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ARTICLES

A COMPARISON OF EQUAL ALCOHOL DOSES OF BEER AND WHISKEY ON ELEVEN HUMAN TEST SUBJECTS[1]

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ABSTRACT

Seven men (aged 23 to 52 years) and four women (aged 26 to 44 years) were hydrostatically weighed to determine their percentage of body fat and lean body weight. Female subjects on average had a higher percentage of body fat (23.5%, range 18.6–30.0%) than males (16.9%, range 7.5–30.2%). Subjects fasted for at least 10 hours prior to an oral dose of alcohol at 1.23 g/kg of lean body weight. Beer containing approximately 5% ethanol was consumed on day one of the experiment and 50.5% whiskey mixed with a carbonated beverage was consumed on day two of the experiment. All alcohol analyses were conducted on the Intoxilyzer 5000®. Female subjects had a slightly higher rate of elimination (0.0195 g/210 L/h, range 0.0169–0.0212) than male subjects (0.0186 g/210 L/h, range 0.0151–0.0225). While there were individual subject differences, on average, equal doses of ethanol per kg of lean body weight given in the same manner, over the same length of time, yielded statistically indistinguishable alcohol concentration results, regardless of subject gender or type of alcoholic beverage consumed.

RÉSUMÉ

Sept hommes (âgés de 23 à 52 ans) et quatre femmes (âgées de 26 à 44 ans) furent pesés hydrostatiquement afin de déterminer leur pourcentage de graisse et leur masse corporelle excluant la graisse. Le pourcentage de graisse chez les femmes (23,5%, plage de 18,6% à 30,0%) s'est avéré supérieur à celui des hommes (16,9%, plage de 7,5% à 30,2%). Les sujets ont jeûné pendant une période minimale de 10 heures avant d'ingérer un dose d'alcool de 1,23 g/kg de masse corporelle excluant la graisse. De la bière ayant une teneur approximative de 5% V/V en alcool fut consommée au cours de la première journée de l'expérience et du whisky à 50,5% mélangé à des boissons gazeuses fut consommé au cours de la seconde journée. Toutes les analyses d'alcool ont été effectuées à l'aide de l'Intoxilyzer® 5000C. La vitesse d'élimination d'alcool a été légèrement supérieure chez les femmes (0,0195 g/210 L/h, plage de 0,0169–0,0212) que chez les hommes (0,0186 g/210 L/h, plage de 0,0151–0,0225). Malgré certaines différences interindividuelles, les doses équivalentes d'alcool éthylique par kilo de masse corporelle administrées de façon identique pendant la même période de temps ont produit des alcoolémies non statistiquement différentes, indépendamment du genre du sujet ou du type d'alcool ingéré.

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INTRODUCTION

Peer-reviewed scientific research dealing with alcohol[5] concentration after beer consumption in human test subjects is rare. Most alcohol research studies utilize beverages containing a higher alcohol concentration than beer. These studies tend to have relatively short drinking times, usually an hour or less, when compared to social drinking situations that generally last several hours (1,2). The shorter drinking time allows the researchers to reduce some of the variables inherent in any drinking study and also reduce the total time needed to complete the research. The quantity of beer that must be consumed in order to obtain a significant alcohol concentration requires a longer drinking time for most test subjects and, therefore, extends the time needed to complete the research.

Since the active intoxicating ingredient in all alcoholic beverages is ethanol, there should be little or no difference between the results of a study that utilizes beer rather than beverages containing a higher alcohol concentration, such as whiskey, if an equal weight of ethanol is consumed in an equal amount of time. To test this hypothesis the Center for Alcohol and Drug Education Studies at Texas A&M University and the Texas Department of Public Safety conducted a study comparing equal alcohol doses of beer to whiskey in eleven human drinking subjects. The need to conduct drinking experiments utilizing beer as the intoxicant is especially important because a survey of drinking drivers showed that 71% of them claimed to have consumed beer (3).

