African Vision and Eye Health
ISSN: (Online) 2410-1516, (Print) 2413-3183



# The effect of acute ingestion of alcohol at 0.05% and 0.10% blood respiratory alcohol concentration on heterophoria

**Authors:**
Alvin J. Munsamy[1]
Ryan S. Hamilton-Hoskins[1]
Talent Bero[1]
Philiswe P. Ximba[1]
Daina Govender[1]
Maryam Soni[1]
Lindokuhle Majola[1]

**Affiliations:**
[1]Discipline of Optometry, University of KwaZulu-Natal, Westville Campus, South Africa

**Corresponding author:**
Alvin Munsamy,
munsamya1@ukzn.ac.za

**Dates:**
Received: 18 Dec. 2015
Accepted: 30 May 2016
Published: 19 Aug. 2016

**How to cite this article:**
Munsamy AJ, Hamilton-Hoskins RS, Bero T. et al. The effect of acute ingestion of alcohol at 0.05% and 0.10% blood respiratory alcohol concentration on heterophoria. Afr Vision Eye Health. 2016;75(1), a342. http://dx.doi.org/10.4102/aveh.v75i1.342



**Introduction:** Alcohol ingestion has a significant effect on speech, vision and coordination. The legal limit for driving under the influence in South Africa is 0.05% blood alcohol concentration (BAC), whilst intoxication is considered to occur at 0.10% BAC. The aim of our study was to investigate the effect of acute alcohol ingestion of 0.05% and 0.10% blood respiratory alcohol concentration (BrAC) on heterophoria.

**Methodology:** The effect of alcohol ingestion on the oculomotor systems of 31 subjects was the basis of this quasi-experimental quantitative study. Various parameters were compared before and after the ingestion of 10% alc red wine. The Alcoscan ALP-1 breathalyser test was used as an indicator of BrAC. Heterophoric, fusional vergence and near point of convergence (NPC) measurements were measured during an experimental phase at 0.05% and 0.10% BrAC levels and a control phase at a 0% BrAC.

**Results:** Mean changes in heterophoria for distance showed an increase of 1.13Δ ± 1.34Δ and 2.19Δ ± 1.70Δ towards esophoria at a BrAC of 0.05% and 0.10% respectively. At near, the results showed a mean increase of 0.84Δ ± 1.75Δ and 0.97Δ ± 1.70Δ towards exophoria at a BrAC of 0.05% and 0.10% respectively. There was a further mean decrease in the positive and negative fusional vergences as well as receded NPC break and recovery measurements at 0.05% and 0.10% BAC.

**Conclusion:** It can be concluded that a BrAC of 0.05% has a minimal effect on heterophoria. However, at a BrAC of 0.1% there is a significant effect on heterophoria, fusional vergences and the NPC. This may or may not be clinically significant.

## Introduction

Alcohol consumption has also been known to have a significant impact on bodily function and cause disturbances within our visual system. In 2013, a Global Status Report on Road Safety in South Africa reported that 31.9% per 100 000 deaths were related to drunk driving.[1] The focus of the study was to use blood respiratory alcohol concentration (BrAC) to determine the effect of alcohol on the oculomotor system at a breath alcohol concentration (BAC) level of 0.05%, the South African legal limit, and at a BAC level of 0.10%, the level of intoxication or drunkenness.

Alcohol is maximally absorbed in the small intestine.[2] The rate of absorption is dependent on the concentration of alcohol consumed, gender, body weight, body fat and also the availability of food in the digestive tract.[3] The liver metabolises approximately one standard drink per hour, with a standard drink being one bottle of beer or one glass of wine.[4] The BAC can be measured by bodily fluids such as blood, saliva, urine, sweat and from a breath sample. Alcohol concentration can also be predicted using mathematical models of BAC taking into account factors that affect absorption and metabolism.[3]

