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TECHNICAL NOTE

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The Rate of Dissipation of Mouth Alcohol in Alcohol Positive Subjects

ABSTRACT: Seven subjects participated in a two-part study to evaluate mouth alcohol dissipation in alcohol positive subjects. In part one, subjects rinsed their mouths with a vodka solution and were breath tested after 1, 2, 3, 4, and 5 min intervals. On average, breath alcohol concentration (BrAC) decreased 20.4% (range 3.2–47.9%) between 1 and 2 min after rinsing. In part two of the study, multiple breath tests were administered after rinsing once with the vodka solution. The BrAC decreased more than 0.020 g/210 L between the first and second tests for all subjects (average 0.095 g/210 L, range 0.021–0.162 g/210 L). The average time for subjects to reach their unbiased BrAC was 9.35 min (range 4–13 min) after rinsing. This study reaffirms the need for duplicate breath testing and confirms that the minimum of a 15-min observation period is sufficient for mouth alcohol to dissipate in alcohol positive subjects.

KEYWORDS: forensic science, mouth alcohol, breath alcohol analysis, fuel cell, alcohol positive subjects, alcohol

Mouth alcohol is any alcohol that is present and unabsorbed in the mouth and therefore can falsely elevate the results of a breath test. In the United States, there is an observation or deprivation period of at least 15 min before starting a breath test. This is meant to prevent the presence of mouth alcohol in the breath sample by allowing adequate time for the mouth alcohol to absorb into the system or evaporate.

There are numerous studies which have studied the amount of time necessary for mouth alcohol dissipation. Simpson et al. (1) evaluated mouth alcohol in alcohol negative subjects and found that the 15-min observation period was critical to assure that mouth alcohol was not influencing a breath test. Langille and Wigmore (2) studied mouth alcohol in alcohol-free subjects and found no mouth alcohol remained after 10 min. Modell et al. (3) looked at mouth alcohol as a result of recent mouthwash use and found that mouthwash posed no significant threat to breath testing after a 10-min waiting period. Harding et al. (4) examined mouth alcohol as a result of dentures and denture adhesive in alcohol negative subjects and found that after a period of 15 min, there was no remaining mouth alcohol. Kempe (5) confirmed that 15 min was sufficient to eliminate all mouth alcohol for all subjects. Most of these studies, and others which have been conducted in regard to mouth alcohol dissipation, include subjects who were alcohol negative at the time of testing. As most driving under the influence cases involve drivers with alcohol in their system, logically, studies should be conducted on mouth alcohol dissipation with alcohol positive subjects.

For subjects with a positive blood alcohol concentration and mouth alcohol, their breath alcohol concentration (BrAC) should return to its true (unbiased) value more quickly than in subjects who are alcohol negative and whose unbiased BrAC is zero. Gullberg (6) found that the time necessary for mouth alcohol to dissipate completely is inversely proportional to the subject's actual BrAC; the higher the BrAC, the smaller the amount of time necessary for the effect of mouth alcohol to disappear and reach unbiased levels (BrAC excluding the mouth alcohol). Lalonde et al. (7) also found a negative correlation between the baseline BrAC and the effect of mouth alcohol. The primary purpose of this study is to evaluate how quickly mouth alcohol dissipates in subjects who are alcohol positive.

By providing a breath sample, mouth alcohol will logically dissipate more quickly than if a subject had been breathing normally. Buczek and Wigmore (8) found that frequent breath sampling did cause faster dissipation of mouth alcohol, and therefore, this effect must be considered when studying the rate of mouth alcohol dissipation. The secondary purpose of this study is to examine the effect of breath alcohol sampling on the rate of mouth alcohol dissipation.

Methods

The study was designed and implemented in accordance with the ethical standards set forth in the Declaration of Helsinki (9). All subjects were required to sign a consent form which advised them of the risks of the study.

Seven volunteers were subjects for this study. Five of the subjects were male and two were female. The distribution of gender was chosen randomly by subject availability.