METHOD

Eleven non-alcoholic subjects gave written informed consent. Seven men (aged 23 to 52) and four women (aged 26 to 44) were hydrostatically weighed to determine their percentage of body fat and lean body weight. Each subject fasted for at least 10 hours prior to the administration of alcohol. All analyses were conducted using an Intoxilyzer 5000® (CMI/MPD, Inc., Owensboro, KY) and reported as grams of alcohol in 210 litres of breath (g/210 L). The subjects were tested prior to drinking to ensure that their breath alcohol concentrations were 0.000 g/210 L. The subjects were given a total dose of alcohol at 1.23 gram per kilogram (g/kg) of lean body weight and the subjects drank over 2 hours and 45 minutes in three 45-minute drinking periods. An equal quantity of alcohol was consumed in each of the 45-minute drinking periods. At the end of each 45-minute drinking period, the subjects underwent a 15-minute deprivation period, to ensure that no residual or mouth alcohol was present (4,5), and were then tested to determine their alcohol concentration. After completion of the three drinking and testing periods, breath testing continued in 20-minute intervals until each subject's alcohol concentration returned to 0.000 g/210 L. Beer, containing approximately 5% ethanol (Budweiser®, Miller Highlife®, and/or Old Milwaukee®) (6), was consumed on day one and whiskey (Wild Turkey 101®) mixed with a carbonated beverage was consumed on day two. The mixed drinks were served in nine-ounce glasses filled with ice. Each drink contained 1¼ ounce of whiskey and enough carbonated beverage to fill the glass. Partial drinks, needed to give the subjects the required dosage, were mixed in the same proportion.

RESULTS

Female subjects had a higher mean percentage of body fat (23.5%, range 18.6–30.0%) than male subjects (16.9%, range 7.5–30.2%). Female subjects had a lower mean lean body weight (46.0 kg, range 38.5–66.8) than male subjects (66.8 kg, range 48.3–81.1). See Tables 1–3.

5. In this paper the unmodified term alcohol means ethanol.

TABLE 1

Height, weight, % body fat, lean body weight, and total ethanol consumed for female subjects. n = 4

Women Subject #	HT. (cm)	WT. (kg)	% Body Fat	Lean Body Wt. (kg)	Total EtOH Consumed (g)
1	162.6	65.5	26.1	48.4	59.4
4	162.6	77.7	30.0	54.4	66.8
8	154.9	47.7	19.4	38.5	47.3
9	160.0	52.7	18.6	42.9	52.7
Mean	160.0	60.9	23.5	46.0	56.6
SD	3.63	13.48	5.47	6.89	8.44

TABLE 2

Height, weight, % body fat, lean body weight, and total ethanol consumed for male subjects. n = 7

Men Subject #	HT. (cm)	WT. (kg)	% Body Fat	Lean Body Wt. (kg)	Total EtOH Consumed (g)
2	188.0	82.7	13.6	71.5	87.8
3	182.9	91.4	11.2	81.1	99.7
5	160.0	58.2	17.0	48.3	59.3
6	185.4	98.6	27.4	71.6	88.0
7	177.8	65.5	7.5	60.5	74.4
10	167.6	80.0	11.6	70.7	86.9
11	167.6	91.8	30.2	64.1	78.7
MEAN	175.6	81.2	16.9	66.8	82.1
SD	10.62	14.73	8.63	10.44	8.63

TABLE 3

Height, weight, % body fat, lean body weight, and total ethanol consumed for all subjects. n = 11

Subject #	HT. (cm)	WT. (kg)	% Body Fat	Lean Body Wt. (kg)	Total EtOH Consumed (g)
1	162.6	65.5	26.1	48.4	59.4
2	188.0	82.7	13.6	71.5	87.8
3	182.9	91.4	11.2	81.1	99.7
4	162.6	77.7	30.0	54.4	66.8
5	160.0	58.2	17.0	48.3	59.3
6	185.4	98.6	27.4	71.6	88.0
7	177.8	65.5	7.5	60.5	74.4
8	154.9	47.7	19.4	38.5	47.3
9	160.0	52.7	18.6	42.9	52.7
10	167.6	80.0	11.6	70.7	86.9
11	167.6	91.8	30.2	64.1	78.7
MEAN	169.9	73.8	19.3	59.3	72.80
SD	11.55	17.00	8.05	13.78	16.92

The breath specimens analyzed 15 minutes after the completion of drinking, at the three-hour point in the study, were the highest or "peak" alcohol concentrations for all subjects on both days of the experiment. The mean peak alcohol concentration for female subjects after consuming beer was slightly higher, 0.1143 g/210 L (range 0.099–0.131) than for male subjects, 0.1127 g/210 L (range 0.104–0.129). The mean peak alcohol concentration for female subjects after consuming whiskey was also slightly higher, 0.1143 g/210 L (range 0.103–0.134) than for male subjects, 0.1107 g/210 L (range 0.092–0.125). The female subjects reached a slightly higher overall mean peak alcohol concentration, 0.1143 g/210 L (range

0.105–0.121) than male subjects, 0.1117 g/210 L (range 0.100–0.122). The overall mean peak alcohol concentration for all subjects after consuming beer was 0.1133 g/210 L (range 0.099–0.131) and after consuming whiskey was 0.1120 g/210 L (range 0.092–0.134). See Tables 4–6.