Kerr et al.[5] defined the scientific and legal definition of drunkenness, based on the BAC, as intoxication of 0.15% BAC (150 mg/dL) or higher. The legal BAC limit in many countries including South Africa is 0.05% measured by a breathalyser, where 0.05% BAC[6] is equivalent to two glasses of 125 mL of wine with an alcohol concentration of 12.00% for a moderate consumer. Moderate consumer of alcohol equates to one glass of wine daily for women and two glasses daily for men.[7] BrAC is measured by a breathalyser; the legal limit is 0.25 mg/L (BrAC) which equates to 0.05% (BAC), whilst 0.50 mg/L (BrAC) equates to 0.10% (BAC). Thus this qualifies the interchangeable use of BrAC and BAC in majority of the studies reviewed. Breath analysis for ethanol is used as an index of BAC based on the principle that ethanol in the blood is represented proportionally by the ethanol in the deep alveolar air.[8]

BAC of as little as 0.05% could lead to frontal lobe sedation resulting in impairment of reasoning and judgement.[9] A level of 0.10% BAC causes sedation of speech and vision, therefore causing impaired coordination, vision and driving skills.[9] Nystagmus manifests at BAC of 0.80%.[10] It is safe to conclude that further investigation is required to determine precise involvement of different alcohol levels on the oculomotor system of the eyes.

Heterophoria is the latent deviation of the line of sight of both eyes, which manifests in the absence of all stimuli of fusion.[11] The normal heterophoria is 1 (±1) prism diopters (Δ) exophoria (XOP) for distance, 3Δ (±3) for near and 0.5Δ hyper or hypophoria.[11]

Heterophoric patients are usually asymptomatic because heterophoria is compensated by fusional reserves. Heterophoria can become decompensated which leads to blur; difficulty changing focus; intermittent diplopia; reduction in stereopsis; asthenopia and headaches.[11] Fusional vergence can break down due to an uncorrected refractive error, deterioration in the patients' health, fatigue, cycloplegic agents and alcohol intoxication which leads to the decompensation of heterophoria.[11,12]

Hogan and Linfield[2] conducted a study at an unspecified BAC and found a mean change of 2.45Δ towards esophoria at distance and 1.15Δ towards exophoria at near. Wilson and Mitchell[13] found an increase in esophoria at distance and an increase in exophoria at near with a BAC of 0.06% on 10 subjects.

A more recent study by Devereux and Pitt consisted of two groups, a low dose group of 17 subjects with a BAC of 0.023% and a moderate dose group of 16 subjects with a BAC of 0.055%.[8] The low dose group had an increase of 0.50Δ esophoria at distance and an increase of 1.30Δ exophoria at near. In the moderate dose group, a mean change of 1.00Δ towards esophoria at distance and 2.10Δ towards exophoria at near occurred. According to the above mentioned studies,[8,13] alcohol ingestion has little or no effect on the vertical heterophoria.

In 1972, it was found that an increase in BAC results in a decreased AC/A ratio and in 1985 Hogan et al.[2,14] found a decrease in negative fusional reserves, but at unspecified BAC levels. Devereux and Pitt,[8] stated that the ingestion of alcohol causes a receded near point of convergence (NPC) with a mean change of 2.25 cm for BAC that ranges from 0.068% to 0.075%.[8] Chronic alcohol ingestion causes a decrease in the amplitude of accommodation,[15] an increase in pupil size,[15] and a reduction of visual acuity at distance (6 m).[13] Hogan and Gilmartin did not find change in ocular accommodation during acute ingestion of alcohol.[14]

It is clear from the above studies that alcohol has an impact on our visual system. The legal BAC limit for driving varies between countries with the UK and the USA being 0.08% and African countries such as Nigeria and South Africa being 0.05%, Ghana 0.08% and Kenya 0.00%.[6] This study seeks to inform clinicians and policy makers about the effect of specified levels of alcohol ingestion on heterophoria and the possible impact on measures related to binocular vision.

The study aims to determine the effect of acute ingestion of alcohol at 0.05% and 0.10% BrAC on heterophoria in individuals between 18 and 30 years of age with no clinically significant binocular vision disorders.

## Methodology

The study design is quasi-experimental, designed as an interrupted time series. A convenient sampling technique was used to determine the participants for the study from the student population at a university in South Africa. The first 31 subjects (17 males and 14 females) who were light to moderate consumers of alcohol weighing 40 kg – 100 kg and no clinical binocular vision disorders were admitted to the study.

