Difference in Blood Alcohol Levels Following Consumption of Whisky and Beer in Man

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The formulation of many pharmaceutical preparations may influence the absorption of their medicinally active principles and thus their blood profiles, or as it has become known, their biological availability. It is also apparent from a number of studies, that the blood alcohol profile, after consumption of alcoholic beverages, may be affected by the form in which the alcohol is consumed. Alcoholic beverages, beer, wine and spirits contain a wide variety of chemical components peculiar to each beverage and the alcohol content varies not only between the beverages but also within the same type of beverage. Such factors and total alcohol dosage may account for the different blood alcohol curves which have been reported.

The first studies which demonstrated a difference in physiological response between alcoholic beverages were those of Mellanby (3). Using the dog as a test animal, he found a higher blood alcohol concentration (BAC) when alcohol was given in the form of whisky as compared to stout, even though both were diluted to the same concentration of alcohol. During the intervening years many studies have been reported comparing, in man, the blood alcohol curves after ingestion of whisky, brandy, beer or wine. In most instances the concentration of alcohol in the blood produced by spirits was higher than that from other alcoholic beverages. The authors of previous Canadian studies, Gardiner and Stewart (2), concluded that there were only slight and nonsignificant differences between the spirits and beer with respect to BACs.

Blood alcohol levels and differences among alcoholic beverages, in this respect, are only one aspect of the picture. The other, of pre-eminent importance, is impairment. It is well known that, for most functions, a consistent relationship exists between BAC and the degree of behavioural or functional impairment present. However, comparative studies of alcoholic beverages in this respect are few. Newman and Abramson (4) found the same degree of incoordination at a slightly higher BAC after the ingestion of dessert wine, than after distilled liquors, while Bjerver and Goldberg (1) observed that driving ability was less impaired after consuming beer than after the consumption of equal amounts of alcohol as distilled spirits. Similar results were obtained by Takala et al (5) who found a greater degree of impairment following consumption of brandy than after the same dose of alcohol in the form of beer, even though drink-rates were adjusted to produce the same blood alcohol levels.

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In view of the paucity of data from this country, we have undertaken a series of studies to clarify the picture for Canadian beverages and to define the effect of alcohol beverage dose on blood alcohol response.

METHOD

The beverages that were chosen were a popular Canadian rye whisky and two well-known Canadian beers. The whisky was served, either neat or diluted 1:3 with water, soda water or most often ginger ale, while beers were served as taken from the bottle. The alcohol content of the whisky was 40% by volume and approximately 13.3% after dilution. The alcohol content of the beers was in one case 4.7 and in the other 5.0% by volume. These beverages were given in doses of 0.25, 0.5, 0.75, 1.0 and in the case of whisky, 1.5 grams of alcohol per kilogram of body weight (g/kg). Most studies were conducted at a dose of 0.75 g/kg of alcohol and this alcohol dose is equivalent to approximately four drinks of spirits or four 12 oz. bottles of beer for a 70 kg man. Beverages were consumed during drinking sessions of 15 to 145 minutes. At a dose of 0.75 g/kg the beverages were consumed in 25 minutes.

The subject pool consisted of 26 males, 22 to 50 years of age with an average age of 32 years. Body weights were 64 to 114 kg with an average of 80 kg. Twelve of the subjects were laboratory workers, 14 were members of the local police force. On the basis of answers to a questionnaire, they might be considered as light to moderate in their drinking habits (two to three drinks per day). The subjects were fasted overnight and then given a light breakfast and a light lunch at noon. Alcohol beverages were consumed after the breakfast or during the afternoon. Each study was done on eight subjects, four of whom were consuming either beer or whisky on a given experimental occasion. Each study consisted of two experiments at weekly intervals using a crossover pattern. BACs were determined from peripheral capillary blood samples (finger prick). Duplicate samples were immediately dispensed into vials for headspace analysis by gas chromatography. Blood samples were taken prior to alcohol consumption and at 30 to 60 minute intervals for six to ten hours thereafter.

Central nervous impairment as indicated by changes of standing steadiness was measured using the statometer developed by Goldberg. Body sway in the Romberg position was converted to electrical impulses and recorded for later analysis on magnetic tape.

RESULTS

Blood Alcohol

Figure 1 illustrates the BACs after consumption of 0.75 grams/kg of whisky diluted with ginger ale and the same dose of alcohol in the form of the two beers. After consumption of whisky, the peak BAC or Cmax, was higher than after the consumption of the same amount of alcohol in either of the two beers. The time required to

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reach these peak values, which is termed that \( t_{\text{max}} \), was also shorter after consumption of whisky than after consumption of either beer. The descending portions of the curves are almost identical and in these experiments the subjects reach a zero blood alcohol value at the same time irrespective of the beverage consumed. To put it in other words, the rate of elimination and the time required to completely eliminate blood alcohol were the same whether the alcohol was consumed as whisky or beer. We found no appreciable differences in the blood alcohol curves for whisky, whether the whisky was consumed neat or diluted 1:3 with water, soda water or ginger ale.

