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Determination of breath alcohol value after using mouthwashes containing ethanol in healthy young adults

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Abstract. – OBJECTIVE: To evaluate breath alcohol value and blood alcohol concentration after using mouthwashes containing ethanol in a panel of healthy young adults. To determine zeroing time of these values and if subjects' body mass index or gender influenced it.

Breathalyzer test is a practice performed to detect alcohol-impaired-drivers that can be penalized. Sometimes Italian judges revoke the penalty justifying that the presence of residual ethanol in the oral cavity can cause false positive values.

PATIENTS AND METHODS: Our study involved 40 young adult volunteers; the cohort was composed of University students aged between 21 and 30 years. They underwent a medical examination to evaluate BMI. We selected four alcoholic mouthwashes available on the market with a different ethanol amount and an ethanol/ water (10/90) mixture as a reference. Breath alcohol concentration values were collected using a portable breathalyzer immediately after the rinse (T0), after 10 and 20 minutes (T10 and T20). We evaluated blood alcohol concentration 5 minutes after the rinse.

RESULTS: All T10 values are lower than 0.5 g/L (Italian BAC driving limit). Differences between average values at T0-T10 are statistically significant ($p < 0.05$). Correlations between BAV and BMI are not statistically significant respectively at T0 (A: $p = 0.54$. B: $p = 0.96$. C: $p = 0.93$. D: $p = 0.53$) and T10 (A: $p = 0.42$. C: $p = 0.99$. D: $p = 0.66$). Differences between male and female groups aren't statistically significant (A: $p = 0.49$; B: $p = 0.79$; C: $p = 0.97$; D: $p = 0.06$).

CONCLUSIONS: High BAV values determined at T-0 are a consequence of residual ethanol present in the oral cavity, the zeroing time of these ones is very swift. Our study shows that rinsing with an alcoholic mouthwash before undergoing the breathalyzer test does not realistically influence the result.

Key Words:
Breath alcohol concentration, Mouthwash, Breathalyzer.

Abbreviations

BAC = Blood Alcohol Concentration (g/L); BAV = Blood Alcohol Value (g/L); BH = Body Height (m); BMI = Body Mass Index (kg/m^{2,5}); BrAC = Breath Alcohol Concentration (g/L); BrAV = Breath Alcohol Value (g/L); BW = Body Weight (Kg); MCE = Mouthwash Containing Ethanol.

Introduction

Mouthwashes are devices frequently used to improve personal oral care and their use is suggested by dentists[1]. In order to improve antibacterial activity, some mouthwashes contain ethanol (MCE). These products are easily available (e.g. supermarkets, pharmacies) and are used by a large number of people. Alcohol-impaired driving roadside screening is a wide practice performed by police officers of several countries in the world. Breath alcohol testing is widely used in law enforcement procedures determining BrAC and consequently the BAC. The conversion from BrAC to BAC is fixed by a constant value based on a BAC/BrAC ratio. This conversion factor is generally ranging from 2000 to 2300, depending on different countries (e.g. France = 2000, Canada = 2100 and Italy = 2300)[2,3].

If the test conducted by police officers results positive the driver is penalized or its license can be suspended. However, in many cases the driver appeals the penalty.

In Italian legislation there are a series of judgments reporting cases of drivers who resulted positive to the breath alcohol examination,

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justifying these values because they had used a MCE before the test. Sometimes the judge revokes the penalty justifying that the presence of residual ethanol in the oral cavity can interfere with the test, causing false positive values as already stated by other authors[4-10]. In other cases the appeal was rejected because the judge asserted that the driver has to verify the compatibility between a swallowed substance and the condition to drive a vehicle in a public road[11]. The presence of these verdicts justified our study to determine if this hypothesis may found a scientific demonstration.

Reviewing literature, it seems that after a rinse with MCE BrAC value rapidly decreases within 10 minutes. However, these studies considered only few mouthwashes[4,12,13]. In our work we increased the number of mouthwashes analyzed and the study group, also evaluating if BMI could interfere with the values collected.

