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A controlled study of the time-course of breath alcohol concentration after moderate ingestion of ethanol following a social drinking session

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Abstract

This paper evaluates the breath alcohol concentration (BrAC), nausea (feeling of being slightly intoxicated) and subjective driving performance after ingesting a moderate dose of alcohol in the presence of a light meal, which intends to approach a social drinking setting. 119 healthy individuals (69 males and 50 females, aged 21.7 ± 3.0) ingested three glasses of wine (95 mL each) and their BrAC was determined by an Alcotest 7410 at 15, 30, 45, 60, 90 and 120 min post-drinking. 46% of females and no male subjects exceeded a BrAC of 0.25 mg/L, the legal limit for driving fixed by some Western countries. 53% of the study population felt nausea during the experimental session and 20% self-reported impairment of their driving skills. In both cases these subjective effects were more pronounced in females. The major determinants of mean BrAC were time post-drinking, gender (male) and body mass index (BMI), all these variables being inversely associated. Females and individuals with a BMI lower than 22.5 kg/m^2 were at an increased risk of exceeding the legal limit of BrAC. The feeling of nausea was significantly associated with gender (females), the ingestion of up to 2 drinks on weekdays, and having exceeded a BrAC of 0.25 mg/L during the experimental study. The main predictor of self-perception of impaired driving skills was the feeling of nausea, followed by a BrAC in excess of 0.25 mg/L. In conclusion, both females and subjects with lower BMI are at an increased risk of exceeding the legal limit of BrAC after moderate alcohol consumption resembling a social drinking setting.

Keywords: Alcohol; Analysis; Breath; Drunk driving; Pharmacokinetics; Alcotest 7410

1. Introduction

Motor vehicle crashes remain a leading cause of death and injury in the industrialized world. Alcohol impairment of drivers is considered one of the most important contributing causes of car crash injuries [1]. The burden of injury attributable to drinking drivers is approximately 30% [2]. Increased awareness of the devastating effects of alcohol misuse on highways has resulted in increased social pressure to enforce driving while intoxicated laws. It is generally accepted that the influence of alcohol drastically deteriorates driver performance to the detriment of traffic safety.

Many public campaigns launched in Spanish media state that the social habit of consuming 2–3 drinks of either beer or wine (~9 g alcohol each) along with a few snacks results in a positive breath alcohol test making the targeted general population afraid of this assertion. However, preliminary data from the Institute of Criminology of the University of Granada do not support this notion [3].

According to the Annual Report of the National Institute of Toxicology [4], of 1621 drivers fatally injured in traffic crashes in Spain in the year 2003, 32% had a blood alcohol concentration (BAC) above the permitted legal limit (0.5 g/L). However, the report fails to show the total number of drivers killed in traffic crashes since only a subset of them (those with any evidence of alcohol consumption) was investigated for BAC. From the Spanish register of road crashes with victims collected by the Government's General Traffic Directorate (Dirección General de Tráfico), a total of 3200 drivers' deaths were recorded in the year 2003. Accordingly, the percentage of

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drivers killed in traffic crashes with a BAC exceeding the legal limit drops to 16%. This new figure suggests that the association between driving under the influence of alcohol and fatal traffic crashes is not as strong as previously thought, although the strength of the effect is still relevant [1,5].

Assessing the degree of alcohol intoxication is not always easy by direct patient observation. Sullivan et al. [6] reported a lack of a significant association between alcohol-related symptoms (reported by experienced medical personnel) and the effective concentration of alcohol in plasma. This type of study strengthens the importance of measuring the alcohol concentration in exhaled air (breath alcohol test) as evidence for driving under the influence of alcohol.

The objective of this paper was to perform a controlled study in healthy young individuals with the aim of evaluating the breath alcohol concentration and the degree of acute alcohol-induced impairment of driving skills after drinking a moderate dose of alcohol in the presence of a light meal, resembling the social environment in ''real world''. Our work hypothesis was that the consumption of three glasses of table wine does not lead to exceeding the legal limit of ethanol in exhaled air permitted by several Western countries for driving automobiles (0.25 mg/L). Previous investigations have studied only a reduced number of volunteers [7] or involved the ingestion of alcoholic beverages in a way (bolus drinking) that differed from a social drinking setting [8].