Paired t-tests comparing peak alcohol concentrations after consuming beer to peak alcohol concentrations after consuming whiskey indicated no statistically significant difference when females were compared to females, and males were compared to males. For females, the p-value was 1.0000 and t = 0.0000. For males, the p-value was 0.6497 and t = 0.4778. Paired t-test results comparing mean female and mean male peak alcohol concentrations after consuming beer and whiskey also did not indicate a statistically significant difference (p = 0.2338; t = 2.6000). Paired t-tests comparing peak alcohol concentrations after consuming beer to peak alcohol concentrations after consuming whiskey for all subjects indicated no statistically significant difference (p = 0.7837; t = 0.2820).

The mean elimination rate for female subjects after consuming beer was higher, 0.0196 g/210 L/hour (h) (range 0.0168–0.0208), than for male subjects, 0.0187 g/210 L/h (range 0.0146–0.0203). The mean elimination rate for female subjects after consuming whiskey was also higher, 0.0195 g/210 L/h (range 0.0170–0.0216) than for male subjects, 0.0184 g/210 L/h (range 0.0155–0.0247). The overall mean elimination rate for female subjects after consuming both beverages was higher, 0.0195 g/210 L/h (range 0.0169–0.0212) than for male subjects, 0.0186 g/210 L (range 0.0151–0.0225). The overall mean elimination rate for all subjects after consuming beer was 0.0190 g/210 L/h (range 0.0146–0.208), after consuming whiskey was 0.0188 g/210 L/h (range 0.0155–0.0247), and for the combined mean of both beverages was 0.0189 g/210 L/h (range 0.0151–0.225). See Tables 4–6.

Paired t-tests comparing elimination rates after consuming beer to elimination rates after consuming whiskey indicated no statistically significant difference when females were compared to females, and males were compared to males. For females, the p-value was 0.8639 and t = 0.1866. For males, the p-value was 0.7433 and t = 0.3429. Paired t-test results comparing mean female and mean male elimination rates after consuming beer and whiskey did not indicate a statistically significant difference (p = 0.0635; t = 10.0000), but the difference was almost statistically significant.

Figures 1–3 are graphs of the alcohol concentration vs. time curves for subject 6 (male), subject 7 (male), and subject 8 (female). These graphs are representative of the three general types of alcohol concentration vs. time curves that resulted from the eleven subjects in this study. Figure 1, the alcohol concentration vs. time curves for subject 6 (male), is representative of the five subjects whose curves were virtually identical after consuming both beer and whiskey. All five of the subjects that produced this type of graph were men (subjects 2, 3, 5, 6, and 10). Figure 2, the alcohol concentration vs. time curves for subject 7 (male), is representative of the four subjects whose beer curves were larger than their whiskey curves. Two of these subjects were men and two were women (subjects 1, 7, 9, and 11). Figure 3, the alcohol concentration vs. time curves for subject 8 (female), is representative of the two subjects whose whiskey curves were larger than their beer curves. Both of these subjects were women (subjects 4 and 8). Figures 4–6 are graphs of the mean alcohol concentration vs. time curves for women, men, and all subjects. The beer curves and the whiskey curves in each of these three graphs are virtually indistinguishable.

DISCUSSION

To make the study more closely resemble a social drinking situation and to enhance the relevance of this study, the alcoholic beverages were consumed over a two hour and

TABLE 4

Peak alcohol concentration and elimination rate data for female subjects. n = 4

Women Subject #	Beer Peak Alc Conc (g/210 L)	Whiskey Peak Alc Conc. (g/210 L)	Difference between Peak Alc Conc. (Beer-Whiskey) (g/210 L)	Beer Elim. Rate (g/210 L/hr)	Whiskey Elim. Rate (g/210 L/hr)	Difference between Elim. Rate (Beer-Whiskey) (g/210 L)
1	0.131	0.110	0.021	0.0201	0.0180	0.0021
4	0.099	0.110	–0.011	0.0168	0.0170	–0.0002
8	0.108	0.134	–0.026	0.0208	0.0216	–0.0008
9	0.119	0.103	0.016	0.0206	0.0212	–0.0006
MEAN	0.1143	0.1143	0.0000	0.0196	0.0195	0.00013
SD	0.01384	0.01357	0.02232	0.00187	0.00229	0.00134

