

*Original Article*

# The Proportion of Individuals with Alcohol-Induced Hypertension among Total Hypertensives in a General Japanese Population: NIPPON DATA90

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Japanese men consume more alcoholic beverages than men in many other developed countries. The high consumption rate of alcoholic beverages among Japanese men may contribute to the high prevalence of hypertension in Japan. In the present study, we calculated the odds ratio for hypertension in alcohol drinkers based on recent criteria using data from a nationwide survey conducted in Japan in 1990, and estimated, among total hypertensives in a general Japanese population, the percentage of hypertensives whose condition was due to alcohol consumption. Of 3,454 male participants, 64.8% were drinkers (1 *gou*/day, 28.9%; 2 *gou*/day, 20.1%; 3 *gou*/day or more, 8.7%; ex-drinkers, 7.0%) and 49.8% were hypertensive, whereas 7.6% of 4,808 female participants were drinkers (1 *gou*/day, 5.2%; 2 *gou*/day or more, 1.3%; ex-drinkers, 1.1%) and 43.1% were hypertensive (1 *gou*=23.0 g of alcohol). In both sexes, drinkers had a higher odds ratio for hypertension than never drinkers, and there was a significant dose-response relationship between the amount of alcohol consumed and the odds ratio for hypertension. Among all hypertensives, the percentage whose hypertension was due to alcohol consumption was 34.5% (95% confidence interval, 10.9%–51.9%) for men and 2.6% (0.8%–5.8%) for women. The corresponding proportion based on daily alcohol intake was 12.7% for 1 *gou*/day, 11.1% for 2 *gou*/day, 5.8% for 3 *gou*/day or more, and 4.8% for ex-drinkers in men, and 1.8% for 1 *gou*/day, 0.7% for 2 *gou*/day or more, and –0.1% for ex-drinkers in women. In conclusion, we found that a large percentage of the hypertensives in a general Japanese male population had alcohol-induced hypertension. (*Hypertens Res* 2007; 30: 663–668)

**Key Words:** alcohol drinking, hypertension, Japan

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## Introduction

Alcohol consumption has been associated with the development of hypertension (1–10), and Japanese men consume more alcoholic beverages than men in many other developed countries, including the United States and the United Kingdom (11–15). These facts suggest that the high consumption of alcoholic beverages among Japanese men may contribute to the high prevalence of hypertension in Japan (12, 16). Thus, it is important to clarify the proportion of hypertensives in the general Japanese population whose hypertension was induced by alcohol. Although this percentage has been determined in previous studies (17), it has not been estimated since the recent establishment of new criteria for hypertension (systolic blood pressure  $\geq 140$  mmHg and/or diastolic blood pressure  $\geq 90$  mmHg).

In the present study, we attempted to estimate the proportion of individuals with alcohol-induced hypertension among total hypertensives in a randomly selected Japanese population using the recently established criteria for hypertension.

## Methods

### Study Design and Participants

NIPPON DATA (National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged) is a series of cohort studies conducted by the National Survey on Circulatory Disorders, Japan. In the present study, we analyzed baseline data from NIPPON DATA90 (data from the Fourth National Survey on Circulatory Disorders, Japan in 1990); the details of this cohort study have been reported previously (18–21).

A total of 8,384 community residents (3,504 men and 4,880 women;  $\geq 30$  years old) from 300 randomly selected districts participated. The overall population aged 30 and over in all districts was 10,956 and the participation rate in this survey was 76.5%. Of the 8,384 participants, 122 were excluded because of missing information in the baseline survey. The remaining 8,262 participants (3,454 men and 4,808 women) were included in the analysis. Accordingly, the participants in the present study were thought to be representative of the Japanese population.

The present study was approved by the Institutional Review Board of Shiga University of Medical Science for Ethical Issues (No.12-18, 2000).