All participants had best corrected visual acuity of 6/6 with no ocular pathology. Also, all participants had an aided or unaided compensated heterophoria of 1Δ XOP±1, and 3Δ XOP±3 at distance and near, respectively, with a NPC of less than or equal to 10 cm. Participants were not under any form of medication and had no systemic diseases.

Breath analysis was used as an indicator of BAC based on the principle that ethanol in the alveolar air is proportional to ethanol in the blood. Accounting for analytical variability and biological considerations, BrAC ranges of 0.045% – 0.054% and 0.095% – 0.110% were permitted.[16] The sensitivity of the breathalyser had an average accuracy of 0.005% BrAC and a certificate of calibration confirmed the device to be in good working condition at levels of 0.020% BrAC, 0.050% BrAC and 0.100% BrAC.

The objectives were to determine the effect of 0.05% and 0.10% BrAC, using a breathalyser, on the distance and near heterophoria, using the Maddox rod at distance and the Slant Modified Thorington test for near.

Ethical permission was obtained before commencement of the study from the School of Health Science Research and Ethics Committee (SHREC) at the University of KwaZulu-Natal (RSA). The study was conducted in accordance with the declaration Of Helsinki. All participants signed an informed consent. The researchers ensured all participants personal safety and a paramedic was available in the event any participants required medical attention.

A preliminary study consisting of seven males and seven females, each having weight categories ranging in 10-kg increments from 40 kg to 100 kg, was used to confirm the amount of alcohol each weight range required to obtain a BrAC of 0.05% and 0.10%. The variables to determine the amount of alcohol ingestion (mL) were functions of weight, gender and fasting for 2 h prior to ingesting the first measure of alcohol. Each participant was given an initial dosage of

150 mL[4] of natural sweet red wine (Namaqua Johannesberger; alc 10%). A study from Brown University[4] was used as a guide to determine the amount of alcohol that needed to be ingested for a particular weight and gender to obtain the target BrAC values.

## Study process

The study commenced with a screening phase to ensure participants' adherence to the study's inclusion criteria. A case history was conducted to rule out systemic disorders and assess alcohol consumption behaviour. Snellen visual acuity and auto-refractions were performed to rule out poor acuity, and ophthalmoscopy was performed to rule out ocular pathology. Distance and near cover test ruled out strabismus, whilst distance Maddox rod and the near modified Thorington assessed heterophoria measurements. Prism-bar step vergence measurements assessed the reserves, the red-lens NPC assessed NPC measurements and the height and weight measurements were taken to satisfy the inclusion criteria as stated previously.

In previous studies which assessed clinical tests of heterophoria measurement, the Maddox rod[17] was found to be the most reliable method and the modified Thorington[18] was considered the most repeatable. Red lens NPC is more sensitive in identifying convergence disorders.[19] Since the present study involved repeated measurement of the patients' heterophoric postures, clinical tests which yielded the best test–retest results were imperative.

The breathalyser measurements were obtained using the Alcoscan ALP-1. Breathalysers are calibrated regularly to maintain accuracy and are considered valid testing devices because they detect and measure current alcohol levels.[3] To ensure standardisation of data collection the optometric measurements were repeated by the same examiners, under the same examination conditions during the screening phase and the experimental and control phases.

## Experimental group measurements

Pre-test visual measurements were obtained prior to consumption of alcohol to compare results before and after consumption. Optometric investigation at 0.05% and 0.10% BrAC comprised Maddox rod (4 m) to obtain the distance heterophoria and the Slant Modified Thorington test was administered at 40 cm to obtain the near heterophoria. Step vergence using a prism-bar was used to measure fusional reserves at distance and near and the NPC was measured using a red lens. All measurements were taken as an average of three readings.

A BrAC measurement of 0% was obtained before ingestion of the alcohol beverage to ensure the subject was not exposed to prior alcohol ingestion that could contaminate results. Male and female participants were to consume red wine (10% alcohol) to reach a BrAC of 0.05%. The amount of alcohol to be consumed was based on the results of the preliminary study.

Following consumption of alcohol, a 15-min waiting period was allocated prior to the breathalyser measurement to avoid residual mouth alcohol which would contaminate BrAC measures.[16] Breathalyser measurements confirmed a BrAC of 0.05%, at which point the necessary visual investigation began.