TABLE 5

Peak alcohol concentration and elimination rate data for male subjects. n = 7

Men Subject #	Beer Peak Alc Conc (g/210 L)	Whiskey Peak Alc Conc. (g/210 L)	Difference between Peak Alc Conc. (Beer-Whiskey) (g/210 L)	Beer Elim. Rate (g/210 L/hr)	Whiskey Elim. Rate (g/210 L/hr)	Difference between Elim. Rate (Beer-Whiskey) (g/210 L)
2	0.117	0.124	–0.007	0.0190	0.0172	0.0018
3	0.119	0.125	–0.006	0.0203	0.0176	0.0027
5	0.112	0.119	–0.007	0.0203	0.0247	–0.0044
6	0.100	0.106	–0.006	0.0146	0.0155	–0.0009
7	0.129	0.112	0.017	0.0184	0.0180	0.0004
10	0.104	0.097	0.007	0.0183	0.0185	–0.0002
11	0.108	0.092	0.016	0.0202	0.0173	0.0029
MEAN	0.1127	0.1107	0.0020	0.0187	0.0184	0.00055
SD	0.00986	0.01298	0.01108	0.00202	0.00293	0.001654

TABLE 6

Peak alcohol concentration and elimination rate data for all subjects. n = 11

Women Subject #	Beer Peak Alc Conc (g/210 L)	Whiskey Peak Alc Conc. (g/210 L)	Difference between Peak Alc Conc. (Beer-Whiskey) (g/210 L)	Beer Elim. Rate (g/210 L/hr)	Whiskey Elim. Rate (g/210 L/hr)	Difference between Elim. Rate (Beer-Whiskey) (g/210 L)
1	0.131	0.110	0.021	0.0201	0.0180	0.0021
2	0.117	0.124	–0.007	0.0190	0.0172	0.0018
3	0.119	0.125	–0.006	0.0203	0.0176	0.0027
4	0.099	0.110	–0.011	0.0168	0.0170	–0.0002
5	0.112	0.119	–0.007	0.0203	0.0247	–0.0044
6	0.100	0.106	–0.006	0.0146	0.0155	–0.0009
7	0.129	0.112	0.017	0.0184	0.0180	0.0004
8	0.108	0.134	–0.026	0.0208	0.0216	–0.0008
9	0.119	0.103	0.016	0.0206	0.0212	–0.0006
10	0.104	0.097	0.007	0.0183	0.0185	–0.0002
11	0.108	0.092	0.016	0.0202	0.0173	0.0029
MEAN	0.1133	0.1120	0.0013	0.0190	0.0188	0.00026
SD	0.01079	0.01263	0.01497	0.00192	0.00265	0.002099

45 minute time period, rather than a single bolus dose. All subjects were administered the same dose of alcohol per kg of lean body weight. Lean body weights were calculated based upon the percentage of body fat derived by hydrostatically weighing each of the subjects.