### Examination

Public health nurses asked the participants about their alcohol consumption habits and classified them into the following five groups: never drinker, current daily drinker of 1 *gou*/day, 2 *gou*/day, or 3 *gou*/day or more, or ex-drinker. The *gou* is a traditional Japanese alcohol drinking unit, and 1 *gou* is equiv-

alent to 180 mL of sake (Japanese rice wine), which contains 23.0 g of alcohol. Its alcohol content is roughly equivalent to 663 mL (1 bottle) of beer, 70 mL (two single shots) of whisky, or 110 mL (a half glass) of “shochu” (spirits made from barley, sweet potato, rice or any combination of these). In order to estimate the proportion of individuals with alcohol-induced hypertension among total hypertensives in the study population, male and female participants were classified into two categories, never drinkers and drinkers, with the latter category consisting of current drinkers and ex-drinkers. We included ex-drinkers in the drinker category because drinkers diagnosed with hypertension might have been advised to quit drinking alcohol. In addition to the above analysis, we estimated the proportion of individuals with alcohol-induced hypertension among total hypertensives by taking the quantity of alcohol consumed into consideration. In this analysis, male participants were classified into the following five categories: never drinker, 1 *gou*/day, 2 *gou*/day, 3 *gou*/day or more, and ex-drinker. Furthermore, female participants were classified into the following four categories: never drinker, 1 *gou*/day, 2 *gou*/day or more, and ex-drinker. A category of 3 *gou*/day or more was not used in women, because only 1.3% of the female participants were heavy drinkers (2 *gou*/day,  $n=36$ ; 3 *gou*/day or more,  $n=27$ ).

Baseline blood pressures were measured once by trained observers using a standard mercury sphygmomanometer on the right arm of seated participants after a sufficient period of rest. Information on the use of antihypertensive agents was also obtained by public health nurses. Referring to the Seventh Report of the Joint National Committee (17), hypertension was defined as a systolic blood pressure  $\geq 140$  mmHg, a diastolic blood pressure  $\geq 90$  mmHg, the use of antihypertensive agents, or any combination of these. Body mass index was calculated as weight (kg) divided by the square of height (m).

### Statistical Analysis

The data were analyzed separately for men and women, because alcohol consumption habits are quite different between the sexes in Japan (7, 11, 16, 22). Initially, one way analysis of variance or a  $\chi^2$  test was used to compare risk characteristics at baseline among the different alcohol-intake categories. Next, we calculated the prevalence of hypertension in each of two alcohol drinking habit categories (never drinkers and drinkers [including ex-drinkers]). A logistic regression model was used to calculate the odds ratio for hypertension in drinkers with never drinkers serving as a reference. Age and body mass index were included in the regression models as potential confounding variables. We estimated the percentage of individuals having alcohol-induced hypertension among total hypertensives—i.e., the population attributable fraction—using the following equation: [prevalence of drinkers among hypertensives  $\times$  (odds ratio – 1)]/odds ratio (23). The 95% confidence interval for the corresponding proportion was calculated using the formula pro-

**Table 1. Baseline Risk Characteristics in 1990 of 8,262 Japanese Participants Based on Sex and Alcohol Drinking Habit: NIPPON DATA90**

	Alcohol drinking habit				
	Never drinker	1 <i>gou</i> /day	2 <i>gou</i> /day (or more for women)	3 <i>gou</i> /day or more	Ex-drinker
<b>Men</b>					
Number of participants ( <i>n</i> (%))	1,217 (35.2)	998 (28.9)	694 (20.1)	302 (8.7)	243 (7.0)
Age (years)*,‡	54.3±14.7	52.9±13.5	51.1±11.8	49.4±10.9	61.3±14.1
Body mass index (kg/m <sup>2</sup> )*,‡	22.8±3.1	22.9±2.9	23.2±2.9	23.5±3.1	22.7±3.3
Systolic blood pressure (mmHg)*,‡	134.8±20.0	138.4±19.9	139.0±19.0	141.0±20.1	141.8±21.1
Diastolic blood pressure (mmHg)*,‡	81.2±10.9	84.0±11.2	85.6±11.9	86.3±12.1	84.0±12.8
Use of antihypertensive agents (%)*,‡	9.9	14.1	13.5	9.6	24.3
<b>Women</b>					
Number of participants ( <i>n</i> (%))	4,442 (92.4)	251 (5.2)	63 (1.3)		52 (1.1)
Age (years)*,‡	53.1±14.2	47.1±11.4	47.7±10.5		51.5±13.7
Body mass index (kg/m <sup>2</sup> )*	22.9±3.3	22.5±3.1	22.8±3.5		22.5±3.4
Systolic blood pressure (mmHg)*,‡	133.9±20.8	131.1±20.8	132.7±19.3		128.2±22.2
Diastolic blood pressure (mmHg)*	79.4±11.7	81.0±13.0	81.6±10.4		77.7±13.2
Use of antihypertensive agents (%)*	15.9	10.8	20.6		19.2