Subjects consumed more alcohol than predicted in the preliminary study to increase the BrAC from 0.05% to 0.10%. The BrAC measurements were continued until the subject reached a BrAC of 0.10%.[16] At this point, the second set of visual measurements were obtained. The times at which the required BrAC levels of 0.05% and 0.10% reached were recorded for each participant for the subsequent control measurements.

## Control group measurements

The 31 participants served as their own controls. These measurements were done on a different day subsequent to the experimental measurements. The researchers used a non-alcoholic beverage, that is, red grape juice to obtain control measurements. Participants consumed an equivalent amount of a non-alcoholic beverage, red grape juice, as the alcoholic beverage during the experimental phase. Optometric measurements were repeated as per the experimental phase at the time recorded to reach 0.05% and 0.10% BrAC in the experimental phase. Breathalyser measurements to confirm 0% BrAC was recorded prior to the initiation of the first optometric investigation and after consumption of the non-alcoholic beverage for both optometric control measurements.

## Data analysis

The results were represented as mean changes in measurements using paired *t*-tests to analyse control and experimental groups. Measurements comprised the distance and near heterophoria, positive and negative fusional vergences and the NPC measurements. All these measurements were obtained at a breath alcohol concentration of 0.00%, 0.05% and 0.10%. All results including 95% confidence interval using Microsoft Excel.

## Results

Table 1 shows the mean change in the horizontal heterophoria at distance. In Tables 1–6, a minus sign indicates an exophoria whilst a positive value indicates an esophoria. It was observed that there was a mean change of 1.13Δ ± 1.34Δ and 2.19Δ ± 1.70Δ in an esophoric direction for BrAC levels of 0.05% and 0.10%, respectively, at a 95% confidence interval. There was no mean change in the vertical heterophoria at distance for BrAC levels of 0.05% and 0.10%.

Table 2 shows the mean change in the horizontal heterophoria at near. It was observed that there was a mean change of 0.84Δ ± 1.75Δ and 0.97Δ ± 1.70Δ in an exophoric direction for BrAC levels of 0.05% and 0.10% respectively at a 95% confidence interval. The vertical heterophoria at near showed a mean change of 0.05Δ ± 0.20Δ towards hyperphoria for the experimental groups; however, these results were not statistically significant at 0.05% and 0.10% BrAC.

As shown in Table 3 there is a mean decrease of 3.29Δ ± 6.27Δ and 4.10Δ ± 6.60Δ of positive fusional vergence at distance for 0.05% and 0.10% BrAC respectively at 95% confidence interval.

As shown in Table 4 there is a mean decrease of 3.42Δ ± 8.19Δ and 7.13Δ ± 8.75Δ of positive fusional vergence at near for 0.05% and 0.10%, respectively. At 0.05% BrAC, the results were not statistically significant; however, at 0.10% BrAC there was statistical significance at 95% confidence interval.

As shown in Table 5, there is a mean decrease of 1.61Δ ± 2.60Δ and 3.19Δ ± 3.02Δ of negative fusional vergence at distance for 0.05% and 0.10% BrAC, respectively, at 95% confidence interval.

Table 6 shows a mean decrease of 0.45Δ ± 3.60Δ and 2.19Δ ± 3.36Δ of negative fusional vergence at near for 0.05% and 0.10% BrAC respectively. At 0.05% BrAC the results were not statistically relevant; however, at 0.10% BAC there was statistical significance at a 95% confidence interval.

Table 7 shows that at distance, 93.75% and 6.25% of the population sample showed compensation and a decompensation of heterophoria, respectively, at a BrAC of 0.05%. Furthermore, 74.50% and 25.50% of the population sample showed compensation and decompensation of heterophoria, respectively, at a BrAC of 0.10%. All results were statistically significant at a 95% confidence interval.

At near, 97.20% and 2.80% of the population sample showed compensation and decompensation of heterophoria, respectively, at a BrAC of 0.05%. Furthermore, 81.25% and 18.75% of the population sample showed compensation and decompensation of heterophoria, respectively, at a BrAC of 0.10%. All results were statistically significant at a 95% confidence interval.

