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DECREASING THE MOUTH ALCOHOL EFFECT BY INCREASING THE SALIVARY FLOW RATE

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ABSTRACT

The retention of alcohol in the oral cavity (the mouth alcohol effect) is a major limitation of breath alcohol testing and requires a wait of 15 to 20 minutes. Currently the only method to reduce this effect is to rinse the mouth with water. In this study, the mouth alcohol effect was found to be substantially decreased by increasing the salivary flow rate. Nineteen female and 11 male alcohol-free subjects on two occasions rinsed their mouths with 20 mL of diluted vodka (20% v/v) for 20 seconds and then expectorated. The subjects kept their mouths closed and provided breath samples into an Intoxilyzer® 5000C five and ten minutes after expectoration with and without chewing one piece of sugar-free gum (a salivary flow promoter). The subjects chewed the gum for five minutes, then removed the gum and provided the breath samples. On the other occasion, the subjects did not chew gum. The mean Intoxilyzer® results (± Standard Error of the Mean (SEM)) after 5 minutes were 0.155 (± 0.012) g/210 L with no gum and 0.022 (± 0.003) g/210 L after chewing gum. Chewing gum caused a mean percent decrease in the BrAC due to the mouth alcohol effect of 85 (± 1.6)% after five minutes. After 10 minutes an Intoxilyzer® result > 0.010 g/210 L was found in 27 subjects (90%) when they did not chew gum, compared to none (0%) when gum was chewed. Increasing the salivary flow rate causes a large reduction in the magnitude and duration of the mouth alcohol effect. The use of salivary flow promoters may allow for more rapid breath alcohol testing after the last consumption of alcohol.

RÉSUMÉ

La rétention d'alcool dans la cavité buccale (alcool résiduel dans la bouche) constitue une limitation majeure dans l'analyse de l'alcool dans l'haleine et nécessite une période d'attente de 15 à 20 minutes. La seule méthode permettant de réduire cet effet consiste au rinçage de la bouche avec de l'eau. Dans la présente étude, la présence d'alcool résiduel dans la bouche a été considérablement réduite par l'augmentation de la salivation. Trente sujets (dix-neuf femmes et onze hommes) dont l'alcoolémie était négative se sont rincé la bouche avec 20 mL de vodka diluée (20% v/v) pendant 20 secondes avant d'expectorer. Les sujets ont gardé la bouche fermée avant de fournir les échantillons d'haleine dans un Intoxilyzer® 5000C cinq et dix minutes après l'expectoration. L'expérience a été reprise chez les mêmes sujets, qui cette fois ont mâché un morceau de gomme sans sucre (promoteur de salivation). Les sujets ont mâché la gomme pendant cinq minutes avant de la jeter et de souffler dans l'instrument. La moyenne des résultats (± écart type) après 5 minutes était 0,155 (± 0,012) g/210 L sans gomme à mâcher et de 0,022 (± 0,003) g/210L avec la gomme à mâcher. L'utilisation de la gomme à mâcher a permis une diminution moyenne de 85 (±1,6)% des résultats associés à l'alcool résiduel après cinq minutes. Un résultat supérieur à 0,010 g/210 L sur l'Intoxilyzer® 5000C a été retrouvé chez 27 sujets (90%) lorsqu'ils ne mâchaient pas de gomme comparativement à zéro (0%) lorsqu'ils avaient mâché de la gomme. L'augmentation de la salivation

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provoque une réduction importante de l'ampleur et de la durée de l'influence de l'alcool résiduel dans la bouche. L'usage de substances augmentant la salivation pourrait permettre de réduire le temps d'attente entre la dernière consommation d'alcool et l'analyse de l'alcool dans l'haleine.

INTRODUCTION

The mouth alcohol effect is potentially one of the major limiting factors in breath alcohol testing. Residual mouth alcohol has been shown to falsely increase the breath alcohol concentration (BrAC) for up to approximately fifteen to twenty minutes (1). This limitation has been recognized for many years and as such a 15-20 minute deprivation period has generally been required prior to evidential breath alcohol testing.

The duration and magnitude of the mouth alcohol effect has been found to depend on numerous factors such as the area of oral cavity exposed to the alcohol solution (i.e. either rinsing or swallowing) (2), the volume of, and concentration of, the alcohol solution (3), the frequency of breath alcohol sampling (4), and the pre-existing breath alcohol concentration of the subject (5). Currently the only method found to reduce the duration and magnitude of the mouth alcohol effect has been to rinse the mouth with water (3,6).

