Alcohol Drinking Patterns and Blood Pressure

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ABSTRACT

Background: Although blood pressure tends to increase with average alcohol consumption, little is known about the effects of drinking patterns on blood pressure. Therefore, the effects of average drinks per day and drinking pattern (defined as the independent and interactive effects of quantity and frequency) on blood pressure were compared.

Methods: Data were obtained from a random sample survey of 1,635 household residents in Erie County, New York. Alcohol-blood pressure relationships were examined using multiple regression analyses that controlled for the potentially confounding influence of 13 additional risk factors for elevated blood pressure.

Results: Consistent with prior research, a positive relationship was found between average drinks per day and diastolic and systolic blood pressure. Analyses examining the effect of drinking pattern indicated that drinking frequency had a positive effect on both diastolic and systolic blood pressure, whereas drinking quantity did not affect either. Furthermore, there was little evidence that the frequency-by-quantity interaction affected blood pressure.

Conclusions: Low average alcohol intake and low blood pressure were associated with infrequent drinking, rather than with frequent drinking of small amounts of alcohol. Results suggest that the standard practice of averaging alcohol consumption may obscure important effects of drinking frequency on health. (*Am J Public Health* 1991;81:452–457)

Introduction

Despite the well documented relationship between average alcohol intake and elevated blood pressure,[1,2] we know relatively little about the effects of drinking patterns on blood pressure, where patterns are defined in terms of specific combinations of quantity drunk per drinking day and frequency of drinking days. Prior research has typically combined quantity and frequency measures of alcohol intake and expressed this information in terms of average consumption (average drinks per day, per week, or per month). However, such averaging may obscure potentially important differences in blood pressure associated with different drinking patterns. For example, although a person who drinks only two drinks every day of the week and one who has 14 drinks on Saturday night both average two drinks a day, blood pressures associated with these two patterns may not be the same.

To investigate the role of drinking pattern in the relationship of alcohol consumption and blood pressure, we examined the relationship between discrete combinations of quantity and frequency of drinking and average drinks per day; determined the effect of average drinks per day on blood pressure; determined the effect of drinking pattern on blood pressure by analyzing the independent and interactive effects of alcohol quantity and frequency; and contrasted the effects of drinking pattern and average drinks per day on blood pressure.

Methods

Sample

Data for the present analyses came from a representative adult household survey of stress, alcohol use, and hypertension conducted in Erie County, New York (N = 1,933). Respondents were identified using a stratified, three-stage probability sampling procedure designed to yield approximately equal numbers of Blacks and all others at three levels of education (less than high school, high school, at least some college). The first stage of sampling was the selection of US census blocks, stratified by race and education, and selected with probabilities proportional to size. In the second stage, housing units were selected with probabilities inversely proportional to the first stage selection probabilities. Finally, one adult (at least 19 years of age) was randomly selected from each household.

The overall sample completion rate was 78.3 percent, with the majority (84.5 percent) of noncompletions due to refusals. To provide population estimates in the present study, the sample was: poststratified by race, education, and sex (females were unintentionally oversampled) to match proportions reported in the 1980 census for Erie County; and weighted by the individual probability of selection.

Present analyses were conducted on a subset of 1,725 (weighted N = 1,630) respondents. Respondents over age 74 were eliminated (N = 75) because few drank alcohol, blood pressure measurements were missing for many, and doing so made our data more comparable to other studies of alcohol and hypertension. An additional 133 respondents who were

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missing one or more of the study variables were deleted in order to ensure comparability across analyses. After exclusions, the weighted sample was 91 percent White, 54 percent female, and 63 percent married; 70 percent had completed at least a high school education. Mean age was 45 years (SD = 16.5). Forty-eight percent of the sample was working; of these, 51 percent held white collar jobs.

Procedures

Data were collected by a corps of 27 interviewers in the summer and fall of 1986. Interviewers received five days of intensive training on general and survey-specific interviewing techniques and three days of training on physical measurements, including blood pressure measurement. Interviews were conducted in respondents' homes using a highly structured interview schedule that included diet, smoking, and physical activity as well as medical history. The entire procedure took about 90 minutes; respondents were paid $25.