Table 8 shows a mean increase of 2.53 cm ± 2.67 cm and 5.27 cm ± 5.57 cm for the break and recovery values, respectively, at a BrAC of 0.05%. Also shown is a mean increase of 6.76 cm ± 8.96 cm and 11.84 cm ± 11.83 cm for the break and recovery values, respectively, at a BrAC of 0.10%. All these changes occurred at a 95% confidence interval.

## Discussion

It was found that there was a significant increase in esophoria of 1.13Δ and 2.19Δ at distance for 0.05% and 0.10% BrAC respectively as seen in Table 1. This was in agreement with Hogan and Gilmartin[14] who found a mean change of 1.40Δ esophoria at distance and Devereux and Pitt[8] who found

**TABLE 1:** Mean change in horizontal heterophoria at distance for blood respiratory alcohol concentration of 0.05% and 0.10%.

| BrAC (%) | Group ($n$ = 31) | Mean change (Δ) | s.d. | $p$ |
|---|---|---|---|---|
| 0.05 | Experimental | 1.13 | 1.34 | 0.000 |
| | Control | -0.10 | 0.75 | |
| 0.1 | Experimental | 2.19 | 1.70 | 0.000 |
| | Control | 0.10 | 0.40 | |

A negative value indicates a change in exophoria direction; a positive value indicates a change in esophoria direction.
Each group consisted of the same 31 participants who were involved in both the control measurement using grape juice and the alcohol-induced experiment using red wine.
BrAC, blood respiratory alcohol concentration.

**TABLE 2:** Mean change in horizontal heterophoria at near for blood respiratory alcohol concentration of 0.05% and 0.10%.

| BrAC (%) | Group ($n$ = 31) | Mean change (Δ) | s.d. | $p$ |
|---|---|---|---|---|
| 0.05 | Experimental | -0.84 | 1.75 | 0.006 |
| | Control | 0.06 | 0.36 | |
| 0.1 | Experimental | -0.97 | 1.70 | 0.000 |
| | Control | 0.23 | 0.56 | |

A negative value indicates an exophoria direction; a positive value indicates an esophoria direction.
BrAC, blood respiratory alcohol concentration.

**TABLE 3:** Mean change for positive fusional vergence at distance for blood respiratory alcohol concentration levels of 0.05% and 0.10%.

| BrAC (%) | Group ($n$ = 31) | Mean change (Δ) | s.d. | $p$ |
|---|---|---|---|---|
| 0.05 | Experimental | -3.29 | 6.27 | 0.036 |
| | Control | -0.87 | 4.19 | |
| 0.10 | Experimental | -4.10 | 6.60 | 0.008 |
| | Control | -0.58 | 5.01 | |

A negative value indicates a decrease; a positive value indicates an increase.
BrAC, blood respiratory alcohol concentration.

**TABLE 4:** Mean change for positive fusional vergence at near for blood respiratory alcohol concentration levels of 0.05% and 0.10%.

| BrAC (%) | Group ($n$ = 31) | Mean change (Δ) | s.d. | $p$ |
|---|---|---|---|---|
| 0.05 | Experimental | -3.42 | 8.19 | 0.160 |
| | Control | -0.87 | 5.28 | |
| 0.10 | Experimental | -7.13 | 8.75 | 0.005 |
| | Control | -1.16 | 6.72 | |

A negative value indicates a decrease; a positive value indicates an increase.
BrAC, blood respiratory alcohol concentration.

**TABLE 5:** Mean change for negative fusional vergence at distance for blood respiratory alcohol concentration levels of 0.05% and 0.10%.

| BrAC (%) | Group (*n* = 31) | Mean change (Δ) | s.d. | *p* |
|---|---|---|---|---|
| 0.05 | Experimental | -1.61 | 2.60 | 0.003 |
| | Control | 0.77 | 2.40 | |
| 0.10 | Experimental | -3.19 | 3.02 | 0.000 |
| | Control | 0.19 | 2.75 | |

A negative value indicates a decrease; a positive value indicates an increase.
BrAC, blood respiratory alcohol concentration.