It has been proposed that the alcohol in the oral cavity is normally dissipated by evaporation, reabsorption of the alcohol, and salivary flow rate (7). To our knowledge, however, there is no published study on the effect of salivary flow rate on the mouth alcohol effect. Therefore, an experiment was conducted to determine the effect of increasing the salivary flow rate, in this case by chewing one piece of long-lasting flavoured sugar-free gum, on the duration and magnitude of the mouth alcohol effect. Chewing this type of gum has been shown to increase the average salivary flow rate by tenfold (8). This study was conducted on alcohol-free subjects as is usual in mouth alcohol experiments.

MATERIALS AND METHODS

Nineteen female and 11 male healthy, alcohol-free subjects, aged between 20-45 years, were tested. A detailed medical history was not obtained from the subjects but none complained of xerostomia (dryness of the mouth). No subject had dentures or any other oral appliance in their oral cavity. The subjects rinsed their mouths with 20 mL of diluted vodka (40% v/v alcohol diluted 1:1 with water for a final alcohol concentration of 20% v/v) for 20 seconds and then expectorated. In order to reduce potential confounding factors such as evaporation of the alcohol from the mouth, the subjects were not allowed to talk and kept their mouth closed except when providing the breath samples. In addition, no smoking, drinking, or eating was allowed during the course of the experiments.

Five and ten minutes after expectorating, the subjects provided breath samples into an Intoxilyzer® 5000C (CMI Inc. Owensboro, Ky, USA) an evidential infra-red breath alcohol testing instrument commonly used in North America (9). The Intoxilyzer® results or BrACs are reported in this study as grams of alcohol in 210 litres of breath (g/210L). This unit, which is widely used in the United States, is equivalent (when multiplied by 1000) to a blood alcohol concentration (BAC) measured in milligrams of alcohol in 100 millilitres of blood when using the forensically acceptable blood to breath alcohol ratio of 2100 to 1. The **Criminal Code of Canada** and the *Recommended Standards and Procedures of the Canadian Society of Forensic Science Alcohol Test Committee* define blood and breath alcohol concentrations in terms of milligrams of alcohol in 100 millilitres of blood (mg/100 mL)(10).

After at least an additional 10 minutes, and when the subject's BrAC as determined by the Intoxilyzer® was again zero, the sequence was repeated. This time after expectorating

TABLE 1

Intoxilyzer results (BrACs) 5 minutes after rinsing the mouth with 20 mL of diluted vodka (20% v/v) for 20 seconds, with and without chewing gum. The percent reduction in the BrAC caused by mouth alcohol is also given

Subject Number	BrAC after 5 minutes, no gum (g/210L)	BrAC after 5 minutes with gum (g/210L)	Percent reduction in BrAC with gum
1	0.201	0.017	92
2	0.177	0.000	100
3	0.231	0.023	90
4	0.183	0.023	87
5	0.183	0.043	77
6	0.045	0.009	80
7	0.179	0.035	80
8	0.171	0.022	87
9	0.137	0.013	91
10	0.137	0.014	90
11	0.113	0.016	86
12	0.128	0.010	92
13	0.143	0.016	89
14	0.219	0.024	89
15	0.276	0.030	89
16	0.159	0.020	87
17	0.129	0.015	88
18	0.203	0.033	84
19	0.221	0.091	59
20	0.277	0.027	90
21	0.095	0.012	87
22	0.032	0.007	78
23	0.089	0.015	83
24	0.098	0.014	86
25	0.233	0.029	88
26	0.121	0.012	90
27	0.231	0.029	87
28	0.055	0.011	80
29	0.031	0.014	55
30	0.162	0.025	85
Mean	0.155	0.022	85
SEM	0.012	0.003	1.6
Range	0.031–0.277	0.000–0.091	55–100

the diluted vodka, the subjects placed one piece of Wrigley's Winterfresh® Extra sugar-free gum in their mouths and chewed at their own rate with their mouths closed. The gum was removed just before providing the first breath sample into the Intoxilyzer® at five minutes. The subjects did not chew any more gum and kept their mouths closed until the second Intoxilyzer® test conducted at 10 minutes.

Wrigley's Winterfresh® Extra sugar-free gum is labelled as containing sorbitol, mannitol, xylitol, and aspartane. One piece of gum placed in the mouth of an alcohol-free subject did not cause a positive Intoxilyzer® 5000C result even when the gum was still in the mouth.

