Ethanol Clearance Rate as a Function of Age, Gender, and Drinking Practices

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ABSTRACT

Accurate estimation of ethanol clearance rate is often necessary in order to calculate a blood alcohol concentration (BAC) at the time of an accident or arrest. To increase the precision of such estimates, the effects of gender, drinking practice and age on ethanol clearance were examined in a between-subjects factorial experiment. Subjects were dosed with alcohol for peak BACs of 85 mg/dL or 105 mg/dL. They were breath tested frequently until their peak BAC, and then at hour intervals on the descending BAC curve. Using the post-peak BACs (three or more) an ethanol clearance rate for each subject was calculated with a linear regression analysis. Gender, drinking practice, and age were found to have statistically significant effects on ethanol clearance rates.

INTRODUCTION

Estimations of the rate of ethanol clearance are often used in forensic situations to predict a BAC at the time of an accident or arrest. Widmark (1932) was among the first to quantify ethanol clearance rates. He reported similar mean rates between males and females. Subsequently, other investigators reported that ethanol clearance rates vary as a function of gender (Sutker et al., 1987; Thomasson, 1995; Cole-Harding et al., 1987), and drinking practice (Smith et al., 1993; Jones et al., 1992; Jones, 1993). Although Cole-Harding reported that age is not a reliable predictor of ethanol metabolism rates, age as a variable has not been studied extensively.

This study examined the effects of age, gender, drinking practice, and their interactions, on ethanol metabolism rates.
METHOD

Subjects
Fifty-one healthy adults were recruited with advertisements in community newspapers to participate in an alcohol study as paid volunteer subjects (Ss). They were screened in terms of health history, current health status, drug and alcohol use. As shown in Table 1, they were grouped by gender, drinking category, and age (21 to 24, 25 to 50, 51 to 70). The Cahalan, Cisin, and Crossley Quantity-Frequency-Variability scale (1969) was used to classify Ss as either light, moderate, or heavy drinkers.

Table 1: Subject Distribution Across Experimental Conditions

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
<th></th>
<th>Females</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Age</td>
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<td>Age</td>
<td>Age</td>
</tr>
<tr>
<td></td>
<td>21-24</td>
<td>25-50</td>
<td>51-70</td>
<td>21-24</td>
</tr>
<tr>
<td>Light Drinkers</td>
<td>n=1</td>
<td>n=6</td>
<td>n=6</td>
<td>n=3</td>
</tr>
<tr>
<td>Moderate Drinkers</td>
<td>n=1</td>
<td>n=2</td>
<td>n=1</td>
<td>n=2</td>
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<tr>
<td>Heavy Drinkers</td>
<td>n=3</td>
<td>n=4</td>
<td>n=2</td>
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</table>

Procedures.
On treatment days, Ss were transported by taxi between their residences and the laboratory. If the Ss reported that they fulfilled the following criteria,

- No food intake within the preceding 4 hours
- No coffee, tea, or other stimulants intake within the preceding 4 hours
- No alcohol consumption within the preceding 48 hours
- No illicit, prescription. OTC drug use during the preceding 7 days
- No current health problems,

The alcohol treatment was administered. The alcohol dose for moderate and heavy drinkers,
expected to produce a peak BAC of 105 mg/dL, was 2.06 g absolute alcohol per Kg of body water. Body water was estimated on the basis of each subject's age, height, weight, and body frame size. Because light drinkers cannot tolerate the same amount of alcohol as moderate and heavy drinkers, their dose was reduced to 1.77 g absolute alcohol/Kg of body water. This amount was expected to produce a peak BAC of 85 mg/dL.

The drinks were a mixture of 80 proof vodka and orange juice. The alcohol-orange juice ratio was 1:1.5 for heavy and moderate drinkers and 1:2 for light drinkers. The total beverage was given as three equal drinks at 10-minute intervals for moderate and heavy drinkers and at 15-minute intervals for light drinkers. Subjects were instructed to pace their drinking evenly and to complete each drink within the allotted period. All subjects began their first drink between 8:00 and 9:00 am.