All breath tests for this study were conducted with an AlcoSensor IV XL™ (Intoximeters, St. Louis, MO). The AlcoSensor IV XL™ measures alcohol content of the breath using a fuel cell and does not contain a slope detector (as would be present in infrared technology). The AlcoSensor IV XL™ used in the study were evaluated for accuracy using a 0.110 g/210 L dry gas ethanol device. All of the instruments measured the standards within

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±0.003 g/210 L of the known concentration. All determinations of accuracy and measures of BrAC were recorded to three digits. The same instruments were used throughout the study with each subject to avoid issues of variation.

The study was conducted in two main parts. The first part examined the loss of mouth alcohol in alcohol positive subjects because of dissipation alone. Subjects were dosed to a low level of alcohol (0.03–0.06 g/210 L) and then rinsed their mouths with a vodka solution (50% 80 proof vodka, 50% water) which was expelled without swallowing. A baseline BrAC was determined by collecting two breath samples a minimum of 2 min apart prior to the subject rinsing with the alcohol solution. Subjects were not determined to be postabsorptive prior to the collection of data. Separate single BrACs were recorded after 1, 2, 3, 4, and 5 min following the rinse of the mouth with the vodka solution, during which time the subjects were advised not to talk or open their mouths to allow for maximum mouth alcohol retention. A new rinse with the vodka solution was conducted for each time period tested (1–5 min).

The second part of the study examined the loss of mouth alcohol from continuous breath testing. The subjects were not given any additional alcohol following the first part of the study and were therefore still at a low level of alcohol (0.03–0.06 g/210 L). Again the metabolic phase of the subjects was not determined prior to the collection of data. Subjects rinsed with the vodka solution and expelled the solution without swallowing. The first breath test was taken 1 min after expelling the rinse solution. Additional breath tests were conducted on a continual basis (at least 1 min apart) until the BrACs of three consecutive samples were consistent, indicating that no mouth alcohol remained. The previously determined baseline along with the actual test results was used to determine consistency (±0.01 g/210 L was used as the cut-off criteria for consistency). The baseline alone was not used because of the possibility of the baseline changing as the subject continued to absorb and/or eliminate alcohol. The baseline agreed with the testing (within a ±0.02 g/210 L, the criteria for duplicate breath testing in California, in all but two cases) without considering absorption or elimination (9). The timing of the additional testing varied for each subject, but was recorded in each case. The objective for sampling for the study was to test the subject every minute, but this was not always possible. The first BrAC (of the three) which was determined to be steady state (nonbiased) was used for all calculations.

Subjects were then dosed to a mid- to high level of alcohol (0.06–0.13 g/210 L). Both parts of the study were repeated using the same testing protocol with subjects at the mid- to high level.

Results and Discussion

Mouth Alcohol Dissipation with Single Sampling

The average decrease in BrAC between 1 and 2 min after rinsing with the vodka solution was 0.060 g/210 L (range 0.003–0.149 g/210 L, $n = 10$) or 20.4% (range 3.2–47.9%, $n = 10$). From a total of 14 samples, four were excluded from this calculation because the instrument reading was greater than a 0.400 g/210 L for either the 1 or 2 min BrAC reading. In one sample, the BrAC increased from 1 to 2 min after rinsing with the vodka solution. However, this sample was not used in the calculations as it was already excluded for having a breath reading >0.400 g/210 L.

The average loss of mouth alcohol between 1 and 3 min is comparable to a real-world situation because evidential tests are typically separated by at least 2 min. The average loss of mouth alcohol between 1 and 3 min was 0.096 g/210 L (range 0.006 increase to 0.226 decrease g/210 L, $n = 10$) or 30.9% (range 21.5% gain to 72.9% loss). From a total of 13 results, three were excluded because of the reading of >0.400 g/210 L on the instrument for either the 1 or 3 min reading. In two readings, the BrAC increased from 1 to 3 min after rinsing with the vodka solution. The increase of the two subject's BrAC over time is unexpected. Because the subjects took a new rinse of the vodka solution for each testing period, this increase may be due to variation in the volume of vodka solution that was used for the rinse or the amount of time the vodka solution was held in the mouth. For future studies, regulating the volume of solution and time of the rinse would eliminate these variables.