Measures

Blood Pressure: Standardized procedures using the American Heart Association protocol were used to measure systolic and diastolic blood pressures (SBP and DBP, respectively).[3] Blood pressure was assessed using mercury sphygmomanometers (Baumanometer, Model 300) calibrated for accuracy on a weekly basis. Respondents were asked not to drink alcohol during the interview. Properly fitted cuffs were placed on the right arm approximately 15 minutes before the end of the interview; respondents were asked to refrain from smoking, drinking coffee, or moving around the room until after their blood pressures were taken. Readings were made to the nearest 2 mmHg, and DBP was taken at the fifth Korotkoff phase (i.e., cessation of pulse sounds). Mean measures of SBP and DBP based on the last two of three readings were utilized in all analyses.

Alcohol Measures: Alcohol measures were adapted from the National Health and Leisure Time Survey.[4] Standard quantity and frequency questions (see Appendix) were asked on usual drinking during the past year. Average drinks per day was calculated by multiplying frequency of drinking by the number of drinks consumed on a typical day and dividing by 365. Quantity (number of drinks consumed on a typical drinking day—drinks per drinking day) was categorized as one or two drinks, three or four drinks, or five or more. Frequency (drinking days during the past year) was also categorized to yield groups of respondents who drank daily or almost daily, one to four times weekly, or less-than-weekly.

Nine drinking patterns were constructed by cross-tabulating the above quantity and frequency categories. They ranged from less-than-weekly drinkers who usually had one or two drinks per drinking day to those who drank daily or almost daily and usually had five or more drinks.

Covariates: The following potentially confounding factors were statistically controlled in all analyses: age (in years); race (1 = other than Black, 2 = Black); sex (1 = male, 2 = female); body mass index (weight in kg/height in meters, squared); marital status (0 = not married, 1 = married/living as married); education (in years); sodium intake (frequency of using salt at the table, in cooking, and eating salty snacks); calcium intake (milligrams per day based on the frequency of consuming calcium-rich foods, calcium supplements, and calcium-containing antacids); current cigarette use (number of cigarettes smoked per day); and two indices of frequency of physical activity.[5]

Also included as covariates were measures of family history of hypertension, self-reported hypertensive status, and whether or not antihypertensive medication was taken in the 24 hours prior to blood pressure measurement. Because a number of respondents were missing information on family history, two dummy variables were constructed, one to represent information concerning a positive family history of hypertension (family history: positive, coded as 0 = no, 1 = yes), and the other to represent missing information (family history: missing, coded as 0 = no, 1 = yes). Similarly, two dummy variables were used to represent information concerning respondents' self-report of their hypertensive status and current use of antihypertensive medication. The first (hypertension: no medication, coded as 0 = no, 1 = yes) represents individuals who reported that they had been told by a doctor or other health professional that they were hypertensive, but had not taken antihypertensive medication during the past 24 hours. The second dummy variable (hypertension: medication, coded as 0 = no, 1 = yes) represents individuals who reported that they were hypertensive and that they had taken antihypertensive medication during the past 24 hours.

Statistical Analysis

Three sets of statistical analyses were conducted. First, multiple regression was used to examine the relationship of average drinks per day to SBP and DBP, while controlling for covariates.[6]

Second, hierarchical multiple regression analysis was used to examine the independent and interactive effects of frequency and quantity on blood pressure.[6,7] More specifically, the hierarchical regression analysis proceeded in the following manner for both SBP and DBP: a block of covariates was first added to the regression equation in Step 1, followed by continuous measures of frequency and quantity in Step 2, which was followed by the interaction between frequency and quantity in Step 3. These hierarchical regression analyses did not contain abstainers because their inclusion would have led to an unbalanced design (i.e., a design with empty cells);[8] abstainers' scores on the quantity and frequency measures were both fixed at zero. Thus, respondents (i.e., abstainers) who had a zero on frequency could only have a zero on quantity, and vice versa. When a two-factor design is unbalanced, it is inappropriate to test for an interaction among its factors.[8] However, a two-way interaction can be tested if the design can be balanced by removing one or more levels of one or more factors.[8] In the present case, a balanced design was achieved by removing abstainers (i.e., the levels that represented zero frequency and zero quantity). Thus, we tested for a quantity-by-frequency interaction among drinkers only.