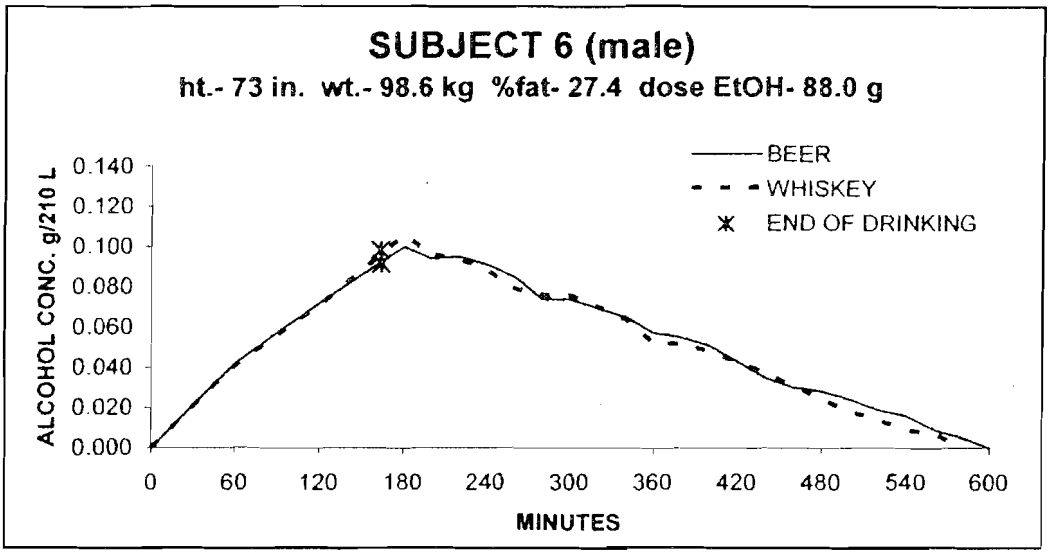

Figure 1. Plot of alcohol concentration against time for Subject 6 (male).

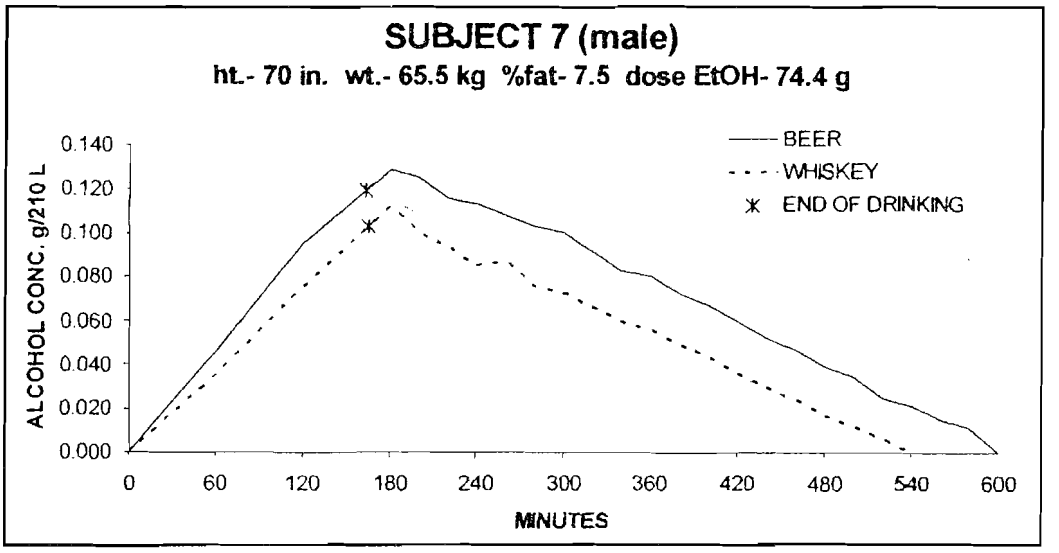

Figure 2. Plot of alcohol concentration against time for Subject 7 (male).

Previous research has shown that there is no difference in the peak alcohol concentration of women and men who were administered the same dose of alcohol per kg of lean body weight (7). The mean percentage of body fat in the study was higher for women (23.5%) than men (16.9%). Research at the University of Texas at Austin indicates the mean body fat percentage for men is 15–18% and 23–26% for women[6]. The mean body fat percentage of the subjects tested in this study fall within these norms. Higher mean percentages of body fat in women have long been recognized. Widmark wrote of this in 1932 (8).

The breath specimens analyzed 15 minutes after the completion of drinking, at the three-hour point in the study, were the peak alcohol concentrations for all subjects on both days of the experiment. No statistically significant difference was found in peak alcohol con-

6. Stanforth, P. Personal communication. Department of Kinesiology and Health Education Adult Fitness Program, University of Texas at Austin, 1990.