BACs were measured with breath specimens obtained with an Intoxilyzer 5000 at five minutes intervals, beginning 15 minutes after completion of drinking. After two consecutive descending BAC readings, the sampling rate was reduced to two Intoxilyzer readings per hour. When a S's BAC returned to zero, he/she was transported home by taxi.

**Calculation of Ethanol Clearance Rates.**

For each S, at least three BAC readings from the linear portion of the clearance phase, i.e., between 70 mg/dL BAC (the point at which the absorption phase was judged to be complete) and 30 mg/dL BAC were used to calculate the slope of a best-fit straight line. For each S, an individually calculated linear regression line was utilized to calculate the corresponding times where the regression line indicated BACs of 70 mg/dL (t_{70 mg/dL}) and 30 mg/dL (t_{30 mg/dL}). The clearance rate (β_{60}) for that individual was then calculated as follows:

\[
β_{60} = \frac{\text{70 mg/dL} - \text{30 mg/dL}}{t_{\text{30 mg/dL}} - t_{\text{70 mg/dL}}} 
\]

The analyses were performed utilizing the β_{60} values as the basic response variable for each S.

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RESULTS

A 2X3X3 between-subjects factorial ANOVA was performed to determine whether ethanol clearance rates varied as a function of gender, drinking practice, and age.

The ANOVA indicated statistically significant differences in clearance rates between females (18.4 mg/dL/h) and males (15.3 mg/dL/h) F(2, 32) = 5.97, p = 0.020; light (15.7 mg/dL/h), moderate (18 mg/dL/h), and heavy drinkers (17.5 mg/dL/h), F(2,33) = 3.52, p = 0.040; ages 21-24 (15 mg/dL/h), ages 25-50 (16.7 mg/dL/h), ages 51-70 (17.5 mg/dL/h), F(2,33), p = 0.007. Figures 1 illustrates differences in clearance rates as a function of gender, drinking practice, and age.

No statistically significant interactions between gender, drinking practice, and age were found. Because of the limited and uneven number of Ss in treatment cells, however, these results may be due to a Type II error. The cell means and standard deviations for all conditions are reported in Table 2.

Figure 1 : Hourly Ethanol Clearance Rates as a function of Gender, Drinking Group, and Age.
Table 2 : Hourly Ethanol Clearance Rates (mg/dL/h) Across Experimental Conditions

<table>
<thead>
<tr>
<th></th>
<th>Males</th>
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<th>Females</th>
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<tbody>
<tr>
<td></td>
<td>Age</td>
<td>Age</td>
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<td>Age</td>
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<tr>
<td>Light Drinkers</td>
<td>n=1</td>
<td>n=6</td>
<td>n=6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 ± 0</td>
<td>14 ± 2</td>
<td>15 ± 4</td>
<td>13 ± 1</td>
</tr>
<tr>
<td>Moderate Drinkers</td>
<td>n=1</td>
<td>n=2</td>
<td>n=1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19 ± 0</td>
<td>16 ± 0</td>
<td>19 ± 0</td>
<td>15 ± 3</td>
</tr>
<tr>
<td>Heavy Drinkers</td>
<td>n=3</td>
<td>n=4</td>
<td>n=2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>14 ± 1</td>
<td>16 ± 2</td>
<td>18 ± 3</td>
<td>17 ± 3</td>
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</tbody>
</table>

DISCUSSION

In general, the results support and extend previously-reported findings. Females were found to have higher average ethanol clearance rates than males. Consistent with findings by Sutker et al. and Cole-Harding, female rates were also found to be more variable than male rates.

Findings by Smith et al., Jones et al., and Jones indicating that drinking practices affect clearance rate were also supported. Moderate and heavy drinkers cleared alcohol at a faster rate than light drinkers.

Age also had a direct effect on clearance rate. All drinking groups, including light drinkers, showed increased clearance rates as a function of age.

The absence of statistically significant interactions between the three variables is perhaps attributable to small and uneven cell sizes within the factorial matrix. Future studies will address these limitations by assembling additional Ss until each cell will have at least seven Ss. The resulting increase in power will make it less likely that a Type II error will occur, and will allow for evaluations of the possible interactions.
Références


