Different Alcohol Drinking and Blood Pressure Relationships in France and Northern Ireland  

The PRIME Study  

Pedro Marques-Vidal, Dominique Arveiler, Alun Evans, Philippe Amouyel, Jean Ferrières, Pierre Ducimetière  

Abstract—To assess the effect of alcoholic beverages consumed on blood pressure levels by day of the week, baseline data from the Prospective Epidemiological Study of Myocardial Infarction (PRIME), including 6523 male subjects who drank at least once a week (5156 in France and 1367 in Northern Ireland), were analyzed. In France, alcohol consumption was rather homogeneous throughout the week, with a slight increase during weekends, whereas in Northern Ireland, Fridays and Saturdays accounted for 66% of total alcohol consumption. After adjustment for age, body mass index, heart rate, tobacco smoking, educational level, marital status, and professional activity, blood pressure levels were higher in Northern Irish drinkers on Monday and decreased until Thursday, whereas blood pressure levels were constant throughout the week for French drinkers (day × country interactions, *P* < 0.05). Conversely, no between-day differences were found regarding teetotalers in both countries. In drinkers, between-day differences and day × country interactions were suppressed after adjustment for the average alcohol consumption of the third day before measurement. We conclude that the binge-drinking pattern observed among Northern Irish drinkers leads to physiologically disadvantageous consequences regarding blood pressure levels, whereas no such fluctuations in blood pressure levels are found for regular consumption. (Hypertension. 2001;38:1361-1366.)  

Key Words: alcohol drinking • blood pressure • periodicity

Cardiovascular disease is the main cause of premature death in industrialized countries. Some authors have shown that the occurrence of cardiovascular events is not regular throughout the week, with an increase on Mondays relative to the other days. Several explanations have been proposed, namely an increase in stress due to the transition from the leisurely pace of life on weekends to work schedule on Mondays. Although this explanation might partly account for the higher occurrence of cardiovascular events on Mondays, the weekly fluctuation of the levels of cardiovascular risk factors, namely blood pressure (BP), has seldom been studied.

Alcohol consumption is positively associated with BP. In France, alcohol consumption is regular throughout the week, whereas in Northern Ireland, most of the alcoholic consumption occurs on Fridays and Saturdays, with little consumption during the other days. Furthermore, it has been shown that the effects of an acute intake of alcohol are somewhat different than that of regular intake. For instance, consistent regular drinking is a more important determinant of the alcohol/BP relationship than intake in the previous 24 hours; additionally, a single intake of alcohol has a depressor effect on BP that lasts for several hours after drinking, whereas repeated intakes for 7 days have both depressor and pressor effects according to the differences in time intervals after the last drink, this biphasic effect being found by other authors. Thus, we wondered whether the pattern of intake in Northern Ireland could also influence BP levels during the week compared with the pattern of intake in France. Hence, we used the data from the Prospective Epidemiological Study of Myocardial Infarction (PRIME), which involved France and Northern Ireland, to analyze the relationships between alcohol consumption and BP levels from Monday to Friday in middle-aged, healthy men.

Methods

Population Sampling

The PRIME Study was established in 1991 in the populations of 4 collaborating centers of Belfast (United Kingdom), Lille, Strasbourg, and Toulouse (France). The target was to recruit 2500 men, age 50 to 59 years, in each center and to follow them for a minimum of 5 years. The sample was recruited to match broadly the social class structure of the background population. The sampling frame was

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based on industry and various employment groups and on health screening centers and general practice. Subjects were informed of the aim of the study, and those who voluntarily agreed to take part were given a morning appointment from Monday to Friday and asked to fast for a period of a minimum of 10 hours.

**Personal and Medical History**

Self-administered questionnaires relating to demographic and socioeconomic factors and diet were completed at home by the participants and checked by the interviewer at the clinic. Data on level of education, occupational activity, personal and family history, tobacco and alcohol consumption, drug intake, and physical activity were collected.

**Alcohol Consumption**

Alcohol consumption was assessed by a questionnaire in which the subject reported his average consumption (in units) of wine, beer, cider, and spirits for each day of the week. Alcohol consumption (expressed in milliliters of pure ethanol per day) was estimated from the average number of milliliters of ethanol in a serving of each type of alcoholic beverage: wine, 12-cL serving, 10% or 12% alcohol (vol/vol); beer, 12-cL serving, 5% alcohol, 25- or 33-cL serving, 6% or 8% alcohol; cider, 12-cL serving, 5% alcohol; and spirits, 2- or 6-cL serving, 20% or 40% alcohol. Because one of the hypotheses of this work was that BP levels were dependent on the average alcohol consumption of the previous days, individual consumption of alcohol of the days before (lag0 = current, lag1 = the day before, lag2 = 2 days before, etc) was computed.