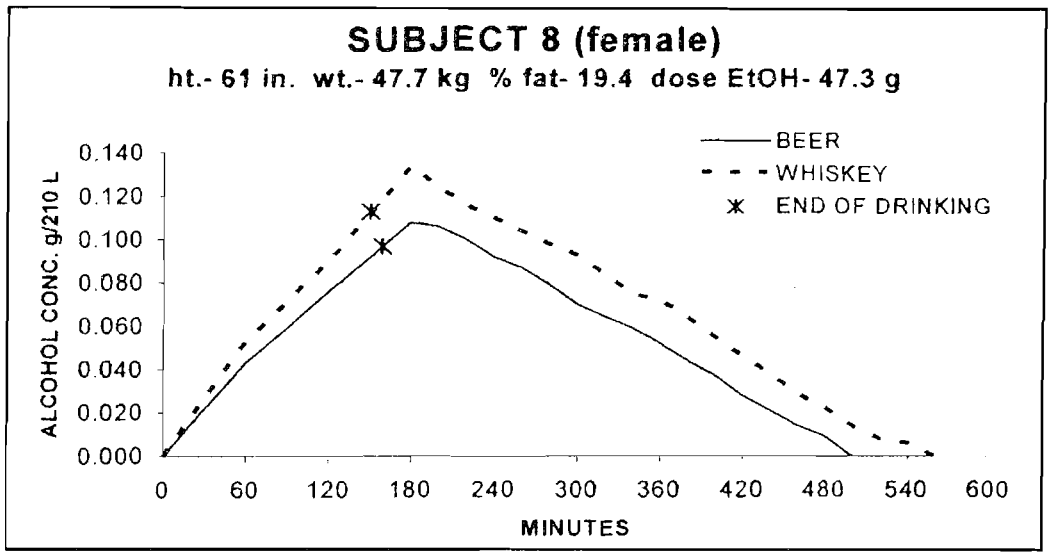

Figure 3. Plot of alcohol concentration against time for Subject 8 (female).

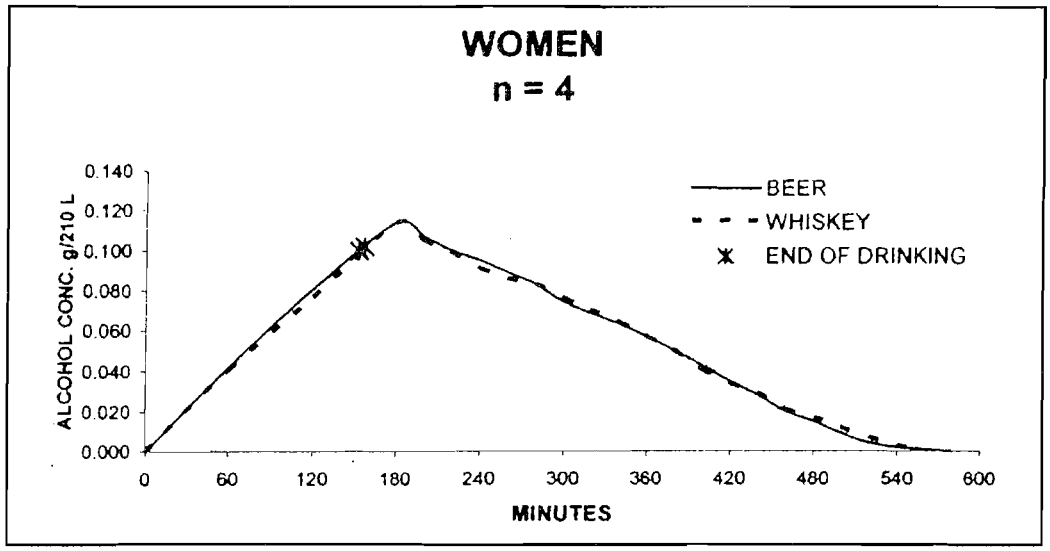

Figure 4. Plot of alcohol concentration against time for the mean results for the female subjects.

centrations after consuming beer and peak alcohol concentrations after consuming whiskey, when the results were analyzed by gender, women compared to women ($p = 1.0000$; $t = 0.0000$), and men compared to men ($p = 0.6497$; $t = 0.4778$). Likewise, no statistically significant difference was found in peak alcohol concentrations after consuming beer and peak alcohol concentrations after consuming whiskey, when the results were analyzed comparing women to men. The mean peak alcohol concentrations were slightly higher for women than men after consuming both beer and whiskey, but the differences were not statistically significant ($p = 0.2338$; $t = 2.6000$). Finally, no statistically significant difference was found in peak alcohol concentrations after consuming beer compared to peak alcohol concentrations after consuming whiskey, when the results were analyzed for all subjects ($p = 0.7837$; $t = 0.2820$). The women in the study had a higher mean elimination rate. The difference in mean elimination rates between women (0.0195 g/210 L/h) and men (0.0186 g/210 L/h) in this study was not sufficient to be considered statistically significant, but the difference may