**TABLE 6:** Mean change for negative fusional vergence at near for blood respiratory alcohol concentration levels of 0.05% and 0.10%.

| BrAC (%) | Group (*n* = 31) | Mean change (Δ) | s.d. | *p* |
|---|---|---|---|---|
| 0.05 | Experimental | -0.45 | 3.60 | 0.200 |
| | Control | 0.77 | 3.17 | |
| 0.10 | Experimental | -2.19 | 3.36 | 0.001 |
| | Control | 0.87 | 3.89 | |

A negative value indicates a decrease; a positive value indicates an increase.
BrAC, blood respiratory alcohol concentration.

**TABLE 7:** Population sample percentage of the compensated and uncompensated heterophoria at 0.05% blood respiratory alcohol concentration and 0.10% blood respiratory alcohol concentration for distance and near.

| Distance and near | *N* | BrAC (%) | Compensated (%) | Uncompensated (%) |
|---|---|---|---|---|
| Distance | 31 | 0.05 | 93.75 | 6.25 |
| | 31 | 0.1 | 74.50 | 25.50 |
| Near | 31 | 0.05 | 97.20 | 2.80 |
| | 31 | 0.1 | 81.25 | 18.75 |

BrAC, blood respiratory alcohol concentration.

**TABLE 8:** Mean change for Near Point of Convergence at blood respiratory alcohol concentration levels of 0.05% and 0.10%.

| BrAC (%) | Group (*n* = 31) | NPC break | | | NPC recovery | | |
|---|---|---|---|---|---|---|---|
| | | Mean change (cm) | s.d. | *p* | Mean change (cm) | s.d. | *p* |
| 0.05 | Experimental | 2.53 | 2.67 | 0.000 | 5.27 | 5.57 | 0.000 |
| | Control | -0.02 | 0.16 | | 0.20 | 1.29 | |
| 0.10 | Experimental | 6.76 | 8.96 | 0.000 | 11.84 | 11.83 | 0.000 |
| | Group | -1.30 | 1.95 | | 0.30 | 1.30 | |

A positive value implies numerical increase in Near Point of Convergence; a negative value implies numerical decrease in Near Point of Convergence.
BrAC, blood respiratory alcohol concentration; NPC, Near Point of Convergence.

a mean change of 1Δ shift towards esophoria at a BrAC of 0.055%. Hogan and Gilmartin[14] believed that this shift was due to excessive tonic vergence. Our findings suggest that as intoxication levels increase, the eyes tend to assume a convergent posture when looking at distance.

Near heterophoria analysis showed a mean increase of 0.84Δ exophoria at 0.05% and 0.97Δ exophoria at 0.10% BrAC. These findings were in agreement with previous studies[8,13,14]; however, their mean increase were all above 1Δ. In the current study, the near heterophoria was measured at 40 cm, whilst in previous studies this was measured either at 30 cm or 33 cm, which may account for these differences.[2,8] Wilson and Mitchell[13] stated that an increase in exophoria was related to the decrease in accommodative vergence associated with reduction in muscle tonus that occurs with the increase in the amount of alcohol ingestion. It is evident that the effect of alcohol ingestion was more prominent on horizontal eye muscles compared to vertical eye muscles as the present study could not obtain conclusive evidence for the impact of alcohol on vertical heterophorias at distance and near. Other studies found no change in vertical heterophorias.[8,13]

Increasing amounts of alcohol resulted in a decrease in positive and negative fusional vergences at distance and near, with a significant reduction noted at a BrAC of 0.10%. Positive fusional vergences were affected to a larger extent at near with alcohol intoxication suggesting a decrease in convergence ability. These findings were in agreement with Devereux and Pitt[8] for a mean BrAC of 0.0615% and 0.075%. Devereux and Pitt[8] also found a mean decrease in negative and positive fusional vergences. Our study and Devereux agree that a BrAC as low as 0.05% causes reduction in the fusional vergences.

It is evident from the current study that as intoxication levels increased there was reduction in fusional vergences which resulted in decompensation of heterophoria as seen in Table 7. At distance and near, 25.50% and 18.75% of the population sample were decompensated, respectively, at a BAC of 0.10%. Whilst at 0.05% BAC, only 6.25% of the population sample at distance and 2.80% at near were decompensated.

