FACTORS AFFECTING THE ABSORPTION RATE OF ALCOHOL INTO THE BLOOD - A PILOT STUDY.

I.E.C. CAMERON A.S. HAMMOND
NEW SOUTH WALES POLICE DEPARTMENT BREATH ANALYSIS SECTION

In recent years, the chemical testing of body fluids (e.g. breath, blood and urine) to determine the blood alcohol concentration has become a common practice in order to obtain evidence in relation to various drink/driving offences. One of the difficulties encountered in presenting evidence of this type is that the reading obtained represents the blood alcohol concentration only at the time the sample was taken, which is almost invariably some time after the time of the alleged offence, such as a traffic infringement or accident.

In some cases, legislation has been so framed that it is an offence to have a blood alcohol concentration in excess of a specified level at the time of testing, provided the test is taken within a specified time (e.g. 2 hours) of the event. In other cases no such provision exists, and in these cases the courts may call for evidence from forensic experts as to what the concentration may have been at an earlier time, and for an opinion as to whether the driver was at that time under the influence of alcohol. It is now generally agreed that it is not possible to determine, with any accuracy, what the concentration would have been at some time earlier than the test, due to wide variations in the rate of rise and fall of blood alcohol concentrations in different individuals, and even in the same individual on different occasions.¹,²
However, it is frequently possible to express an opinion as to the range within which the concentration would have fallen at an earlier time, and it has been considered that this opinion can be more informed and more accurate if certain extra information is available, such as the times between which drinking occurred, the nature and strength of the beverage consumed, and the nature and quantity of any food ingested during, or in close proximity to the drinking period. Other factors which may influence the rate and extent of the rise and fall of the blood alcohol concentration after a period of drinking include the occurrence of physical exertion during, or in close proximity to the drinking period, the emotional state of the subject and his state of health (particularly in regard to the gastro-intestinal tract and liver).

The object of the study on which this paper is based was to examine some of the widely held beliefs as to the effect of some of the above factors on the rate and extent of the rise and fall of the blood alcohol concentration after drinking. In a series of six experiments, twelve subjects were given measured amounts of alcohol over a period of one hour. The amount consumed by each individual was selected having regard to his normal drinking habits, and his own assessment of the quantity he could comfortably consume in the hour under the conditions of the experiments. However, in each of the six experiments he was required to consume the same amount of alcohol. All subjects were young adult males in good health, but varying widely in body weight.

The beverages used were:-

(i) New South Wales beer (4.6% ethanol v/v).
(ii) A light white Australian wine (9.2% ethanol v/v).

The blood alcohol concentrations were determined by breath analysis, using the Breathalyzer. Frequent analyses were undertaken at intervals of approximately 10 minutes, commencing 15 minutes after the completion of
drinking and continuing well into the elimination phase. Occasional concomitant analyses of freshly secreted urine were also undertaken, and these gave good correlation with the breath analysis results, generally being the same or slightly higher. Each subject was tested prior to the commencement of each experiment, to ensure that no alcohol was present in his blood. The six experiments were conducted at intervals of one week.

The six experiments were designed as follows:-

**DAY 1** The consumption by each subject of a specified quantity of beer, in one hour, on an empty stomach (i.e. several hours after a light breakfast).

**DAY 2** Consumption by each subject of the same quantity of beer as on Day 1, but commencing 15 minutes after the ingestion of a substantial fatty meal (fried chicken, fried potatoes, cheesecake and milk).

**DAY 3** Consumption by each subject of the same quantity of beer as on Day 1, but commencing 15 minutes after the ingestion of a substantial low-fat meal (tinned salmon, cheese, salad, fruit juice).

**DAY 4** Drinking conditions the same as on Day 1, but each subject was required to engage in intermittent, moderately strenuous exercise during the first hour after completion of drinking.

**DAY 5** Drinking conditions the same as on Day 1, except that each subject was given the same quantity of alcohol in the form of light wine (alcohol 9.2% v/v) instead of beer (alcohol 4.6% v/v).