The aim of our work was: to determine BAV values in healthy subjects with a breathalyzer test during the first 20 minutes after MCE administration; to determine if BMI and gender of the subjects could influence the results. Blood sample was used as a reference.

Patients and Methods

The study involved 40 healthy Italian Dental School students: 29 females and 11 males with a mean age of 23.3 years, range 19.0-30.0 (Table I). They were informed of the purpose of the study, which was approved by our local Ethics Committee, and enrolled after giving their signed informed consent. We excluded students on medication, those with oral piercings or with any kind of dental reconstruction and women who were possibly pregnant or on period. None of the candidates was excluded from the study. Later on, the selected subjects underwent a medical examination to evaluate their body profile, using the parameters BW, BH and BMI calculated as [BW(kg)*1.3]/[BH(m)^2.5]. The subjects couldn't smoking for 12 hours prior the test and not drink alcohol or eat for 6 hours prior to the test.

On different days 30 subjects rinsed their mouth with four different commercially available MCEs (Table II) and to 10 other subjects with an ethanol/water mixture (10/90 v/v), used as a reference. A portable electrochemical fuel cell breathalyzer (LION Alcometer SD400, Lion Laboratories LTD, Barry, United Kingdom) with disposable mouthpieces was used for the experiments. This device evaluates BrAV and calculates the BAC using the breath-to-blood ratio of 1:2300. The BAC values calculated by our breathalyzer were named in the present work as BAV (Blood Alcohol Value). BAC values were determined on blood samples taken from the subjects.

Subjects performed a rinse with saline solution for 30 seconds and to make sure that the initial BAV value was 0.00 g/L, a breathalyzer test was performed (T_i values). The subjects placed the disposable mouthpiece on the top of the pre-calibrated breathalyzer and, after taking a deep breath, placed their lips on the mouthpiece and blew out forcefully until the acoustic signal of the breathalyzer sounded out.

Later, the subjects rinsed the mouth with the provided mouthwash. The amount of MCE and the rinse time were in accordance to the products indications (Table II). At the end of the rinse time, the subjects spat out MCE and immediately underwent a breathalyzer examination to evaluate BAV (T_0). A second examination was conducted 10 minutes after (T_{10}). During this time, subjects were asked to keep their mouths closed, not to drink or rinse, to prevent any alcohol dispersion. If a positive value was found after the second examination as well, the subjects were asked to undergo a third examination, 20 minutes after the rinse (T_{20}).

Table I. Group's age and corresponding BMI values.

Gender	Subjects (n)	BMI			AGE (years)		
		Mean ± SD	Min	Max	Mean ± SD	Min	Max
Male	11	23.8 ± 3.5	18.5	29.2	24.1 ± 3.5	19.0	30.0
Female	29	22.5 ± 2.8	17.5	28.3	22.9 ± 2.1	21.0	30.0
Total	40	22.8 ± 3.0	17.5	29.2	23.3 ± 2.6	19.0	30.0

Table II. Characteristics of mouthwashes used in the study.

Mouthwash	Ethanol (%)	Rinse dosage (mL)	Rinse time (seconds)
A	21.6	20.0	30.0
B	4.0	15.0	30.0
C	10.0	15.0	60.0
D	n.d.	10.0	60.0
Reference	10.0	15.0	45.0

Table III. BAV values from the experiments.

Mouthwash	T_i (g/L)	T_0 (g/L)	T_{10} (g/L)	T_{20} (g/L)
A	0.00	3.75 ± 0.44	0.07 ± 0.10	0.00
B	0.00	0.08 ± 0.04	0.00	0.00
C	0.00	3.49 ± 0.65	0.04 ± 0.05	0.00
D	0.00	2.85 ± 0.76	0.02 ± 0.03	0.00
Reference	0.00	3.16 ± 0.60	0.09 ± 0.09	0.00

As a control, 5 minutes after the rinse, BAC values were evaluated in subjects that at T_0 saturated the breathalyzer obtaining the highest attainable BAV values (4.00 g/L).