The present study also noted a mean recession in the NPC and this was in agreement with the previous authors.[2,8,13,14] These findings[2,8,13,14] operated at a similar BAC range between 0.055% and 0.070% as the present study. The previous studies were limited to NPC break point values, whilst the current study measured the effect of alcohol ingestion on the NPC break and recovery values. The present study also noted that the NPC recedes approximately two folds when alcohol ingestion increases from 0.05% to 0.10% BrAC.

The mean recovery findings were significantly larger and this was supported with reduction in positive fusional vergence findings at near at both 0.05% and 0.10% BrAC. Wilson and Mitchell[13] concluded that the reduced convergence standard may be associated with a reduction in muscle tonus whilst Devereux and Pitt[8] explained the receded NPC as a decrease in neuromuscular coordination.

These complimentary findings of an exophoric shift at near, a reduction in positive fusional vergence at near, coupled with a recession of the NPC, suggest that alcohol ingestion greater than 0.05% BrAC may induce a convergence insufficiency shift. The researchers would also caution that with the consumption of alcohol there is a likelihood of developing an uncompensated exophoria at near which could break into an intermittent exotrope in patients who already have or are borderline convergence insufficiency cases. At near, alcohol ingestion affects binocular vision and accommodative vergence.[8] Modern occupations are heavily dependent upon near tasks; these may be affected in those workers that engage in alcohol consumption levels greater than 0.10% BAC the previous night.

Horn found that people with normal esophoria tend to perceive their surroundings smaller than normally perceived at both distance and near.[20] The present study findings of an increase in eso-posture and reduction of negative fusional vergence at distance may impact drivers. At the South African legal limit of 0.05%, the heterophoric changes can be tolerable. Wilson and Mitchell[13] found a mean change of 3.10Δ at a BAC of 0.0628%. The findings of the present study showed a mean increase of 2.19Δ in distance esophoria at a BrAC of 0.10%. The concerns regarding convergence tolerance at higher BrAC levels should be noted. Furthermore, the impact of this esophoric shift at distance may be amplified in conditions with poor contrast especially at night. These findings would warrant the consideration of the road traffic inspectorate to consider the screening of binocularity routinely when renewing drivers licence permits nationally, particularly habitual esophores. Although the study did not obtain the impact of elevated alcohol consumption on stereopsis, the induced distance esophoria under the influence of alcohol may impact depth perception judgement during braking at stop streets and maintaining a safe following distance whilst driving, especially under poor daylight conditions and at night.

Limitations experienced in this study included a limited sample size with a statistically significant representation of gender to allow for analysis of the impact of gender on the study. Access to all race groups and the ability to mask the control beverage to have a placebo effect proved challenging.

The researchers recommend a randomised control trial with a larger sample size be repeated with the similar methodology. A similar study using subjects older than 30 years to compare to the present studies' results using a younger age of less than 30 years. Finally, the use of driving simulators and specific visual tasks involving activities of daily living at the various BAC levels directly analyses the implications of the heterophoric changes.

# Conclusion

The study highlights the effect of alcohol at 0.05% BrAC and 0.10% BrAC on heterophoria. It can be concluded that increasing levels of alcohol ingestion results in an esophoric shift at distance and an exophoric shift at near. The real life implication is the impact on judgement perceptions whereby esophores over-estimate and exophores under-estimate depth perception.[13] It also causes a receded NPC and a reduction in positive and negative fusional reserves at distance and near, with the change being more significant at a BrAC of 0.10%. This indicates that increasing levels of alcohol intoxication result in a decreased convergent ability at near. Countries[6] with legal BrAC limit greater than 0.05% or greater should therefore consider lowering their BrAC limit.

# Acknowledgements

We would like to acknowledge the statistician Mr Mustafa and the breathalyser supplier Mr MacArthur.

## Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

## Authors' contributions

A.J.M. was the project facilitator and supervisor. R.S.H-H., T.B., P.P.X., D.G., M.S. and L.M. all contributed towards the introduction, the literature review, research study and design, as well as the final research presentation.