**DAY 6** Drinking conditions identical with Day 1.
It was decided to use the Breathalyzer for determining the blood alcohol concentrations in these experiments, as it provides a convenient means of obtaining a number of samples for analysis at relatively short intervals. On the other hand, it has been shown that the Breathalyzer, in many cases, tends to give a lower reading than that obtained from a direct analysis of venous blood. The reason for this discrepancy appears to lie mainly in the fact that the Breathalyzer is calibrated on the assumption that the distribution ratio of alcohol between blood and breath (alveolar air) is 2100:1. Obviously, if this physiological ratio is greater in some individuals, then the reading obtained by breath analysis will tend to be lower, and recent studies suggest that the ratio is greater in many, if not most, individuals. This has certain advantages from a medico-legal point of view, in that it can be argued that the use of the Breathalyzer cannot be said to unfairly disadvantage a person suspected of a drink/driving offence. However, for the purposes of this study, the question is irrelevant, as the object was to examine the comparative effect on the blood alcohol concentration of varying the drinking conditions, in the ways outlined above — namely the effects of consumption of different types of food, the effect of exercise, and the effect of varying the concentration of the beverage, as compared with drinking on an empty stomach.

DISCUSSION OF RESULTS.

The maximum blood alcohol concentrations achieved by each subject are provided in Table I, and some representative blood alcohol curves are illustrated in Figures 1 - 4.

EXPERIMENTS 1 & 6

In these two experiments the drinking conditions were identical, namely consumption of the same quantity of beer
on each occasion under fasting conditions. It will be noted that in the majority of cases there is a significant variation in the maximum concentration achieved, and in some cases (e.g. Subjects 1 and 11) the variation is quite marked. One must therefore conclude that a subject will not necessarily achieve the same concentration each time he consumes the same amount of liquor, even under identical drinking conditions (see Figure 1). The time taken after completion of drinking to reach the maximum concentration varied from 15 minutes to 90 minutes, with an average of 42 minutes.

**EXPERIMENT 2.**

The effect of consumption of a fatty meal before drinking was generally to produce significantly lower blood alcohol readings, and in some cases (e.g. Subjects 8 and 10) the difference between these curves and the fasting curves was very marked (see Figure 4). The only exceptions were Subjects 11 and 12, who achieved a slightly higher reading at the peak concentration, but who subsequently exhibited lower readings than in the fasting state throughout the remainder of the blood alcohol curve. The time taken after completion of drinking to reach the maximum concentration varied from 21 to 75 minutes, with an average of 36 minutes.

**EXPERIMENT 3.**

The consumption of a low-fat meal immediately before drinking was again to produce lower peak concentrations, and generally lower blood alcohol curves, although the difference was generally not as great as with a fatty meal. In some cases the curve was comparable to that seen with the fatty meal (Figures 1, 2 and 3), while in others it was intermediate between the fasting curve and the "fatty meal" curve (Figure 4). One subject (Subject 9) achieved a higher peak concentration in this experiment than in either of the experiments in the fasting
TABLE I

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>EXP.1</th>
<th>EXP.2</th>
<th>EXP.3</th>
<th>EXP.4</th>
<th>EXP.5</th>
<th>EXP.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.105</td>
<td>0.08</td>
<td>0.075</td>
<td>0.07</td>
<td>0.110</td>
<td>0.08</td>
</tr>
<tr>
<td>2</td>
<td>0.100</td>
<td>0.075</td>
<td>0.09</td>
<td>0.07</td>
<td>0.065</td>
<td>0.085</td>
</tr>
<tr>
<td>3</td>
<td>0.08</td>
<td>0.06</td>
<td>0.065</td>
<td>0.055</td>
<td>0.100</td>
<td>0.075</td>
</tr>
<tr>
<td>4</td>
<td>0.095</td>
<td>0.075</td>
<td>0.075</td>
<td>0.095</td>
<td>0.095</td>
<td>0.110</td>
</tr>
<tr>
<td>5</td>
<td>0.105</td>
<td>0.085</td>
<td>0.08</td>
<td>0.100</td>
<td>0.110</td>
<td>0.095</td>
</tr>
<tr>
<td>6</td>
<td>0.055</td>
<td>0.035</td>
<td>0.05</td>
<td>0.06</td>
<td>0.05</td>
<td>0.045</td>
</tr>
<tr>
<td>7</td>
<td>0.07</td>
<td>0.04</td>
<td>0.07</td>
<td>0.08</td>
<td>0.07</td>
<td>0.08</td>
</tr>
<tr>
<td>8</td>
<td>(N/A)</td>
<td>0.03</td>
<td>0.06</td>
<td>0.06</td>
<td>0.055</td>
<td>0.075</td>
</tr>
<tr>
<td>9</td>
<td>0.07</td>
<td>0.045</td>
<td>0.08</td>
<td>0.06</td>
<td>0.100</td>
<td>0.075</td>
</tr>
<tr>
<td>10</td>
<td>0.075</td>
<td>0.04</td>
<td>0.07</td>
<td>0.08</td>
<td>0.07</td>
<td>0.09</td>
</tr>
<tr>
<td>11</td>
<td>0.100</td>
<td>0.08</td>
<td>0.075</td>
<td>0.09</td>
<td>0.110</td>
<td>0.075</td>
</tr>
<tr>
<td>12</td>
<td>0.05</td>
<td>0.06</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.055</td>
</tr>
</tbody>
</table>