Statistical Analysis

Paired samples *t*-test was used to evaluate differences between the values measured at different times (i.e. T_0 with T_{10}; T_{10} with T_{20}). Any possible correlation between the BAV values at T_0 and T_{10} and the BMI values were evaluated with Pearson's correlation coefficient, considering values lower than 0.19 as a very tiny correlation[14]. To evaluate differences in BAV values among gender a t-test, assuming equal variances, was used. We considered as statistically significant a *p*-value ≤ 0.05.

Results

The highest attainable BAV value (4.00 g/L) was observed at T_0 in 32 subjects; all BAC values determined in these subjects were 0.00 g/L.

The BAV average values (Table III) decreased to figures close to zero from T-0 to T-10 in all the formulations (Figure 1).

In detail, at T_0 for MCE-A the maximum value collected was 4.00 g/L, while minimum was 1.94 g/L. For MCE-B the maximum was 0.12 g/L and the minimum was 0.00 g/L. For MCE-C we collected a maximum value of 4.00 g/L and a minimum of 1.16 g/L. For MCE-D the maximum value was 4.00 g/L and the minimum was 1.63 g/L. For the Reference the maximum was 3.79 g/L while minimum was 1.94 g/L.

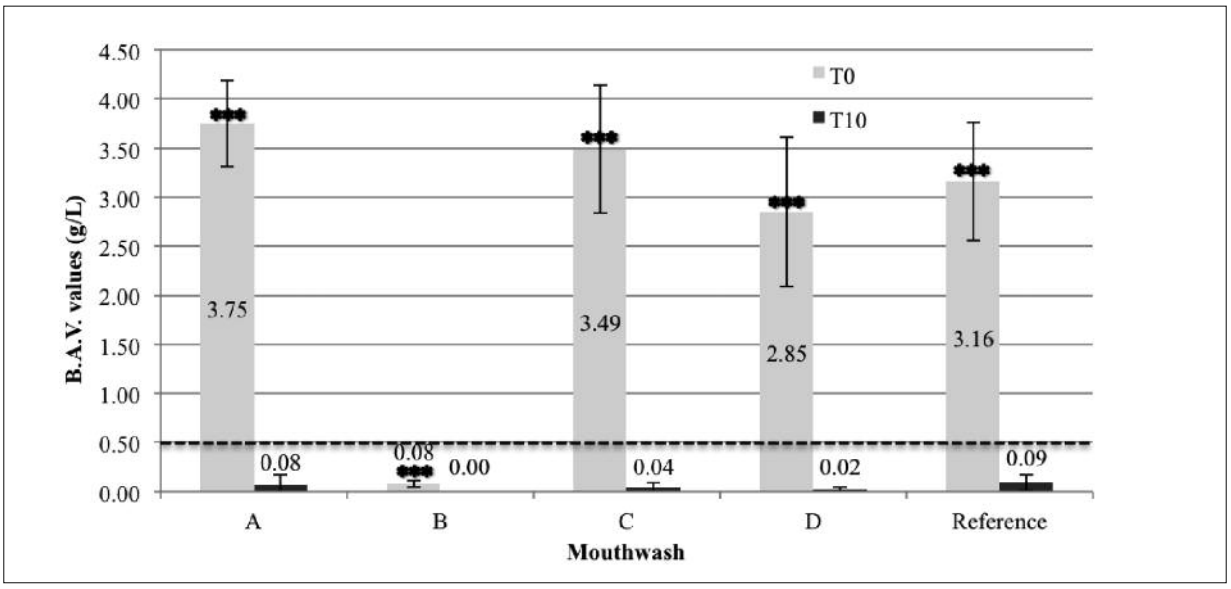

Figure 1. BAV values obtained during measurements at T0 and T10. Error-bar as Standard Deviation, black dotted line corresponds to the most common Italian BAC driving limit.