The differences between the whisky and beer blood alcohol curves in terms of \( C_{\text{max}} \) and \( t_{\text{max}} \) values were present when whisky and the beers were compared over a wide dose range. These studies are summarized in Figure 2. In this Figure we have plotted the \( C_{\text{max}} \) values on the ordinate and the \( t_{\text{max}} \) values on the abscissa for dose levels of the 0.25, 0.5, 0.75, 1.0 and 1.5 g/kg of alcohol in the form of whisky or beer. The coordinates representing each beverage at a given dose have been joined. It should be noted that the figure for the 1.5 g/kg dose of alcohol as beer, has been extrapolated from the remaining data as our subjects were unable to consume this volume of alcohol as beer in the required drinking time. At the 0.25 g/kg dose level there were no significant differences between the coordinates for beer or whisky. At all higher dose levels the differences were statistically significant and the magnitude of these differences increased with increasing doses of alcohol.

**STATOMETRY**

In order to determine whether different beverages at similar BACs reflected different degrees of impairment, psychomotor testing was carried out using a Statometer. With this device body sway and coordination were measured before and after the ingestion of 0.75 g/kg of alcohol in the form of whisky or the two beers.

Under normal circumstances, when the body is in the erect position and standing still, there is a significant body sway that is made up of forward and backward — sagittal — as well as side to side — lateral — components. Under the influence of alcohol, body sway dramatically increases in both frequency and amplitude.
Before, and at hourly intervals after, ingestion of the beverages, subjects were required to stand on the Statometer platform with feet together and hands by the body (Romberg position) for 70 seconds with the eyes open and then 70 seconds with the eyes closed. Appropriate transducers, mounted in the platform, detected the direction and intensity of body sway in both directions, and transformed the mechanical movements of the body into electrical signals. These analog signals were recorded and stored on magnetic tape and monitored on a Grass Polygraph. For evaluation, the stored analog signals were converted in an A/D converter into impulses, counted during one second periods and printed out. Mean amplitudes and variability of sway were then statistically analyzed.

In this study, the post-treatment data were compared to those of the pre-treatment period and expressed as percent change against time. It may be seen from Figure 3 which illustrates the course of the changes in amplitude for sagittal sway with eyes closed and open, that body movements in general reflect body alcohol concentrations. An increase in body sway occurs as BAC builds up and this reverts to normal, coincident with elimination of blood alcohol. The extent of these changes was found to be greater with whisky than with beer, particularly with the eyes closed and this was the case for either sagittal or, as illustrated in Figure 4, lateral sway. The same profile for change in body sway was observed when whisky, again at 0.75 g/kg dose level of alcohol, was compared with a second beer.

DISCUSSION

The results of our studies with Canadian beers and a Canadian whisky confirm the differences in BAC reported for different alcoholic beverages by others. As exemplified by our studies at a dose of 0.75 g/kg of alcohol in the form of whisky or beer,
Figure 3  Standing steadiness: Lateral sway.

Figure 4  Standing steadiness: Sagittal sway.
consumed over a period of 25 minutes, BAC is greater following ingestion of whisky and impairment greater as measured by the Statometer, than after the consumption of the same amount of alcohol as beer. The studies which we have done at different levels of beverage consumption demonstrate the importance of alcohol dosage in determining whether or not such differences are observed. In this respect not only alcohol dosage but also drinking times are crucial and, as has been shown by many others, differences may not be present when the beverages are consumed in the “fed” as contrasted with the “fasting” state. Differential absorption rates of the alcohol from the different alcoholic beverages have been considered as an explanation and various factors may influence this rate of uptake. These include alcohol concentration and volume in which the given dose of alcohol is consumed, as well as extract content or buffer capacity of the beverage, but as yet one cannot draw firm conclusions as to the mechanism involved.

The social implications of these findings are not as straightforward as they might appear. It is apparent that under certain circumstances the consumption of alcohol in the form of one alcoholic beverage may produce higher BACs and a greater degree of impairment than when the same dose of alcohol is consumed in a different alcoholic beverage. Our findings with respect to the $C_{\text{max}}$ for these alcoholic beverages consumed during a relatively short time period demonstrate that there is a dose threshold above which differences in the BAC are present. In this study, when the beverages were consumed over a 25-minute period this threshold appeared to be lower than 0.5 g/kg. At 0.75 g/kg also consumed in 25 minutes, the differences in the $C_{\text{max}}$ between beverages were clearly present.

On the other hand, on the basis of preliminary results from recent studies, it appears that when the drinking period is extended it is necessary to raise the dose of alcohol to obtain similar differences. This suggests that there is a moving threshold at which BAC differences related to beverage appear and that this threshold is dose and drinking duration dependent. In the near future we hope to have a complete definition of this threshold for alcoholic beverage differences and similarities over a range of dosage and drinking durations. The relevance of beverage differences for any social drinking pattern could then be judged against this model. Until such a model is available, in our opinion, one should use caution in generalizing with respect to alcoholic beverage differences or lack thereof from studies of any one dosage or drinking duration.

REFERENCES