# References

1. South Africans Against Drunk Driving | SADD – Statistics. [cited n.d.]. Available from http://www.sadd.org.za/education/statistics
2. Hogan RE, Linfield PB. The effects of moderate doses of ethanol on heterophoria and other aspects of binocular vision. Ophthal Physiol Opt. 1983;3(1):21–31. http://dx.doi.org/10.1111/j.1475-1313.1983.tb00576.x
3. Carey KB, Parlesak, A. Comprehensive handbook of alcohol related pathology [serial online]. Victor R, Preedy RRW, editors. Academic Press, 2004 [cited 2015 Jul 29]; 106 p. Available from: https://books.google.com/books?id=UXfdAAAAQBAJ&pgis=1
4. Alcohol & Your Body. Brown University Health Education [serial online]. [cited 2015 Jul 29]. Available from: http://www.brown.edu/Student_Services/Health_Services/Health_Education/alcohol,_tobacco,_&_other_drugs/alcohol/alcohol_&_your_body.php
5. Kerr WC, Greenfield TK, Midanik LT. How many drinks does it take you to feel drunk? Trends and predictors for subjective drunkenness. Addiction. 2006;101(10):1428–1437. http://dx.doi.org/10.1111/j.1360-0443.2006.01533.x
6. Global Health Observatory Data Repository. World Health Organization; [cited 2015 Jul 13]. Available from: http://apps.who.int/gho/data/view.main.HIV1510?lang=en
7. Dufour MC. What is moderate drinking ? Alcohol Res Heal. 1999;23(1):5–14.
8. Devereux C, Pitt A. Visual function objective measure of intoxication [serial online]. Division of Orthoptics, La Trobe University; 1992. Available from: https://infrastructure.gov.au/roads/safety/publications/1992/pdf/visual_alcohol.pdf
9. Insel PM. Discovering nutrition [serial online]. 4th ed. Jones & Bartlett Publishers, 2013 [cited 2015 Jul 29]; 178 p. Available from: https://books.google.com/books?hl=en&lr=&id=an0vCrQxaB8C&pgis=1
10. Citek K, Ball B, Rutledge DA. Nystagmus testing in intoxicated individuals. Optometry [serial online]. 2003 [cited 2016 Apr 19];74(11):695–710. Available from: http://www.ncbi.nlm.nih.gov/pubmed/14653658
11. Scheiman M, Wick B. Clinical management of binocular vision: Heterophoric, accommodative, and eye movement disorders [serial online]. Lippincott Williams & Wilkins, 2008 [cited 2015 Aug 13]; 748 p. Available from: https://books.google.com/books?id=jGGROHBFYt8C&pgis=1

12. Bartlett JD. Clinical ocular pharmacology [serial online]. Elsevier, 2013 [cited 2015 Sep 15]; 944 p. Available from: https://books.google.com/books?id=kA8lBQAAQBAJ&pgis=1
13. Wilson G, Mitchell R. The effect of alcohol on vision. Med Sestra. 1976;35(4):31–33.
14. Hogan RE, Gilmartin B. The relationship between tonic vergence and oculomotor stress induced by ethanol. Ophthal Physiol Opt. 1985;5(1):43–51. http://dx.doi.org/10.1111/j.1475-1313.1985.tb00634.x
15. Campbell H, Doughty MJ, Heron G, Ackerley RG. Influence of chronic alcohol abuse and ensuing forced abstinence on static subjective accommodation function in humans. Ophthal Physiol Opt. 2001;21(3):197–205. http://dx.doi.org/10.1046/j.1475-1313.2001.00567.x
16. Precision of breath testing instruments [serial online]. [cited 2015 Sep 15]. Available from: http://forcon.ca/learning/approved_inst.html
17. Cridland N. The measurement of heterophoria. Clinical and Experimental Optometry. 1941;24(8):340–363. http://dx.doi.org/10.1136/bjo.25.4.141
18. Moon B, Park S, Cho HG. Repeatability and reliability of a new phoria test using flashed and auto-flashed presentation. J Opt Soc Korea. 2012;16(4):418–424. http://dx.doi.org/10.3807/JOSK.2012.16.4.418
19. Pang Y, Gabriel H, Frantz KA, Saeed F. A prospective study of different test targets for the near point of convergence. Ophthal Physiol Opt. 2010;30(3):298–303. http://dx.doi.org/10.1111/j.1475-1313.2010.00731.x
20. Uri D, Horn NF, Horn N. Visual esophoria and exophoria in relation to personality. Sr Honor Proj. 2011:1–18. (Unpublished).