**BP Measurement**

BP was measured once with an automatic device (Spengler SP9) at the end of the examination after a 5-minute rest in the sitting position and before blood draw. A standard cuff size was used, but a large cuff was available when necessary. At least 3 measuring devices were available at any time in each center, and all 3 were equally used. To avoid systematic differences between centers, the devices were circulated between them. The devices were recalibrated every 3 months in the coordinating center in Paris.

**Statistical Analysis**

Statistical analysis was conducted with the use of SAS software. Subjects with history of angina pectoris, myocardial infarction (MI), and possible coronary heart disease and those treated for hypertension and/or dyslipidemia were excluded from the analysis. Results were expressed as mean ± SD or adjusted mean ± SEM or number of subjects and percentage, unless otherwise stated. Univariate comparisons were performed at any time in each center, and all 3 were equally used. To avoid systematic differences between centers, the devices were circulated between them. The devices were recalibrated every 3 months in the coordinating center in Paris.

**Results**

**Population**

Of the initial 10,595 subjects, 593 were excluded because of history of angina pectoris, MI, or possible coronary heart disease and 1825 because of medical treatment for hypertension or hypercholesterolemia. Of the 8177 remaining subjects (5926 for France and 2251 for Northern Ireland), 6730 reported consuming alcohol at least once per week (5363 in France and 1367 in Northern Ireland). Finally, 207 subjects from France were excluded because they had been sampled on a Saturday. The clinical characteristics of the subjects are summarized in Table 1. French drinkers were significantly older, had a higher body mass index, had a lower heart rate, were more well educated, smoked less, and were more frequently married than Northern Irish drinkers. Finally, French drinkers drank less total alcohol, less beer, less spirits, and more wine than their Northern Irish counterparts (Table 1).

Average alcohol consumption was slightly higher in Northern Ireland than in France (325 ± 333 versus 317 ± 249 mL of ethanol per week; P < 0.01, Kruskal-Wallis test). Breakdown by day of the week indicated that total alcohol consumption was evenly distributed throughout the week (with a slight increase on weekends) in France, whereas Fridays and Saturdays accounted for two thirds of total alcohol consumption in Northern Ireland (Figure).

**BP Levels by Day of the Week**

After adjustment for age, body mass index, heart rate, number of years of education, marital status, occupational activity, and smoking status, drinkers from Northern Ireland had significantly higher levels of systolic BP (SBP) and lower
levels of diastolic BP (DBP) than their French counterparts (Table 2). In addition, significant between-day differences and country × day interactions were noted for SBP and DBP. Those differences and interactions remained significant even after adjustment for total alcohol consumption (data not shown). Close inspection of the data indicated that in Northern Ireland, SBP and DBP levels were higher on Monday and decreased until Thursday, with a further increase on Friday (Table 2). Conversely, no such relationship was found for nondrinkers (Table 3).

### Correlation Between Cardiovascular Risk Factors and Prior Alcohol Consumption

In Northern Ireland, SBP and DBP were significantly correlated with the mean amount of alcohol consumed 3 and 4 days before (lag3 and lag4), whereas the correlations for the other lags were not statistically significant. Conversely, in France the relationship between SBP and DBP and the amount of alcohol consumption did not show any fluctuation for all lags tested.

### Effects of Adjustment for the Amount of Alcohol Consumed

Because BP levels were significantly associated with average alcohol consumption 3 days before, an adjustment on lag3 was performed by introducing the alcohol consumption 3 days before in the model. Additionally, because the effect of the alcohol consumed on Fridays and Saturdays was supposed to decrease during the next week (higher effect on Mondays to Wednesdays, lower afterward), a day × lag3 interaction was

### TABLE 2. Distribution of BP Levels in Drinkers in France and Northern Ireland

<table>
<thead>
<tr>
<th>BP/Day</th>
<th>France 95% CI</th>
<th>Northern Ireland 95% CI</th>
<th>Between-Country Test</th>
<th>Between-Day Test</th>
<th>Country×Day Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td>132 (130–133)</td>
<td>137 (134–139)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuesday</td>
<td>131 (130–133)</td>
<td>134 (132–137)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wednesday</td>
<td>131 (130–132)</td>
<td>133 (131–135)</td>
<td>14.31†</td>
<td>4.47†</td>
<td>4.07†</td>
</tr>
<tr>
<td>Thursday</td>
<td>132 (130–133)</td>
<td>130 (128–133)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friday</td>
<td>132 (131–133)</td>
<td>133 (131–135)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DBP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td>84 (83–84)</td>
<td>83 (82–84)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuesday</td>
<td>83 (82–84)</td>
<td>82 (81–84)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wednesday</td>
<td>83 (82–84)</td>
<td>82 (80–83)</td>
<td>28.04‡</td>
<td>2.62*</td>
<td>2.99*</td>
</tr>
<tr>
<td>Thursday</td>
<td>83 (83–84)</td>
<td>80 (79–81)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friday</td>
<td>84 (83–84)</td>
<td>81 (80–83)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are adjusted mean and 95% CI. Data are adjusted for age, body mass index, heart rate, educational level, occupational activity, marital status, and smoking status.