Third, to compare adjusted blood pressures in the nine drinking pattern groups with those of abstainers, we conducted two dummy variable regression analyses.[6] In each analysis, we examined the relationship of nine dummy variables to either SBP or DBP, while controlling for the covariates. Each dummy variable represented one of the nine drinking patterns with abstainers serving as the reference category. Therefore, in each regression equation, the unstandardized regression coefficient for a given dummy variable represented the mean difference in adjusted blood pressure for a specific drinking pattern compared to abstainers, and the constant represented the average adjusted blood pressure for abstainers.

As noted earlier, data were weighted to adjust means and regression coefficients for the complex survey design. However, standard errors have not been

TABLE 1—Average Drinks per Day (Mean ± Standard Deviation) by Drinking Patterns [weighted N = 1630*/100%]

Quantity	Frequency: Less than Weekly	Weekly	Daily	Total
Light	.05 ± .05	.48 ± .29	1.37 ± .55	.29 ± .43
(1–2 drinks)	[462/28%]	[237/15%]	[58/4%]	[757/47%]
Moderate	.18 ± .10	1.12 ± .51	2.91 ± .61	.92 ± .89
(3–4 drinks)	[163/10%]	[212/13%]	[39/2%]	[413/25%]
Heavy	.42 ± .20	2.62 ± 1.59	6.84 ± 1.46	2.64 ± 2.43
(5+ drinks)	[52/3%]	[101/6%]	[28/2%]	[180/11%]
Total	.11 ± .13	1.12 ± 1.09	3.07 ± 2.29	.79 ± 1.31
	[677/42%]	[550/34%]	[124/8%]	[1351/83%]

*Including abstainers: Weighted n = 279/17%.

TABLE 2—Regression Coefficients and Standard Errors of Multiple Regression of Systolic and Diastolic Blood Pressure on Average Drinks per Day and Covariates (N = 1630*)

Variables	Systolic Blood Pressure: b	Standard Error	Diastolic Blood Pressure: b	Standard Error
Age	.47	.03	.11	.02
Sex	−6.53	.78	−5.00	.51
Race	.06	1.29	1.19	.85
Body Mass	.34	.07	.26	.05
Marital Status	−2.12	.78	−.26	.51
Education	−.56	.15	−.09	.10
Sodium Intake	−.37	.20	−.38	.13
Calcium Intake	−.002	.001	−.003	.001
Family History: Positive	2.07	.87	1.14	.57
Family History: Missing	1.31	1.55	−.63	1.02
Hypertension: No Medication	8.78	1.02	5.73	.67
Hypertension: Medication	9.32	1.22	2.35	.80
Current Cigarette Use	.01	.03	−.005	.02
Activity	.46	.41	−.24	.27
Exercise	−.004	.02	−.01	.02
Average Drinks per Day	1.21	.32	.55	.21
Constant	108.13	4.03	71.59	2.64

*Abstainers included.

adjusted for design effects because the requisite statistical programs to do so were not available to us.

Results

Drinking Pattern

Mean values for average drinks per day associated with each pattern are presented in Table 1. As expected, marginal values for average drinks per day increased both as the frequency of drinking increased (r = .64) and as the usual quantity consumed on a typical drinking day increased (r = .56). Heavy drinking was more prevalent among daily drinkers than among those who drank less frequently. However, the magnitude of the relationship among drinkers is relatively modest (r = .23), which provides further justification for analyzing the independent and interactive effects of quantity and frequency on blood pressure.

Although quantity definitely influences average drinks per day, given the distribution of drinking in this household sample, frequency seems to play a more important role than quantity in determining which drinking patterns are associated with lower mean values of average drinks per day and which are associated with higher values. For example, mean averages of one drink or more per day were associated with moderate and heavy weekly drinking, and with daily drinking, irrespective of quantity; averages of less than one drink per day were associated with light, weekly drinking and less-than-weekly drinking, irrespective of quantity.

The most prevalent drinking patterns, accounting for 43 percent of the population, were characterized by light drinking less-than-weekly or weekly, both of which were associated with low average drinks per day. In contrast, only 8 percent of the population drank as often as daily or nearly every day.