2. Materials and methods

2.1. Instrumentation

A calibrated breath alcohol analyzer (Dräger Alcotest 7410) was used throughout the study to measure the breath alcohol concentration (BrAC). In order to compare the performance of this instrument with that of the ethylmetre intended for evidential use by the police at the roadside (Dräger Alcotest 7110), a preliminary test was carried out in a subgroup of subjects that ingested different doses of ethanol. Both instruments (Alcotest 7410 and 7110) were equipped with different measuring systems (electrochemical sensor and absorption of infra-red radiation in the 9.5 μm region, respectively). Since both instruments produced similar readings we finally decided to use the Alcotest 7410 because it is easier to use and less effort is required to blow in it. In contrast, it fails to detect residual alcohol in the mouth after the last drink; however, given that this was a controlled study, all ethanol measurements were started 15 min after the last drink. This time appears to be more than adequate for the mouth alcohol to decrease to unbiased levels [9]. The instrument response was zero in all tests with breath samples from alcohol-free subjects. No individual failed to complete a satisfactory test on the Alcotest 7410, nor was unable to master the technique. All precautions for evidential measurement were fulfilled.

2.2. Drinks

Spanish red wine (from Calvente Warehouse Company) with a content of 12% of alcohol by volume certified by oenologists from the Company was used throughout the study. In the experimental sessions, each participant ingested three drinks of this wine (26.4 g ethanol, an average ethanol load of 0.37 g/kg body weight, range 0.24–0.58 g/kg) over 30 min together with a light meal (3 snacks) consisting of either jam, sausage or cheese appetizer (sandwich). Each glass of wine contained 8.8 g alcohol (95 mL × 0.78 g/mL × 12%), and was gradually ingested over 10 min together with a snack. Fifteen minutes after the end of drinking subjects started providing breath samples through the breath alcohol analyzer. In order to perform the experiment with the stomach reasonably empty it was performed after a 2–3 h fast (period of time since the last meal of each study subject).

2.3. Subjects

A total number of 119 previously healthy university students (69 males and 50 females, aged 19–31 years, mean 21.7 ± 3.0) agreed to participate in the study. None of them had been diagnosed with liver disease or any other condition that could affect the results of the test. After giving informed consent, each subject ingested three glasses of wine under the above-mentioned protocol and their breath alcohol content was determined from an end-expiratory sample at various times post-drinking (15, 30, 45, 60, 90 and 120 min).

Duplicate breath samples were obtained from a subset of individuals by using a second Alcotest 7410. As the difference found was less than 0.02 mg/L it was assumed a complete overlapping of results between the two instruments, so that the study was completed by using the reading of only one instrument.

The study population was also given a short questionnaire including questions regarding the possession of a driving licence for either car or motorcycle, if they currently drive a car or a motorcycle, and the number of alcoholic beverages they usually drink on weekdays and on weekend days. They were also asked to report their perceptions about alcohol effects during the experimental session, namely whether or not they felt nausea and judged themselves fit to drive.

2.4. Statistical analysis

Continuous data were expressed as mean ± standard deviation (S.D.). The significance of the differences in the mean values of different parameters between groups of individuals was tested using Student's *t*-test. The prevalence of categorical variables was compared by the Chi square test. The association between BrAC and anthropometric variables was assessed by the Spearman correlation test. GEE (generalized estimating equation) models were used to analyse the time-course of ethanol levels in exhaled air and to perform the test of repeated measures for each variable included in the study. Using this method, models were developed to ascertain which study variable influenced the concentration of ethanol in exhaled air. Multiple logistic regression models were used to adjust a BrAC exceeding the legal limit of 0.25 mg/L, a feeling of nausea after drinking and a self-perception of impaired driving skills, which permitted odds ratios for each predictor (alcohol-related variables) to be estimated. As no male exceeded the legal limit for BrAC, exact logistic regression analysis was used instead of standard logistic regression analysis. The statistical analyses were performed by using the statistic packages SPSS 12.0, STATA 8.1 and Log Xact 4.

3. Results and discussion

Table 1 summarizes overall results of our study population and the different variables studied. It was comprised by young individuals whose main alcohol consumption was focused on weekends. The alcohol intake was clearly higher in males. Statistically significant differences were observed for all variables after adjusting for gender. As the differences found in basic features (such as age and BMI) between males and females might affect the time-course of alcohol concentration in exhaled air, a multivariate analysis was necessary to control for any confounding effect of these variables.

The consumption of alcohol was significantly higher in male than in females. Differences were even greater on weekends as 66.7% of males had more than 5 drinks each weekend day in contrast to 32% of females. Also, the percentage of females who lacked alcohol consumption on weekdays was significantly higher than that of males (74 vs. 45%, data not shown). This higher alcohol consumption rate might have led to some