The remaining results for mouth alcohol loss are presented in Table 1. As is expected, the amount of mouth alcohol which has dissipated increases with time. The average decrease of BrAC during each time period reflects the inclusion of the mouth alcohol that was present in those samples.

The subjects were asked to not talk in this portion of the test. Not talking is an unrealistic condition as officers often keep the individuals talking during the waiting periods. Asking participants not to speak was done during the study to maximize the effect the mouth alcohol could have on the BrAC results.

It is possible that an individual could have multiple mouth alcohol inducing events; such as a regurgitation before each test. Although studies by Kechagias et al. (10), Gullberg (11), and Gabe and Roos (12) all found that regurgitation did not significantly alter the results of a breath test, this theory exceeds the confines of this paper and would need more research to determine the likelihood of producing two results that meet the criteria for acceptance.

Mouth Alcohol Dissipation with Multiple Sampling

When subjects provided multiple breath tests after rinsing with the vodka solution, the difference between the first and second sample was >0.02 g/210 L in every case. The average decrease was 0.095 g/210 L (range 0.021–0.162 g/210 L, $n = 21$) or 37.3% (range 12.5–67.5%) between the first and second breath sample. Two results were not used in this calculation because the instrument read >0.400 g/210 L for either the first or second breath sample. Because the actual value for these samples was not known, the

TABLE 1—*Demonstrates the average loss of mouth alcohol concentrations over different waiting periods.*

	Mean Change in BrAC (g/210 L)	Range (g/210 L)	Standard Deviation	95% Confidence Interval	% Change in BrAC	Range (%)	Standard Deviation %	Sample Size (*n*)
1–2 min	−0.060	−0.003 to (−0.149)	0.045	±0.090	−20.5	−3.2 to (−47.9)	14.3	10
1–3 min	−0.096	0.06 to (−0.226)	0.090	±0.180	−30.9	21.5 to (−72.6)	27.8	10
1–4 min	−0.120	−0.012 to (−0.232)	0.062	±0.124	−43.0	−4.3 to (−70.1)	18.0	11
1–5 min	−0.165	−0.057 to (−0.279)	0.062	±0.124	−52.4	−31.7 to (−76.4)	15.5	11

BrAC, breath alcohol concentration.

percent loss could not be calculated. The first and second tests were separated by an average of 1.6 min (range 1–3 min).

In most jurisdictions, a difference of greater than 0.020 g/210 L between the first and second test would cause a third test to be scheduled. While officers in the field would keep a subject from ingesting alcohol within 1 min of an evidential test, it is possible for a subject with alcohol in their stomach to regurgitate immediately prior to a breath test, thus causing mouth alcohol. If this was to occur without the officer knowing, as is often argued in court, the difference in results between the first and second breath tests would be enough to trigger a third test in those jurisdictions where automatic scheduling is used. The results of this study demonstrate that the 0.020 g/210 L criterion for acceptance of a breath test is adequate to alert the user to the presence of mouth alcohol.

In some jurisdictions, the required amount of time between tests is >2 min. Although this would clearly lead to greater differences in the BrAC when mouth alcohol was present in one of the samples (because of dissipation of the mouth alcohol), the results of this study show that it is unnecessary; the loss of mouth alcohol over a 2-min period was sufficient to cause the scheduling of a third test (a difference >0.02 g/210 L) in every subject.