Values indicate the mean±SD or the % of participants in that category. One *gou* contains 23.0 g of alcohol. \*Mean values were compared among the categories by one way analysis of variance. †Proportions were compared among the categories by a  $\chi^2$  test. ‡The difference among the alcohol drinking habit categories was statistically significant ( $p<0.05$ ).

posed by Greenland (24). Finally, in order to investigate the corresponding proportion of individuals with alcohol-induced hypertension by daily intake of alcohol, we analyzed the data using the above equation after classifying the male and female participants into five and four categories, respectively, based on their habits of alcohol consumption.

The statistical analysis was performed using SPSS 14.0J for Windows (SPSS Japan Inc., Tokyo, Japan). *p* values were two-sided, and values of  $p<0.05$  were considered statistically significant.

## Results

The mean values or proportions of risk characteristics for male and female participants grouped according to their alcohol consumption habits are summarized in Table 1. Of the 3,454 male participants (mean age, 53.3 years old), 64.8% had a current or past alcohol consumption habit and 49.8% were hypertensive, whereas only 7.6% of the 4,808 female participants (mean age, 52.7 years old) had a drinking habit and 43.1% were hypertensive. For both sexes, the mean age was higher in never drinkers and ex-drinkers than in daily drinkers. For men, the mean body mass index was lower in never drinkers and ex-drinkers than in daily drinkers of 2 *gou*/day or more.

Male drinkers had a higher prevalence of hypertension compared to never drinkers (54.2% for drinkers vs. 41.7% for never drinkers), and we confirmed a significantly higher odds ratio for hypertension in drinkers after adjustment for age and body mass index (1.96; 95% confidence interval, 1.67–2.29).

Although female drinkers had a somewhat lower prevalence of hypertension (41.3% for drinkers vs. 43.3% for never drinkers), we confirmed a significantly higher odds ratio for hypertension in drinkers after adjustment for the same confounding factors (1.54; 95% confidence interval, 1.20–1.98). The proportion of individuals with alcohol-induced hypertension among total hypertensives was estimated to be 34.5% (95% confidence interval, 10.9%–51.9%) in men and 2.6% (95% confidence interval, 0.8%–5.8%) in women (the results described above are not shown in Table 1).

There was a dose-response relationship between daily alcohol intake and the odds ratio for hypertension in both sexes (Table 2). Even the odds ratio for hypertension in daily drinkers who consumed 1 *gou*/day was significantly higher in both sexes. Table 2 shows the percentage of individuals with alcohol-induced hypertension among total hypertensives in each daily-intake category. The proportion of individuals with alcohol-induced hypertension was highest in daily drinkers of 1 *gou*/day in both sexes.

## Discussion

In the present study, we found a large proportion of individuals with alcohol-induced hypertension among all hypertensive participants in a representative Japanese male population. Approximately one-third of male hypertensives—but only a few percent of female hypertensives—had hypertension due to alcohol consumption. There are prominent regional differences in alcohol consumption in Japan (11, 22, 25), which may affect the proportion of individuals with alcohol-induced

**Table 2. Prevalence of Hypertension, Odds Ratio for Hypertension in Alcohol Drinkers, and Proportion of Individuals with Alcohol-Induced Hypertension among Total Hypertensives in 1990 Grouped by Sex and Alcohol Drinking Habit among 8,262 Participants: NIPPON DATA90**

