation detected during cover-uncover testing in pre- and post-alcohol detoxification assessments in chronic heavy alcoholics. Abbreviations: Pre, pre-detoxification; Post, day 31 post-detoxification; O, orthotropic; X, exophoria.**

**Table 1. Comparison of accommodative functions in pre- and post-alcohol detoxification assessments in chronic heavy alcoholics**

| Accommodation tests | | Pre (Mean ± SD) | Post (Mean ± SD) | *P*-value* |
|---|---|---|---|---|
| NPA (D) | OD | 7.41 ± 1.23 | 7.48 ± 1.29 | 0.684 |
| | OS | 7.58 ± 1.40 | 7.42 ± 1.33 | 0.354 |
| | OU | 8.53 ± 1.56 | 8.22 ± 1.62 | 0.301 |
| NRA (D) | | 2.41 ± 0.46 | 2.40 ± 0.45 | 0.857 |
| PRA (D) | | -2.15 ± 0.61 | -2.20 ± 0.59 | 0.327 |
| AF (CPM) | OD | 5.98 ± 3.50 | 6.60 ± 3.49 | 0.170 |
| | OS | 6.18 ± 3.69 | 7.10 ± 3.78 | 0.169 |
| | OU | 7.10 ± 3.93 | 7.40 ± 4.51 | 0.688 |
| MEM (D) | OD | 0.77 ± 0.45 | 0.81 ± 0.53 | 0.382 |
| | OS | 0.79 ± 0.47 | 0.85 ± 0.77 | 0.365 |

**Abbreviations: Pre-, pre-detoxification; Post, day 31 post-detoxification; SD, standard deviation; NPA, near point of accommodation; D, Diopters; OD, right eye; OS, left eye; OU, both eyes; NRA, negative relative accommodation; PRA, positive relative accommodation; AF, accommodative facility; CPM, cycle per minute; MEM, monocular estimation method.*Pre- and post-rehabilitation results were compared using a paired *t*-test.**

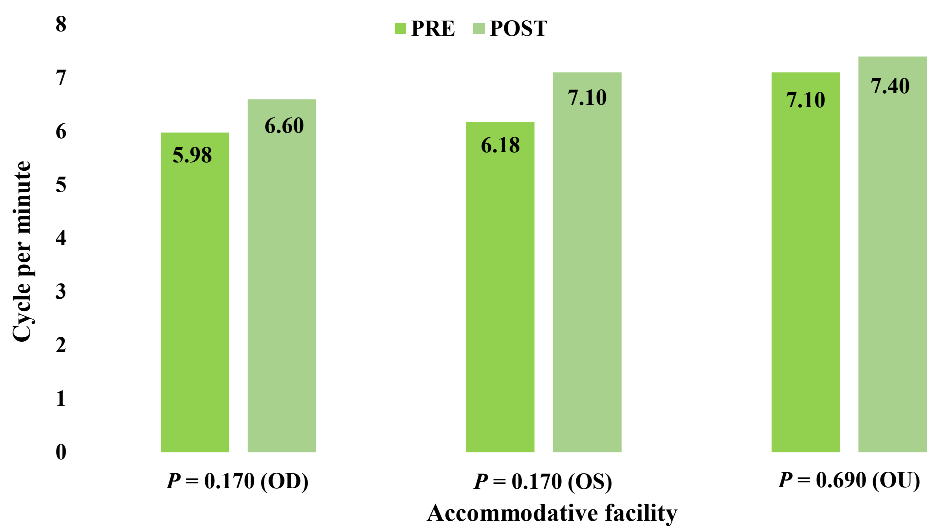


**Figure 2. Comparison of accommodative facility (AF) in pre- and post-alcohol detoxification assessments in chronic heavy alcoholics. Abbreviations: Pre, pre-detoxification; Post, day 31 post-detoxification; OD, right eye; OS, left eye; OU, both eyes. Note: Pre- and post-rehabilitation results were compared using a paired *t*-test.**

**Table 2. Comparison of vergence functions of chronic heavy alcoholics between pre- and post-alcohol detoxification assessments**

| Vergence Tests | | Pre (Mean ± SD) | Post (Mean ± SD) | *P*-value* |
|---|---|---|---|---|
| NPC (cm) | Break | 9.88 ± 5.25 | 9.32 ± 4.70 | 0.487 |
| | Recovery | 14.96 ± 7.08 | 13.86 ± 5.62 | 0.421 |
| Distance NFV (PD) | Break | 7.32 ± 3.19 | 6.76 ± 3.73 | 0.558 |
| | Recovery | 5.33 ± 3.10 | 4.75 ±3.76 | 0.549 |
| Near NFV (PD) | Blur | 7.50 ± 3.33 | 8.00 ± 3.54 | 0.598 |
| | Break | 13.48 ± 5.04 | 13.60 ± 5.16 | 0.915 |
| | Recovery | 10.00 ± 4.32 | 10.20 ± 4.60 | 0.842 |
| Distance PFV (PD) | Blur | 8.00 ± 4.00 | 7.33 ± 3.05 | 0.423 |
| | Break | 13.24 ± 8.57 | 12.32 ± 5.70 | 0.578 |
| | Recovery | 8.58 ± 3.78 | 8.83 ± 4.85 | 0.747 |
| Near PFV (PD) | Blur | 10.67 ± 1.15 | 10.67 ± 1.15 | 1.000 |
| | Break | 22.88 ± 11.68 | 21.36 ± 11.54 | 0.388 |
| | Recovery | 15.10 ± 6.48 | 14.00 ± 6.92 | 0.344 |
| VF(CPM) | | 12.56 ± 3.33 | 12.56 ± 2.87 | 1.000 |