Blood Pressure

Results of the multiple regression equations predicting SBP and DBP from average drinks per day are summarized in Table 2. Blood pressure had the expected relation to all covariates except race and sodium intake. Failure to observe higher average blood pressures among Blacks than Whites reflects their relatively small weighted numbers in these population-based analyses. Unweighted analyses are planned to investigate racial differences in the relation of blood pressure to drinking patterns. The negative relation of blood pressure to sodium intake reflects the lower discretionary salt intakes among individuals who had been told they were hypertensive, presumably in response to medical advice.

After covariates were taken into consideration, average drinks per day made a statistically significant contribution to the prediction of both SBP and DBP. The b values indicate that SBP was elevated an average of 1.21 mmHg, and DBP was elevated an average of 0.55 mmHg, for every increment of one drink in average drinks per day.

Drinking Pattern and Blood Pressure

Systolic Blood Pressure: The hierarchical regression analysis examining the independent and interactive effect of quantity and frequency on SBP revealed a significant positive relationship between frequency and SBP, but no significant effect for quantity and no significant quantity-by-frequency interaction (Table 3). The b value for frequency of drinking days during the past year indicated that SBP increased .021 mmHg with every additional day of drinking. Thus, SBP would be an average of 6.6 mmHg higher among those who drank daily than among those who drank only once a week (365 − 52 = 313 × .021 mmHg per drinking day per year = 6.6 mmHg).

TABLE 3—Regression Coefficients and Standard Errors of Hierarchical Multiple Regression of Systolic and Diastolic Blood Pressure on Drinking Frequency, Quantity, and Covariates among Drinkers (N = 1351*)

	Systolic Blood Pressure		Diastolic Blood Pressure	
Variables	b**	Standard Error	b**	Standard Error
Step 1				
Age	.47	.03	.13	.02
Sex	−6.88	.81	−5.80	.54
Race	.02	1.47	1.42	.99
Body Mass	.46	.08	.31	.05
Marital Status	−3.08	.83	−.93	.56
Education	−.48	.17	.09	.11
Sodium Intake	−.40	.21	−.33	.14
Calcium Intake	−.001	.001	−.002	.001
Family History: Positive	1.79	.91	1.29	.61
Family History: Missing	1.00	1.78	−1.20	1.19
Hypertension: No Medication	8.28	1.09	5.32	.73
Hypertension: Medication	11.19	1.35	2.23	.91
Current Cigarette Use	.02	.03	.01	.02
Activity	.88	.43	−.13	.29
Exercise	.02	.03	.01	.02
Step 2				
Quantity	.15	.19	−.011	.13
Frequency	.021	.004	.015	.003
Step 3				
Quantity-by-Frequency	−.001	.002	−.003	.001

*Abstainers omitted.
**Regression coefficients were taken from the step at which they were entered; therefore, each coefficient is controlled for all other variables entered at the same step and prior steps.

The dummy variable regression analysis comparing SBP among abstainers and drinkers found that compared to abstainers, mean SBP was significantly higher among light daily, moderate weekly, moderate daily, or heavy weekly drinkers (Table 4). These results paralleled the hierarchical regression results, indicating that relative to abstention, more frequent drinking was associated with increased SBP within each quantity category, whereas a tendency for SBP to increase with quantity was observed only among weekly drinkers.

Diastolic Blood Pressure: Overall, the main effects of the hierarchical regression analysis examining the independent and interactive effect of quantity and frequency on DBP were similar to those observed for SBP (Table 3). The b value for frequency indicated that DBP increased .015 mmHg with every additional day of drinking. Thus, DBP would be approximately 4.7 mmHg higher among daily drinkers compared to the individual who drank once a week.

In addition, there was a quantity-by-frequency interaction (Table 3). We explored the nature of the interaction by analyzing the effect of frequency among light, moderate, and heavy drinkers, and the effect of quantity among less-than-weekly, weekly, and daily drinkers. This set of follow-up analyses, however, failed to uncover a strong, readily interpretable, functional form for the quantity-by-frequency interaction. The fact that this interaction was weak and failed to replicate with systolic blood pressure indicates that it may be a chance finding.