### TABLE 3. Distribution of BP Levels in Nondrinkers in France and Northern Ireland

<table>
<thead>
<tr>
<th>BP/Day</th>
<th>France 95% CI</th>
<th>Northern Ireland 95% CI</th>
<th>Between-Country Test</th>
<th>Between-Day Test</th>
<th>Country×Day Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td>129 (125–133)</td>
<td>131 (127–135)</td>
<td>0.95*</td>
<td>0.38*</td>
<td>0.90*</td>
</tr>
<tr>
<td>Tuesday</td>
<td>129 (125–133)</td>
<td>131 (127–135)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wednesday</td>
<td>131 (127–135)</td>
<td>129 (125–133)</td>
<td>0.51*</td>
<td>1.00*</td>
<td>0.43*</td>
</tr>
<tr>
<td>Thursday</td>
<td>128 (124–132)</td>
<td>132 (128–136)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friday</td>
<td>127 (123–131)</td>
<td>130 (126–134)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DBP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monday</td>
<td>82 (80–84)</td>
<td>81 (79–83)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuesday</td>
<td>83 (81–85)</td>
<td>82 (80–84)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wednesday</td>
<td>84 (82–86)</td>
<td>81 (79–83)</td>
<td>0.51*</td>
<td>1.00*</td>
<td>0.43*</td>
</tr>
<tr>
<td>Thursday</td>
<td>81 (79–83)</td>
<td>81 (79–83)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friday</td>
<td>81 (79–83)</td>
<td>80 (80–84)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Values are adjusted mean and 95% CI. Data are adjusted for age, body mass index, heart rate, educational level, occupational activity, marital status, and smoking status.

*P=NS (analysis by generalized linear model).
also introduced. This adjustment canceled out the differences between days as well as the country×day interaction for SBP and DBP (Table 4). Further adjustment on lag_3 or on other lags did not improve the model (not shown).

**Discussion**

In this study we found that Northern Irish drinkers had BP levels that were high on Mondays and decreased until Thursday, whereas no such evolution was found for French drinkers. Our data are in agreement with other studies in which the diagnosis of hypertension was more likely on Mondays for weekend drinkers than for regular drinkers and in which binge drinkers had higher BP levels on Mondays relative to Thursdays, this difference being lost when subjects shifted to a continuous drinking pattern. Furthermore, our data also indicate that the effect of binge drinking on SBP and DBP levels could also influence the risk of MI, with a higher risk on Mondays for weekend drinkers than for regular drinkers and DBP levels could also influence the risk of MI, with a higher risk on Mondays for weekend drinkers than for regular drinkers.

The biological mechanisms by which acute alcohol consumption modulates BP levels are still controversial: acute alcohol consumption has been shown to modulate intracellular sodium and to decrease adrenoceptor-mediated cardiovascular reactivity, but the precise relationships between the rise in BP after regular, moderate alcohol consumption remain to be assessed. It should also be stressed that alcohol consumption occurs mostly with meals in France, whereas Northern Irish binge drinkers tend to consume alcohol without any other nutritional intake. Because blood alcohol levels are influenced by the concomitant absorption of a meal, chronic alcohol consumption, the concentration of ingested ethanol, and the time during which alcohol is consumed, it is conceivable that the metabolic effects of alcohol depend on the pattern of alcohol drinking. It is also possible that binge drinking is associated with an increased consumption of cigarettes, which could lead to an increase in fibrinogen levels, or with the consumption of salted food such as peanuts and potato chips, which would increase BP levels. Although we did not assess the daily consumption of cigarettes or salted food, those hypotheses deserve further investigation. Another possible explanation for the higher BP levels on Monday among binge drinkers might be the metabolic effects of beer that are not related to alcohol. For instance, beer intake has been associated with hyponatremia due to the hyposmolality of the beer ingested; this would lead to secondary hyperaldosteronism, with an increase in vascular tone and hypertension. Indeed, a stronger relationship between SBP and DBP was found for beer (Spearman correlation = 0.17 and 0.16 for SBP and DBP, respectively, for France) and for wine (Spearman correlation = 0.04 for SBP and 0.02 for DBP, respectively, for Northern Ireland) than for for wine (Spearman correlation = 0.04 for SBP and 0.02 for DBP, respectively, for Northern Ireland).
respectively, for Northern Ireland [both \( P=\text{NS} \)]. It is thus tempting to speculate that the high amount of beer consumed during weekends by Northern Irish drinkers would lead to transient hyponatraemia, with an increase in aldosterone levels, leading to higher BP levels on Mondays. Another possibility would be the higher potassium content as well as the higher potassium/sodium content of wine relative to other alcoholic beverages, which could modulate BP effects.29