**Abbreviations: Pre, pre-detoxification; Post, day 31 post-detoxification; SD, standard deviation; NPC, near point of convergence; cm, centimeter; NFV, negative fusional vergence; PD, prism diopters; PFV, positive fusional vergence; VF, vergence facility; CPM, cycle per minute.*Pre- and post-rehabilitation results were compared using a paired *t*-test.**

The NSBVA showed no difference before and after the rehabilitation, and its percentage remained constant. Of the 25 participants, 18 (72%) had NSBVA, including AE (n = 1, 4%), AI (n = 1, 4%), AICE (n = 1, 4%), AIF (n = 7, 28%), CI (n = 5, 20%), CIAI (n = 1, 4%), and PCI (n = 2, 8%).

## DISCUSSION

We found a high frequency of NSBVA with a 12.56 years mean heavy alcohol consumption duration among the heavy alcoholics studied here, which remained constant post-detoxification. Furthermore, accommodative functions, vergence functions, and AF remained unchanged 31 days after detoxification.

Chronic alcohol consumption is hazardous to the health [19, 20]. The ocular complications of alcohol intake have been a point of considerable debate. A broad spectrum of ocular impacts of alcohol consumption has been described [6-8]. Wegner et al. [21] found that visual short-term memory was not affected significantly in recently detoxified patients. The impairment of visual motion perception and speed discrimination persist three weeks of detoxification. Attentional capacities were impaired during early detoxification but recovered within three weeks of abstinence. The results imply that visuoperceptive sub-skills may improve at different times after alcohol detoxification [21]. This may explain the persistence of chronic alcohol consumption effects on binocular functions 31 days after detoxification as observed in our study.

In a critical narrative review, Creupelandt et al. [22] reviewed articles on visuoperceptive impairments in severe alcohol use disorder (AUD) in the last seven decades. The included studies investigated the long-term effects of chronic alcohol intake. The authors highlighted the general paucity of research on the long-lasting visuoperceptive abilities among individuals with AUD. Additionally, the recruitment of heterogeneous groups with different comorbidities, various rates of lifetime alcohol consumption, and diverse abstinence periods made it challenging to draw comprehensive conclusions [22]. Both parvocellular and magnocellular damage have been reported in participants with AUD. Reduced static amplitude of accommodation, slight mydriasis, peripheral parasympathetic neuropathy, isolated ametropia, cataract, or age-related macular degeneration are associated with alcohol consumption. More serious deficits have been noted in individuals with a long history of severe AUD [22]. This narrative review by Creupelandt et al. highlighted a lower recovery rate in older participants with severe AUD, mainly among those with the longest severe AUD periods [22]. The authors proposed interventions such as cognitive training programs in addition to visuoperceptive exercises to enhance the recovery of visuoperceptive deficits in severe AUD [22]. In the current study, the mean duration of alcohol consumption is 12.56 years, which may explain the lack of recovery in binocular vision parameters after one month in detoxified alcoholic men. However, implementing interventions such as vision therapy may enhance the recovery rate, which should be addressed in future studies.

In a descriptive cross-sectional study, Pocas et al. [23] recruited alcohol consumers with a minimum duration of 6 years of dependence and ex-consumers with an abstinence duration ranging from 6 months to more than 10 years. The participants were of either sex with an age range of 31 to 76 years (mean age: 52.47 years). Phorias were detected in 18.13% of the participants; 64.52% of whom were consumers. Altered NPC values were found in 69.76% of the consumers. Increased periods of abstinence resulted in improved NPC values, but the association was not statistically significant. Near stereoacuity was altered in 62.75% of the participants (58.85% of the consumers). Near negative fusional vergence (NFV) and positive fusional vergence (PFV) was altered in 36.24 and 45.64% of the participants, respectively (68.51 and 73.53% of these respective alterations occurred in the consumers). Overall, changes in visual function were more common in the consumer than the abstainer group [23]. The participants of the current study were also alcohol consumers with a minimum duration of 6 years of heavy alcohol consumption; however, only males were included. The mean near stereoacuity was 148.13 seconds of arc, which is less than the average range [24]. The frequency of phorias in pre- (n [%], 7 [28%]) and post-detoxification assessments (n [%], 6 [24%]) were higher than those in Pocas's study (18.13% among all participants: 17.35% in consumer group versus 20% in the abstinent group). The mean post-detoxification values for NPC, near and distance NFV, and PFV did not change significantly in the current study. These results signify that alcohol-associated deficits in binocular vision parameters may persist long after alcohol detoxification, though further validation is essential.