As seen in Fig. 1, the mouth alcohol loss followed an exponential decay curve; the rate of alcohol loss was greatest immediately following the rinsing of the vodka solution and decreased as the levels approached the actual BrAC. The average time for subjects to reach steady-state levels was 9.35 min (range 4–13 min, $n = 25$) after rinsing with the vodka solution. The minimum observation period of 15 min, which is used in the United States, is sufficient to protect against mouth alcohol in alcohol positive people (1–7, 13; https://njcourts.judiciary.state.nj.us/web0/mcs/case_law/state_v_filson.pdf; http://ecilcrime.com/2009/05/10/new-case-on-observation-period/; http://www.duiattorney.com/dui-basics/test-timing [accessed

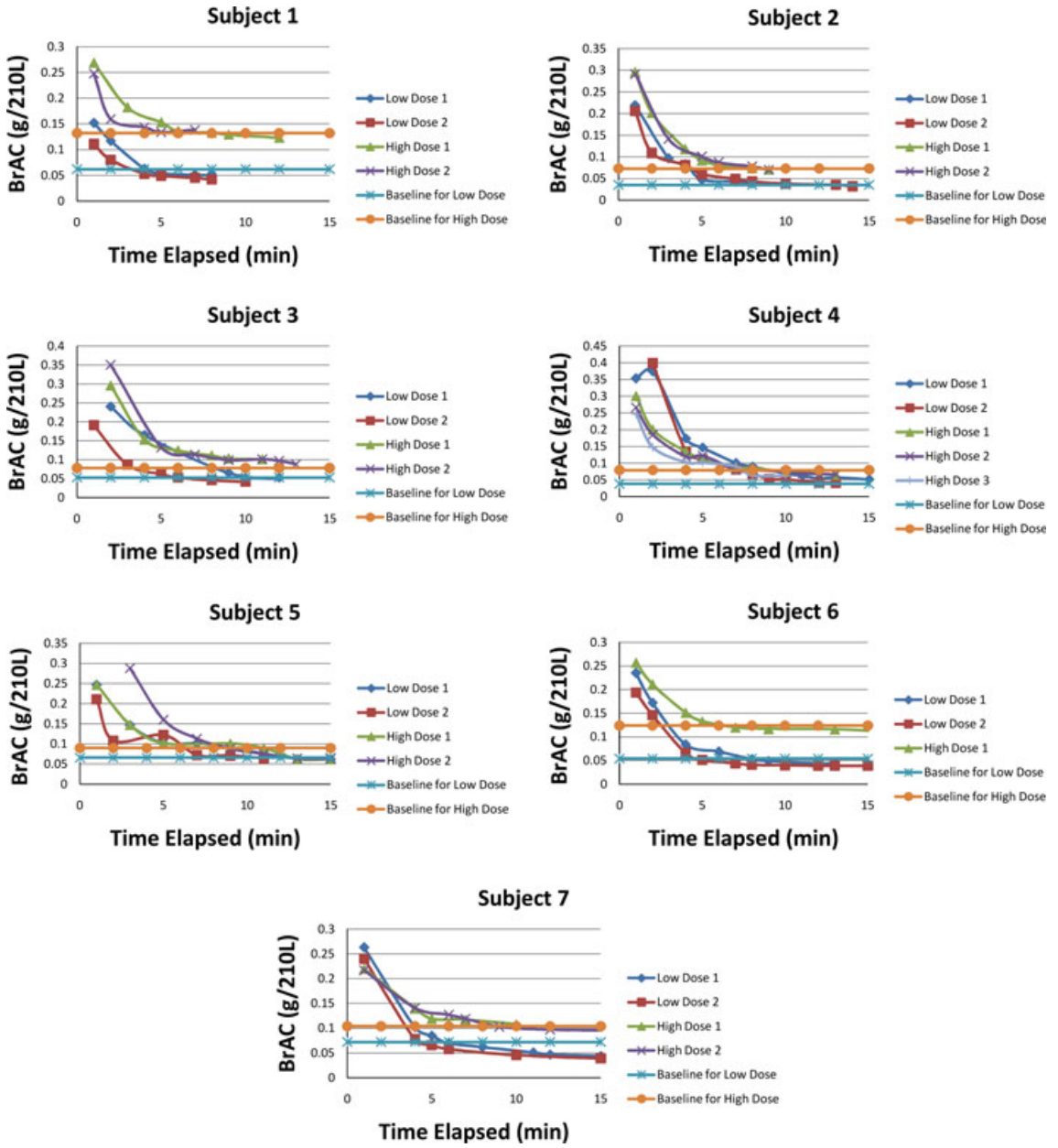

FIG. 1—*The dissipation curves of mouth alcohol for each subject (subjects have three to five curves each). Number of curves depends on number of times the subject was tested. The plateau represents the unbiased breath alcohol concentration of the subject.*