The dummy variable regression analysis comparing DBP among abstainers and drinkers found that, compared to abstainers, mean DBP was significantly higher among light weekly, light daily, or moderate daily drinkers (Table 4). Again, these results supported the hierarchical regression results by indicating that relative to abstention, more frequent drinking increased DBP at every level of quantity, but that higher quantity did not increase DBP within the frequency categories.

Discussion

To summarize, our analyses revealed a significant increase in blood pressure, particularly SBP, with increasing average drinks per day. However, consideration of drinking patterns indicated that, among drinkers, this increase was influenced more by the frequency of drinking than by the quantity of alcohol consumed. Although a quantity-by-frequency interaction was observed for DBP, it was not observed for SBP, and its pattern had no ready explanation. Finally, relative to abstainers, respondents who drank less often than weekly tended to have lower blood pressures, and those who drank weekly or more often tended to have higher blood pressures.

As reviewed by Gleiberman and Harburg,[9] a number of epidemiological studies have reported that individuals having relatively low average alcohol intakes tend to have lower mean blood pressures than abstainers, exhibiting a U- or J-shaped alcohol-blood pressure relation. Although not statistically significant, this tendency was also observed in the present study, as indicated by the fact that blood pressure among abstainers tended to be higher than that among less-than-weekly drinkers, who had low average drinks per day. Studies are needed to determine whether very light or occasional alcohol use exerts a physiological protective effect or if it is associated with psychological or behavioral correlates related to lower blood pressure.[9]

Methods employed to measure and analyze alcohol-blood pressure relationships may influence its interpretation. Studies in alcoholic men[10] and pregnant women[11] found that self-reported frequency was more reliable than self-reported quantity. Thus, lower reliability may have contributed to our failure to observe a significant effect of quantity on blood pressure in the present study. Also, it is important to note that the prepotency of frequency in the relationship between alcohol use and blood pressure is obscured by employing measures of average alcohol intake. Analyses of drinking pattern, in which the independent and interactive effects of quantity and frequency are taken into consideration, clearly indicate that drinking patterns characterized by infrequent drinking are associated both with low blood pressures and relatively low average drinks per day. Conversely, daily drinking is associated both with high blood pressures and relatively high average drinks per day.

Data from the 1979 National Survey of US drinking practices indicate that light, daily drinking was reported by only 2 percent of the US population,[12] suggesting that relatively few people who report low average drinks per day are light, daily drinkers. Therefore, it may be misleading to attribute purported health benefits as-

TABLE 4—Regression Coefficients and Standard Errors of Multiple Regression of Systolic and Diastolic Blood Pressure on Drinking Patterns

Variables	Systolic Blood Pressure b	Systolic Blood Pressure Standard Error	Diastolic Blood Pressure b	Diastolic Blood Pressure Standard Error
Age	.46	.03	.09	.02
Sex	−6.46	.79	−4.90	.52
Race	.12	1.29	1.23	.84
Body Mass	.36	.07	.29	.05
Marital Status	−2.14	.79	−.42	.51
Education	−.68	.15	−.19	.10
Sodium Intake	−.38	.20	−.39	.13
Calcium Intake	−.001	.001	−.002	.001
Family History: Positive	2.06	.87	1.03	.57
Family History: Missing	1.60	1.55	−.57	1.02
Hypertension: No Medication	8.52	1.02	5.63	.67
Hypertension: Medication	9.04	1.21	2.16	.79
Current Cigarette Use	.02	.03	−.002	.02
Activity	.45	.41	−.34	.27
Exercise	−.01	.02	−.01	.02
Light, Less-Than-Weekly	.87	1.13	−1.17	.74
Light, Weekly	2.10	1.36	2.24	.89
Light, Daily	8.55	2.17	6.87	1.42
Moderate, Less-Than-Weekly	−1.81	1.50	−.32	.98
Moderate, Weekly	3.46	1.43	.38	.93
Moderate, Daily	6.33	2.55	3.77	1.67
Heavy, Less-Than-Weekly	−3.50	2.35	−1.47	1.54
Heavy, Weekly	5.16	1.82	.81	1.19
Heavy, Daily	5.07	2.99	2.87	1.95
Constant (Abstainers)*	108.45	4.20	72.33	2.74

*Because abstainers served as the reference category, the constant represents the adjusted blood pressure for abstainers. The b weights for each drinking pattern (e.g., light, less-than-weekly) represent the magnitude of the difference in blood pressure for the drinking pattern compared to abstainers. Thus, the adjusted blood pressure for each drinking category is equal to the sum of the constant and its b weight.

sociated with low average drinks per day to light, daily drinking.