state. The time taken after completion of drinking to reach the maximum concentration varied from 15 minutes to 40 minutes, with an average of 25 minutes. It is noteworthy that the average time taken to reach peak concentration in the two experiments involving consumption of food was significantly shorter than in the two fasting experiments (Experiments 1 and 6).

EXPERIMENT 4

Engaging in moderately strenuous exertion immediately after drinking gave widely varying results in different subjects. Some subjects (Figures 1 and 4) showed significantly lower curves than in the fasting experiments without exercise while others (Figures 2 and 3) showed no significant variation. It has been suggested that exercise, by increasing the circulation rate, may speed up the processes of absorption and elimination. Others have contended that exercise, by causing a shunt of blood from the visceral circulation to the active muscles, may slow
down these processes. Neither of these theories is supported by this experiment and we conclude that exercise cannot be shown to have any consistent effect on the rates of absorption or elimination of alcohol from the blood (although the number of subjects is small). The time taken to reach the maximum concentration after completion of drinking varied from 18 to 93 minutes, with an average of 39 minutes. These times are comparable with those obtained in Experiments 1 and 6.

EXPERIMENT 5.

The administration of the same quantity of alcohol in the form of wine (9.2% alcohol v/v) instead of beer (4.6% alcohol v/v) thereby doubling the concentration of the beverage again produced no clear-cut variations. Some subjects (subject 1) achieved marginally higher peak concentrations, while others (subjects 2 and 8) reached significantly lower peak concentrations. The times taken to reach the maximum concentration varied from 18 to 48 minutes, with an average of 33 minutes. This suggests that an increase in the concentration of the beverage may slightly increase the absorption rate, but one must exercise caution in drawing conclusions from this experiment again due to the small numbers involved, and the fact that stronger beverages (e.g. spirits) were not included.

SUMMARY

The object of this study was to examine some of the widely held beliefs as to the effect of various factors on the absorption of alcohol into the blood.

In a series of six experiments, twelve subjects were given measured amounts of alcohol, each subject ingesting the same quantity in each experiment, but with other conditions varied.

The factors examined were:

(i) effect of a fatty meal before drinking.
(ii) effect of a low-fat meal before drinking.
(iii) effect of varying the concentration of the beverage.
(iv) effect of exercise immediately after drinking.
(v) repeatability of results, for the same subject when drinking under identical conditions on different occasions.

It was found that ingestion of food before drinking caused a significant lowering of the peak blood alcohol concentration, which was most pronounced in the case of fatty food.

Varying the concentration of the beverage produced no consistent pattern of variation in the peak blood alcohol concentration.

Exercise immediately after drinking again produced no consistent pattern of variation in the results.

It was found that the same subject, drinking under identical conditions on two separate occasions, could show significant differences in the peak blood alcohol concentration reached.

REFERENCES.


FIGURE 3

- No food
- Fatty meal
- Low-fat meal
- Exercise
- Wine
- No food

BLOOD ALCOHOL CONCENTRATION

0 0.02 0.04 0.06 0.08 0.10

0 1 2 3 HR

TIME OF TESTING
FIGURE 4

- No food
- Fatty meal
- Low-fat meal
- Exercise
- Wine
- No food

BLOOD ALCOHOL CONCENTRATION

TIME OF TESTING

0 1 HR 2 HR 3 HR