The subjects were instructed to exhale as long as possible into the instrument and the final result that appeared on the screen was recorded. Whether or not the instrument detected mouth alcohol as INVALID SAMPLE was not recorded, as this has been reported in a previous study (4). The spit-trap mouthpiece was changed after each breath test. The Intoxilyzer® 5000C reports all BrACs < 0.007 g/210 L as zero.

The accuracy of the Intoxilyzer® was checked after every fourth subject test using a simulator (Model 34C, Guth Laboratories Inc., Harrisburg, PA) (11). All the results were within +/– 5% of the target value of 0.100 g/210 L.

TABLE 2

Intoxilyzer results (BrACs) 10 minutes after rinsing the mouth with 20 mL of diluted vodka (20% v/v) for 20 seconds with and without chewing gum. The gum was chewed for the first five minutes only and then removed from the mouth

Subject Number	BrAC after 10 minutes, no gum (g/210L)	BrAC after 10 minutes with gum (g/210L)
1	0.040	0.000
2	0.017	0.000
3	0.042	0.000
4	0.041	0.000
5	0.049	0.007
6	0.007	0.000
7	0.047	0.007
8	0.057	0.000
9	0.028	0.000
10	0.008	0.000
11	0.016	0.000
12	0.016	0.000
13	0.024	0.000
14	0.078	0.000
15	0.048	0.000
16	0.059	0.007
17	0.031	0.000
18	0.054	0.010
19	0.023	0.000
20	0.071	0.008
21	0.014	0.000
22	0.000	0.000
23	0.011	0.000
24	0.018	0.000
25	0.061	0.009
26	0.027	0.000
27	0.092	0.009
28	0.015	0.000
29	0.011	0.000
30	0.037	0.007
Mean	0.035	0.002
SEM	0.004	0.0007
Range	0.000-0.092	0.000-0.010

RESULTS AND DISCUSSION

Table 1 shows the Intoxilyzer® results for the 30 subjects, five minutes after rinsing the mouth with diluted vodka for 20 seconds, with and without gum. The percent reduction in the mouth alcohol effect due to chewing the gum for five minutes is also shown. As seen in Table 1, the mean BrAC caused by the mouth alcohol effect was 0.155 g/210 L (range 0.031- 0.277 g/210 L) without chewing gum, which was reduced to a mean BrAC of 0.022 g/210 L (range 0.000 – 0.091 g/210L) after chewing gum. These differences were statistically significant using a paired t-test ($p<0.0001$). The mean reduction in the mouth alcohol effect after chewing gum for approximately five minutes was 85% (range 55 – 100%).

Table 2 shows the Intoxilyzer® results at 10 minutes after rinsing the mouth with diluted vodka. The percent reduction was not calculated as the BrACs were low and most of the Intoxilyzer® results after chewing gum were zero so that virtually all the reductions were 100%. The mean BrAC was 0.035 g/210 L (range 0.000 – 0.092 g/210 L) without chewing gum and 0.002 g/210 L (range 0.000 – 0.010 g/210 L) after chewing gum. It appears that even though the gum chewing ceased after 5 minutes, it still caused a reduction in the mouth alcohol effect after 10 minutes. Without chewing gum, a BrAC > 0.010 g/210 L was found

