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Correlation between blood alcohol concentration (BAC), breath alcohol concentration (BrAC) and psychomotor evaluation in a clinical monitored study of alcohol intake in Brazil

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ABSTRACT

Background: Policies that establish maximum blood alcohol concentrations (BACs) or breath alcohol concentration (BrACs) for drivers while driving can reduce traffic accidents by approximately 20%. In Brazil, the National Transit Council (CONTRAN) considers positive BAC and/or BrAC tests or signs of psychomotor capacity alterations as evaluated by a police authority to be an administrative infraction or even a crime. The observed clinical symptoms of alcohol intoxication based on a subject's appearance may not necessarily reflect the quantified BAC and/or BrAC. This study compared the clinical symptoms identified by a medical authority (M) and a non-medical authority (NM) with BAC and BrAC measurements.
Methods: Brazilian health volunteers (n = 15) drank ethanol (40% v/v) and, at scheduled times, the subjects underwent blood draws for BAC analysis, were tested for BrAC analysis, and underwent psychomotor alteration assessments performed by M and NM.
Results: Concentration-time profiles of the BACs and BrACs of the volunteer subjects were generated. The BAC values reached a peak at 60 min and subsequently decreased with time. The average BrAC values decreased with time after ingestion. During the evaluations, M was able to identify a lack of static equilibrium until 240 min and a lack of dynamic equilibrium until 120 min. A lack of upper limb motor coordination was observed until 90 min, and a lack of coordination in the lower limbs was observed only during the first hour. Regarding the tests performed by NM, the signs related to the subjects' appearances were observed more frequently, until 60 min. The other analyzed symptoms were not identified. Naturally, the signs reported by both M and NM disappeared with time.
Conclusion: The evaluations of psychomotor changes performed by Brazilian M were superior to those performed by NM. However, independent of the examiner, at the alcohol concentrations reached in this study, the psychomotor alteration evaluations were ineffective compared with the BAC and BrAC results.

Introduction

The use of alcoholic beverages has been a part of many cultures for thousands of years (McGovern, 2009). Protection of the health of the population by preventing and reducing the harmful effects of alcohol use is a public health priority and a major goal of the World Health Organization (WHO, 2014).

Alcohol consumption not only influences the incidences of diseases, injuries, and other health problems, but also has effects in the area of disorders. In addition to environmental factors, the effects of alcohol consumption are determined according to the following three factors: the volume of alcohol consumed, the consumption pattern, and on rare occasions, the quality of alcohol consumed (WHO, 2010). The highest levels of consumption are observed in the developed countries of Europe and in America. In 2012, approximately 3.3 million deaths, or 5.9% of all deaths worldwide, were attributed to alcohol consumption (WHO, 2014).

Alcohol and steering countermeasures are cost-effective strategies to reduce the harmful use of alcohol and the number of traffic accidents attributable to alcohol, which are more likely to occur

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when drivers have blood alcohol concentrations above 0.04% (Bloomberg, Peck, Moskowitz, Burns, & Fiorentino, 2009).

Policies that establish maximum blood alcohol concentrations (BACs) for drivers or even alcohol prohibition while driving using sobriety controls and random tests have been shown to be good strategies that can reduce traffic accidents by approximately 20% (Elder et al., 2002).

Data about the maximum BAC values permitted for drivers are available for 177 countries, and the maximum values allowed are generally between 0.05 and 0.07% (61 countries) or 0.08–0.15% (46 countries). Eighteen countries have no limit, and 25 countries report that only BAC values of zero are allowed, i.e., these countries tolerate no drinking and driving (WHO, 2014).

In Brazil, the National Transit Council (CONTRAN) considers a blood test with any BAC, a BrAC test yielding a value equal or greater than 0.05 mg/L, or signs of psychomotor capacity alterations as evaluated by a police authority to be an administrative infraction. However, according to the same resolution, it is considered a crime to have a blood test that results in a value equal to or greater than 60 mg/dL of alcohol per liter of blood, and an infrared breath analyzer test that results in a value equal or greater than 0.34 mg/L of alcohol per liter of expired alveolar air or to exhibit psychomotor capacity alterations (Resolução 432, 2013).