Introducing a \( \text{lag}_3 \times \text{day} \) interaction was found necessary to mimic the effect of the large amount of alcohol consumed at weekends in Northern Ireland, because it was expected that this effect would decrease during the week. Indeed, the introduction of the \( \text{lag}_3 \times \text{day} \) interaction canceled out the differences in BP levels between days, whereas without this interaction the differences and interactions persisted (not shown). Similar results were obtained when the average alcohol consumption for Saturday (and its interaction with the day of the week) was used, but because this model did not take into account the amount of alcohol consumed the other days of the week, it was not retained. Nevertheless, those findings indicate that the amount of alcohol consumed during the weekend will influence BP levels on Mondays (and their decrease until Thursdays) among Northern Irish drinkers. Interestingly, adjustment for total alcohol consumption did not cancel out the between-day differences or the country \( \times \) day interaction. Thus, in this study time elapsed since last drink appears to be more important than total alcohol consumption in explaining the between-day differences and the country \( \times \) day interaction for BP levels. Still, the reasons for BP levels being correlated with the average amount of alcohol consumed 3 days before remain to be assessed.

The question that motivated this study was whether the amount of alcohol consumed on weekends in Northern Ireland could partly account for the higher incidence of MI observed in populations with a similar pattern of alcohol intake. If it was alcohol that explained this higher incidence of MI on Mondays among drinkers, then no such increase in MI risk or in BP levels should be found among Northern Irish teetotalers. Indeed, no between-day differences were found for SBP and DBP for Northern Irish teetotalers, and no country \( \times \) day interactions were found when Northern Irish teetotalers were compared with their French counterparts. Again, those findings support the hypothesis that the high intake of alcohol on weekends could partly explain the higher incidence of MI on Mondays, via an increase in SBP and DBP levels.

Finally, it should be stressed that in this study BP levels were assessed in different subjects for each day of the week. Hence, it would be possible that the differences observed in Northern Irish drinkers be attributable to differences in the characteristics of the subjects attending the clinic. Nevertheless, no between-day differences were found regarding age, body mass index, years of school, marital and smoking status, and occupational activity (employed/unemployed) among drinkers in Northern Ireland (data not shown), making this possibility unlikely to explain such differences.

In summary, our results indicate that the binge-drinking pattern observed among Northern Irish drinkers leads to physiologically disadvantageous consequences regarding BP levels, whereas no such fluctuations in BP levels are found for a regular consumption. The fluctuations in BP levels due to the binge-drinking pattern could also partly explain the higher incidence of MI on Mondays in countries characterized by a high alcohol intake on weekends.

### Appendix

#### The PRIME Study

The PRIME Study is organized under an agreement between INSERM and the Merck, Sharp and Dohme-Chibret Laboratory, with the following participating laboratories: Strasbourg MONICA Project, Department of Epidemiology and Public Health, Faculty of Medicine, Strasbourg, France (D. Arveiler, B. Haas); Toulouse MONICA Project, INSERM U558, Department of Epidemiology, Paul-Sabatier-Toulouse Purpan University, Toulouse, France (J. Ferrières, J.B. Ruidavets); Lille MONICA Project, INSERM U508, Pasteur Institute, Lille, France (P. Amouyel, M. Montaye); Department of Epidemiology and Public Health, The Queen’s University of Belfast, Belfast, Northern Ireland (A. Evans, J. Yarnell); Department of Atherosclerosis, SERLIA-INSERM U325, Lille, France (G. Luc, J.M. Bard); Laboratory of Hematology, La Timone Hospital, Marseille, France (I. Juhan-Vague); Laboratory of Endocrinology, INSERM U326, Toulouse, France (B. Perret); Vitamin Research Unit, University of Bern, Bern, Switzerland (F. Gey); Trace Element Laboratory, Department of Medicine, The Queen’s University of Belfast, Belfast, Northern Ireland (D. McMaster); DNA Bank, INSERM U525/SC7, Paris, France (F. Cambien); and Coordinating Center, INSERM U258, Villejuif, France (P. Ducimetière, P.Y. Scarabin, A. Bingham).

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### References


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