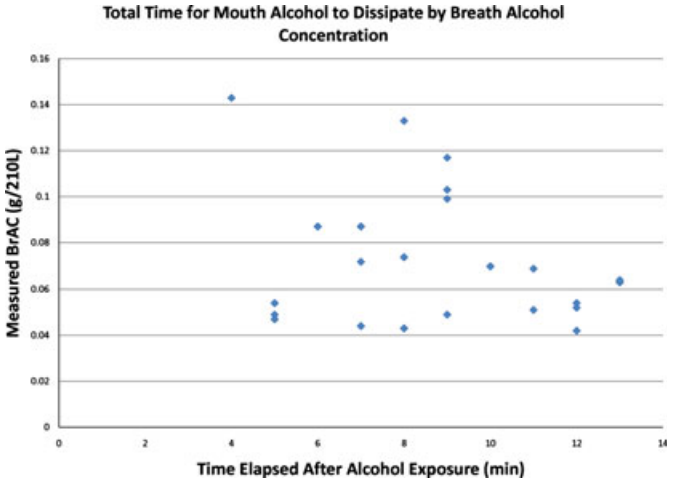

FIG. 2—*Demonstrates that in this study, there is no relationship between the amount of time for mouth alcohol to dissipate and the unbiased breath alcohol concentration. The correlation coefficient was −0.263 (SE = 0.028,* n = *23).*

September 14, 2010]). In the event that mouth alcohol is introduced immediately prior to the first breath test, two tests with a waiting period between them can serve as a warning that mouth alcohol might be present. The officer or instrument can then schedule additional testing as appropriate.

As demonstrated in Fig. 2, there is not a significant relationship between the actual BrAC and the rate of dissipation of mouth alcohol in this study. The correlation coefficient was calculated to be −0.263 (standard error = 0.028). This is an area where further research may be warranted because other studies, such as those conducted by Gullberg (4) and Lalonde et al. (7), have suggested that there is an inverse relationship. A larger sample size would make it clearer if a relationship between BrAC and the rate of dissipation is present.

Comparison of Results

When subjects provided multiple breath tests, the mouth alcohol loss was greater than when they provided single tests after each rinse with the vodka solution even when more time had elapsed. This confirms that providing a breath test in itself causes additional depletion of the mouth alcohol consistent with the findings of Buczek and Wigmore (8).

Conclusions

In most jurisdictions, subjects provide two breath samples for an evidential test. If providing the first breath sample lowers the BrAC when mouth alcohol is present (through the depletion of mouth alcohol), the second sample will be lower in comparison to the first test. This should trigger the scheduling of a third test where automatic scheduling is used. This once again affirms the need for duplicate testing as a safeguard against mouth alcohol.

The substantial loss of mouth alcohol over 1 to 2 min demonstrates the need for agencies to conduct at least two breath tests in evidential testing. As expected, a waiting period of 2 min between tests resulted in a larger difference between the two values than it did with a wait of only 1 min. These results further affirm that a waiting period, specifically 2 min or more between tests, serves as another way to detect mouth alcohol in samples.

This study reaffirms the need for the pretest observation period to allow any possible mouth alcohol to dissipate. As all subjects in the study reached base levels within 13 min, the current minimum of a 15-min observation period is more than adequate as a precaution against mouth alcohol.

As a 15-min observation period and duplicate breath testing with at least a 2-min wait are each sufficient to protect against mouth alcohol individually, it can be concluded that the combination of the two is sufficient to protect against mouth alcohol in instruments that do not contain mouth alcohol detectors (fuel cell devices).

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