Even among professional skippers, a significant decrease in accommodation was found under the influence of acute alcohol consumption [25]. Casares-Lopez et al. [11] investigated the effects of two different doses of alcohol following consumption in accommodation dynamics. Overall, they recorded a deterioration of accommodation dynamics. A significant impairment of AF was found in both intake conditions [11]. We compared accommodative functions in before and one month after alcohol detoxification in chronic heavy alcoholics. Interestingly, even one month after supervised abstinence from alcohol ingestion, the mean values of the accommodative functions did not change significantly. The PRA was found to be a little less and the binocular AF was greater than normal mean values [16]. The findings indicate that alcohol consumption effects on accommodative functions may persist even after one month following abstinence.

Casares-Lopez et al. [9] assessed the visual performance of 37 male and female participants (aged 20–56 years) by measuring the contrast sensitivity function, halo perception, stereopsis, and retinal image quality under the influence of acute alcohol consumption. The breath alcohol concentrations of all of the participants were beyond the legal alcohol limit for driving in most countries. Significant impairment of all visual functions was recorded following alcohol consumption. The mean baseline near stereoacuity, which was measured using the Frisby Near Stereotest, was 18.2 seconds of arc and was significantly impaired after alcohol consumption (38.6 seconds of arc) [9]. Using the Titmus fly Stereotest, we also noted impaired near stereoacuity in our participants. This study did not directly compare acute and chronic alcohol consumption effects. However, our findings indicate the negative effects of alcohol consumption on vision functions and stereopsis. The precise time course of recovery can be determined with a longer follow-up study.

Campbell et al. showed that alcohol intake could affect the static subjective accommodation function [26]. Two groups of participants, 37 males with chronic alcohol consumption and 37 age-matched controls who consumed less than 21 units of alcohol per week, were compared. The mean (SD) duration of alcohol abuse in chronic alcoholics was 5 (15) years. On admission, the mean amplitude of accommodation for the alcoholics (4.7 diopters) was lower than that of the controls (5.9 diopters). A significantly smaller slope of the age-dependent wane in accommodation values was recorded for the alcoholics as compared to that for the controls (0.215 versus 0.332 diopters per year). This impairment was greater in the younger alcoholics. Following a week of forced abstinence, the authors found no measurable change in accommodation. A larger resting pupil diameter was detected in the alcoholics than in the controls, who had a higher incidence of small pupils. They concluded that chronic alcohol intake adversely affects subjective static accommodation, mainly in younger alcoholics [26]. In the current study, the PRA was found to be slightly less and the AF greater than normal mean values [16]. The mean values of accommodative functions did not change significantly at day 31 following alcohol detoxification.

The prevalence of NSBVA from February 2014 to December 2015 among schoolchildren in urban and rural areas of the state of Tamil Nadu in southern India were 31.5 and 29.6%, respectively. The most prevalent anomaly was CI (16.5 and 17.6% in urban and rural settings, respectively) [27]. However, our literature survey revealed an information gap is studies on NSBVA in chronic alcoholics. The present study found NSBVA to be present in 72% of the participants, which is higher than its reported prevalence among Indian schoolchildren [27]. Out of 72% of participants who had NSBVA, 28% had AIF, 20% had CI, 8% had PCI, and an equal number (4%) had AI, AE, and CIAI or AICE, which remained the same before and after alcohol detoxification. AIF was the most frequent anomaly among long-term heavy alcoholics. This decrease in response may be due to the capacity of alcohol to impair the impulse conduction and transmission in excitable cells of the nervous system [28].

To the best of our knowledge, this is the first study to report on NSBVA percentages in a selected group of chronic heavy alcoholics in India. This paper may serve as a reference for this specific group of chronic heavy alcoholics despite the study being limited by its small sample size. Binocular functions, such as sensory, motor, accommodation, and vergence functions, did not change significantly 31 days after the supervised abstinence. This indicates that short-term detoxification may not be successful in the recovery of theses abilities. Measuring binocular vision functions in people with a history of alcohol consumption may be helpful in early intervention to avoid further deterioration of binocular functions. In the future, longitudinal studies including a broad spectrum of drinkers need to be conducted to provide more details in this regard. Furthermore, studies on longer follow-ups and interventions, such as vision therapy, could confirm or refute the persistence of observed effects of chronic alcohol consumption on binocular functions and NSBVA.

## CONCLUSIONS

The binocular vision parameters did not change significantly after one month of alcohol detoxification in chronic heavy alcoholics. Most long-term alcoholics who participated in this study had NSBVA, which indicates that long-term heavy alcohol consumption may cause NSBVA and that short-term alcohol detoxification may not recover the binocular abilities. However, further validation is required in this regard. The importance of binocular vision assessment in the period of detoxification in this population is worth noting. The effect of vision therapy and longer abstinence periods need to be studied to confirm the benefits of such intervention in chronic heavy alcoholics.

## ETHICAL DECLARATIONS

**Ethical approval:** This study was approved by the Institutional Human Ethical Committee of Chitkara University, Punjab, India. The aim of the study and procedures used were explained to potential participants and written informed consent obtained from each participant prior to their recruitment.
**Conflict of interests:** None

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