The difference between the average values collected at T_0-T_{10} was statistically significant for all the formulations ($p < 0.05$). The relationship between BAV values at T_0 and BMI was really poor and not statistically significant for all the formulations as demonstrated by the calculated correlation coefficient (A = 0.12; B = -0.01; C = -0.02; D = -0.12 and Reference = 0.05). Also BAV values at T_{10} and BMI did not show a significant correlation (A = -0.15; B = n.d.; C = -0.01; D = -0.08 and Reference = 0.03). The differences between T_0 values in the male and the female groups were not statistically significant for all the formulations ($p > 0.05$).

All T_{20} BAV values were 0.00 g/L.

Discussion

This research study shows that ethanol contained in MCE and in our Reference can alter the results of a single breathalyzer test. The positive values of BAV from samples collected within twenty minutes after MCE administration could only be considered as a consequence of the presence of residual alcohol in the mouth cavity.

Modell et al[12] found similar results: they considered three different MCEs (6.0; 18.9 and 26.9% ethanol) and observed that BAV values decreased exponentially and after 10 minutes they were well below the intoxication value of 80 mg/dL. Worner et al[4] demonstrated that after a rinse with an MCE containing 18% ethanol, the mean time required for BAV to go back to 0.00 g/L was 11.32 minutes. Also Fessler et al[13] considered a MCE (ethanol 21.6%) rinse, evaluating that the mean time needed to return to baseline was 13.35 minutes.

So, the highest initial values founded in our work could not be considered as a state of inebriation, since they should correspond to an alcoholic coma. Moreover, the analysis of the blood samples collected showed that every subject had a BAC value of 0.00 g/L, in contrast with corresponding BAV values.

Even if MCEs alter breathalyzer test's result at first, it has to be considered the whole Italian police's breath alcohol testing protocol where two tests are performed within 20 minutes, with more than 5 minutes interval between them[15]. In this case, the latter test could never be positive if the driver only rinse with MCE, because it's not possible that relevant amounts of ethanol remain for such a long time in driver's mouth. It is evident that two consecutive positive test results are possible only if ethanol is present in the blood circulation.

If we consider an hypothetical situation where the breathalyzer test is conducted right after MCE rinse as we did in our study, we notice that it's possible to obtain a false positive value, obtaining two consecutive BAV values higher than 0.00 g/L. Therefore, this circumstance could only occur if the BAC driving limits is 0.00 g/L (e.g. for Italian traffic code: for the first two years of driving license or for professional drivers). However, this hypothesis does not represent a real situation since we must consider the time necessary for the police officer to stop the driver, to ask him how long it has passed from his last ingestion of alcohol and to explain how the test is conducted. In this circumstance police officers may collect positive BAV value at first, but the second test will be negative due to the swift zeroing time of BAV values.

So, there are no scientific reasons to believe that Italian police's breath alcohol testing protocol could be altered by MCE.

Modell et al[12] could not evaluate any gender differences due to their small sample size. However, even if our sample size was greater no significant differences were found between genders. Moreover, BAV values did not depend from BMI of the subject, demonstrating that driver body profile does not affect the BAV value after MCE rinse.

Conclusions

The BAV values are only influenced by residual alcohol in the oral cavity due to MCE rinse, and this explains why BAV decreasing rate is really considerable. Even if MCE could alter the outcome of a single breathalyzer test, a simple protocol, based on two sampling performed at more than 5 minutes between them, could neutralize this drawback.

Alcohol-related crashes are a top safety problem in several countries. Roadside breath alcohol testing is one of the most powerful deterrent available for police enforcement. MCE are frequently used by a lot of people and in some cases are used as justification to evade the traffic code. The results of the present work indicate that the assumption of MCE containing significant amounts of alcohol cannot justify the positivity of the alcohol-measuring test and cannot be used as a tool for a legal appeal.

Consent

Written informed consent was obtained from all of the subjects.

Ethical approval

The study was approved by our Hospital Ethics Committee.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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