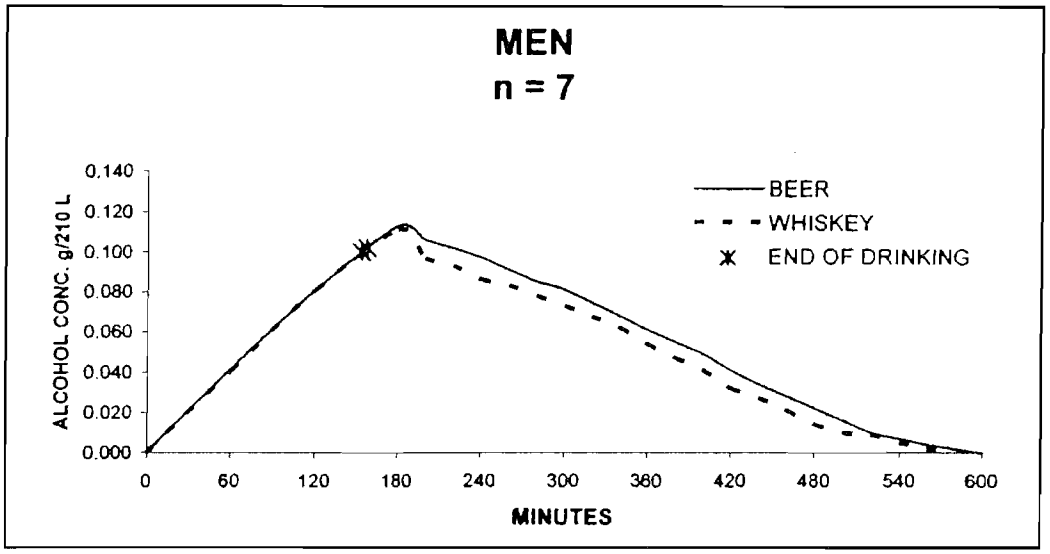

Figure 5. Plot of alcohol concentration against time for the mean results for the male subjects.

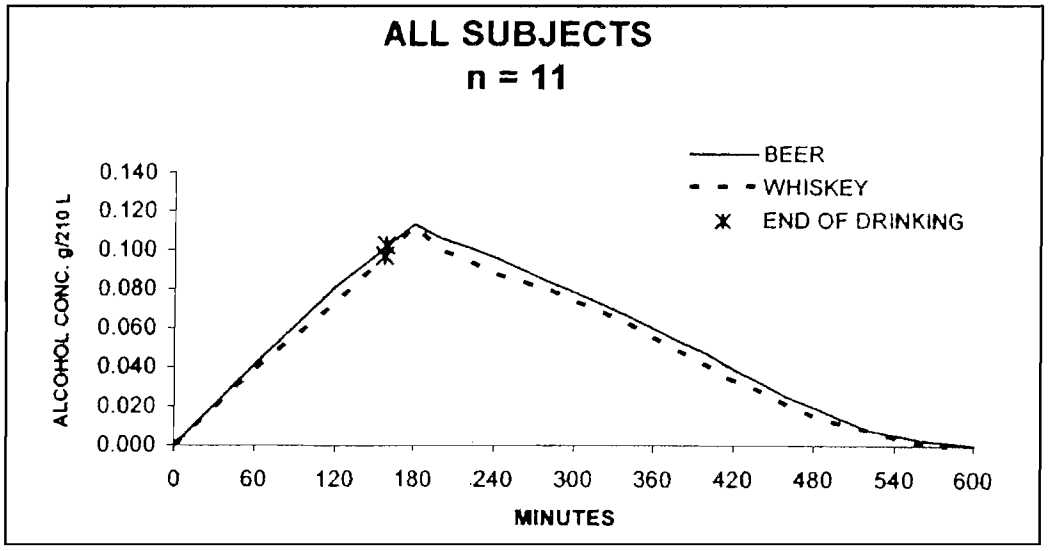

Figure 6. Plot of alcohol concentration against time for the mean results for all subjects.

be scientifically significant because higher elimination rates in women have been noted in previous studies (9,10). While there were individual subject differences, on average, equal doses of ethanol per kg of lean body weight given in the same manner, over the same length of time, yielded statistically indistinguishable alcohol concentration results, regardless of subject gender or type of alcoholic beverage consumed.

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