However, according to the Federal Constitution of Brazil and comparable documents of other countries, the individual reserves the right to not produce evidence against him/herself and thus may refuse to undergo an infrared breath analyzer test and/or a blood alcohol examination (Brasil. Constituição da República Federativa do Brasil, 1988). In these cases, only the signs present during an evaluation for altered psychomotor capacity can be used to establish a state of intoxication. These signs can be verified by a clinical examination with a conclusive report signed by a medical expert or by an agent of the Transit Authority.

This study aims to compare evaluations of psychomotor capacity alterations as performed by a medical expert and an agent of the Traffic Authority and to correlate the results of these evaluations with alcohol concentrations as measured in the exhaled air and blood. Thus, it may be possible to estimate whether evaluations of the psychomotor changes are effective in the detection of drunkenness at lower concentrations of alcohol that are still below the limit considered to be an administrative infraction.

Materials and methods

The study protocol was approved by the institutional review board for human subject investigations under No. 740.681.

Subjects and conditions

Healthy volunteers (10 women and 5 men) with mean age of 23.9 ± 4.7 years and mean body mass index (BMI) of 21 ± 2.1 kg/m^2 volunteered to participate in the study and signed an informed consent form (ICF). The subjects drank vodka (40% v/v) in amounts that were calculated to result in an ethanol level of 0.50 g per kg body weight. The drinks were consumed within 10 min.

Blood samples and ethanol analysis

Venous blood samples were collected from an indwelling catheter at specific intervals after the completion of the drinking (30, 60, 90, 120, 150, 180, 210, 240, and 270 min). The blood was drawn into Vacutainer® tubes containing 100 mg NaF and 20 mg EDTA as preservatives. The ethanol determinations were performed with headspace gas chromatography (Varian 3380®).

Breath-alcohol analysis

The Alco-Sensor III (Intoximeters, Inc., St. Louis, MO, USA) is a quantitative infrared breath analyzer that is approved for the testing of intoxicated drivers by the Brazilian police authorities. An Alco-Sensor III was borrowed from the police department for use in this study. The subjects provided breath samples according to a fixed time schedule (30, 60, 90, 120, 150, 180, 210, 240, and 270 min). Each subject performed a prolonged deep exhalation into the heated inlet tube of the instrument.

Psychomotor capacity assessment by the transit authority

The transit authority evaluated the clinical symptoms of alcohol intoxication at the same standard times at which the other tests were applied. The parameters included the following: odor of alcohol on the breath, sleepiness, decreased alertness, red eyes, changes in speech volume, slurred speech, vomiting, hiccupping, and balance difficulties.

Psychomotor capacity assessments by the medical authority

The legal medical doctor evaluated the clinical symptoms of alcohol intoxication at the same standard times, and the parameters included appearance (red eyes and an odor of alcohol) and behavior (distortions of speech and memory). Moreover, the following sobriety tests were performed: the *Walk and Turn* test was performed to assess dynamic balance, the *One Leg Stand* was performed to evaluate the lower limbs and the static balance, and the *Finger-to-Nose* and *Finger-to-Finger* tests were performed to assess the upper limbs.

Regarding the psychomotor capacity assessments as performed by both the medical authority and the non-medical transit authority, at least two different signs had to be identified to conclude that a test was positive.

Statistical analysis

The qualitative variables are presented as counts and percentages, and the quantitative variables are presented as the means ± the standard deviations (SDs). The normalities of the variables were tested with the Shapiro–Wilk test. Student's *t* tests were used for the comparisons of the means between independent and paired samples. Simple linear regression models with null intercepts for all moments of the evaluations of the volunteers were used to predict the results of the blood alcohol tests based on the values obtained from the infrared breath analyzer. The adequacies of the models were evaluated according to residual analyses and the coefficient of determination (R^2). The analyses were conducted in the free R version 3.1.3 software, using a 5% level of significance.

Results

The ethanol concentration-time profiles in the venous blood and the end-expired breath for the volunteer subjects are presented in Table 1. From this table, it is apparent that the average blood alcohol values peaked at 60 min and subsequently decreased with time. The average breath alcohol measurement values decreased with time beginning immediately after alcohol intake.

Regarding the clinical assessments performed by the M (Table 2), no positive results for the parameters related to the external examinations (i.e., appearance and behavior) were observed during the data collection period time. The only issues identified were a lack of static equilibrium from 30 min to 240 min and a lack of dynamic equilibrium from 30 min to 120 min. A lack of upper limb