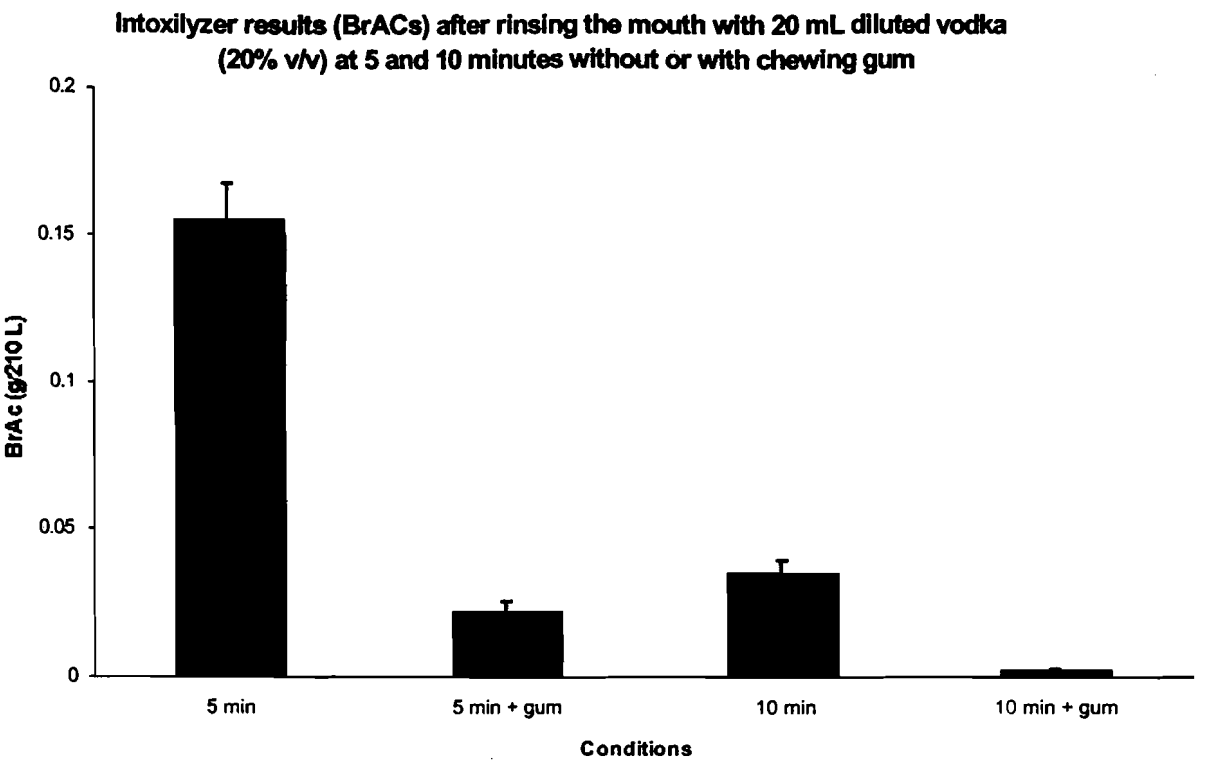

Figure 1. Bar graph of the mean BrAC (bar) ± SEM (line) after rinsing the mouth with 20 mL of diluted vodka (20% v/v alcohol) at five and ten minutes without or with chewing gum, respectively.

in 28 (90%) of the subjects after 10 minutes, whereas in the subjects who chewed gum, even though the subjects no longer continued to chew gum after 5 minutes, no BrACs > 0.010 g/210 L were found in any subject. The difference in the Intoxilyzer® results after 10 minutes was also statistically significant using a paired t-test ($p < 0.0001$).

Figure 1 shows the mean (shaded bar) and the standard error of the mean (SEM) (line) for all four conditions.

Saliva is a fluid consisting of over 99% water that is secreted by the parotid, submandibular, and sublingual glands. The unstimulated saliva flow, which keeps the mouth moist and lubricates the mucous membrane, is approximately 0.5 mL/minute (12). The salivary flow rate can be increased by gustatory (taste) and mechanical (chewing) stimuli and has been shown to increase initially to 5.5 mL/minute by chewing long-lasting flavoured gums similar to the gum used in this study (8), which is more than 10 times the unstimulated salivary flow rate. The stimulated salivary flow rate was found to decrease with time to 2.0 mL/minute after five minutes and to 1.4 mL/minute after 10 minutes (8). No salivary flow rates were measured in our subjects, but all subjects reported increased salivation while chewing gum.

It is generally believed that mouth alcohol is normally dispersed by evaporation from talking and breathing thorough the mouth and by salivation. The 85% reduction in the mouth alcohol effect at five minutes achieved by increasing the salivary flow rate through the chewing of gum as shown in this study indicates the importance of salivation in dispersing mouth alcohol. Increasing the salivary flow rate may provide an alternative to rinsing the mouth with water to reduce the mouth alcohol effect.

Another interesting aspect is that it has been argued in criminal courts in Ontario and other jurisdictions that the subject had food, candy, chewing tobacco, or gum hidden in their mouth during the evidential breath alcohol test without the police being aware of it and that these substances would act like a sponge and soak up and retain the alcohol beyond the 15 –20 minute deprivation period. These substances, however, when chewed, promote the flow of saliva and, as shown in this study, the duration and magnitude of the mouth alcohol effect is actually decreased not increased.

CONCLUSIONS

Increasing salivary flow rate has been shown to cause a substantial reduction in the duration and magnitude of the mouth alcohol effect. Although more research is required into the use of salivary promoters (especially under more realistic forensic situations), it has the potential to reduce the time required before conducting a breath alcohol test. This may allow more rapid testing of subjects especially under field conditions and may allow research into determining BrACs shortly after drinking ceased rather than a 15-20 minute delay.

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