We believe that recognition of the importance of drinking frequency in determining the effects associated with average drinks per day is important for public health policy. The relatively low correlation between quantity and frequency among drinkers and the fact that few people in the US drink daily,[12] suggests that average drinks per day does not adequately represent actual drinking practices in the US. Accordingly, findings of health risks or benefits based on analyses employing average drinks per day cannot be translated directly into public health policy. The present data suggest that previously reported health benefits associated with low average drinks per day[2,9] are likely to be related to light, weekly drinking and infrequent drinking, rather than to light, daily drinking.

This is the first time that elevations in blood pressure have been attributed to drinking frequency, even in light drinkers, and it is important that these analyses be replicated. Assuming for the moment that they prove to be reliable, it is interesting to speculate about how frequent drinking might influence blood pressure. It has been hypothesized that individuals who recently drank alcohol may have elevated blood pressure because they are experiencing mild withdrawal symptoms or direct pressor effects of alcohol.[2] If this is so, it may be that individuals in our sample who reported drinking daily or nearly every day were more likely to be undergoing these effects. Criqui, *et al*,[13] have noted that repeated acute elevations in blood pressure related to frequent alcohol use are functionally equivalent to a chronic condition. Thus, elevations in blood pressure related to daily drinking could have significant implications for cardiovascular health and should not be dismissed as a short-term phenomenon.

Mean SBP was 6.6 mmHg higher and DBP was 4.7 mmHg higher among daily drinkers than among individuals who drank only once a week. Blood pressure elevations of this magnitude have both clinical and population significance. The association of DBP with stroke and with coronary heart disease (CHD) was recently investigated in nine major prospective observational studies, correcting for risk underestimates in previous reports related to "regression dilution" bias.[14] It was found that a long-term difference of 5–6 mmHg in usual DBP was associated with about 35–40 percent less stroke and 20–25 percent less CHD.[14] Data from the Multiple Risk Factor Intervention Trial[15] indicate that SBP is more strongly associated with CHD death than DBP, suggesting that the effect of frequent drinking on SBP may represent a greater CHD risk than is indicated by its effect on DBP.

The potential effect on health of relatively small reductions in mean blood pressure is illustrated by an overview of unconfounded randomized trials of antihypertensive drugs.[16] In 14 such trials, the mean treatment duration was five years, lowering mean DBP 5–6 mmHg; stroke was reduced by 46 percent, and CHD was reduced by 14 percent.

Within the DBP range covered by prospective observational studies (about 70–100 mmHg), there was no evidence of any "threshold" below which lower levels of DBP were not associated with lower risks of stroke and of CHD. Although increased risk may be small at lower DBP levels, the net effect is substantial when aggregated over the large numbers of people affected. Also, there are large numbers of individuals with moderately elevated blood pressures among whom relatively small increases might result in levels associated with diagnosed hypertension.

In sum, the effect of alcohol consumption on blood pressure has public health as well as clinical relevance. The present study illustrates how the standard practice of averaging alcohol consumption may obscure important effects of drinking pattern on health, and it is important that the study be replicated to determine the reliability of its findings. These results suggest that it may be useful to examine the independent and interactive effects of drinking quantity and frequency on other conditions thought to be influenced by alcohol intake, as well as in future epidemiologic studies of the alcohol-blood pressure relationship. □

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APPENDIX

Frequency: Thinking back over the past 12 months, how often did you drink any kind of alcoholic beverage, that is, beer, wine, and liquor? Asked only of people who had reported drinking during the past year, respondents chose from eight categories: every day; almost every day; three or four times a week; two times a week; once a week; two or three times a month; once a month; or less than once a month.

Quantity: During the past 12 months, about how many drinks, on the average, would you have on a typical day when you drank? A drink is a 4 oz glass of wine, a 12 oz beer, or a drink containing 1 oz of liquor. Responses were open-ended.