Alcohol drinking habit	Number of participants ( <i>n</i> (%))	Hypertension			Alcohol-induced hypertension among total hypertensives (%)
		Cases	Prevalence (%)	Adjusted odds ratio* (95% confidence interval)	
Men					
Never drinkers	1,217 (35.2)	508	41.7	1.00	
1 <i>gou</i> /day	998 (28.9)	514	51.5	1.74 (1.45–2.10)	12.7
2 <i>gou</i> /day	694 (20.1)	371	53.5	2.06 (1.67–2.53)	11.1
3 <i>gou</i> /day or more	302 (8.7)	168	55.6	2.46 (1.86–3.25)	5.8
Ex-drinkers	243 (7.0)	160	65.8	2.05 (1.49–2.81)	4.8
Women					
Never drinkers	4,442 (92.4)	1,923	43.3	1.00	
1 <i>gou</i> /day	251 (5.2)	101	40.2	1.58 (1.17–2.14)	1.8
2 <i>gou</i> /day or more	63 (1.3)	30	47.6	2.09 (1.17–3.72)	0.7
Ex-drinkers	52 (1.1)	20	38.5	0.94 (0.49–1.79)	−0.1

One *gou* contains 23.0 g of alcohol. Hypertension was defined as a systolic blood pressure  $\geq 140$  mmHg, a diastolic blood pressure  $\geq 90$  mmHg, the use of antihypertensive agents, or any combination of these. \*Odds ratios were calculated by a logistic regression model adjusted for age and body mass index.

hypertension among all hypertensives (22). Therefore, only data from a nationwide random sampling survey such as ours will generate a reliable estimate of the proportion of individuals with alcohol-induced hypertension among all hypertensives in the general Japanese population.

Previously, Ueshima *et al.* (16) reported that hypertension in 32% of Japanese hypertensive men (based on previous criteria of systolic blood pressure  $\geq 160$  mmHg, diastolic blood pressure  $\geq 95$  mmHg, the use of antihypertensive agents, or any combination of these) aged 30–69 could be attributed to alcohol drinking using data from the nationwide survey in 1980. In 1990, using more recent criteria for hypertension (17) (*i.e.*, different from the above criteria), we calculated the odds ratio for the prevalence of hypertension in drinkers, and estimated the percentage of Japanese hypertensives whose condition could be attributed to alcohol. It is difficult to compare our results directly with the corresponding proportion in other countries due to the lack of available data. However, Japanese men consume more alcoholic beverages than men in many other developed countries (11–15). Klag *et al.* (12) previously reported that, in the 1970s, the prevalences of daily drinkers in a male population aged 35–59 working for an office in Japan or the United States were 48% (heavy drinkers, 6%) and 40% (heavy drinkers, 0%), respectively, and then estimated that hypertension in 29% of Japanese and 21% of American hypertensives (based on the same previous criteria) could be attributed to daily alcohol consumption (12). The prevalence of daily drinkers in Japanese male office workers is almost the same as the results from the nationwide survey in 1980 (16), although we do not have any information on the prevalence of daily drinkers in the whole male population in the United States at that time. In addition, Zhou *et al.*

(13) recently reported that in the 1990s, the mean alcohol intake per day in a male population aged 40–59 was 186.8 kcal for Japan, 70.4 kcal for the United States and 116.1 kcal for the United Kingdom (7 kcal = 1.0 g of alcohol). Judging from these observations, the proportion of individuals with alcohol-induced hypertension among all hypertensives might be much higher in the Japanese male population than in the male population in other developed countries such as the United States and the United Kingdom.

We demonstrated that even a low-to-moderate alcohol intake of 1 *gou*/day contributes to the high prevalence of hypertension in Japan. Approximately 37% of all men and 75% of all women with alcohol-induced hypertension had a low-to-moderate alcohol intake. This is because the number of low-to-moderate drinkers was much greater than the number of heavy drinkers of 2 *gou*/day or more; approximately 50% of male current drinkers and 80% of female current drinkers were in the category of low-to-moderate alcohol intake. These results suggest that moderation of alcohol intake is not enough to reduce the prevalence of hypertension in the Japanese population. From the viewpoint of preventing hypertension, quitting habitual alcohol intake or never drinking in the first place may be required rather than reducing alcohol intake. However, a J-shaped association between alcohol intake and arterial stiffness quantified by pulse wave velocity has been suggested (26), even among normotensive individuals (27). A J-shaped association between alcohol intake and coronary heart disease (28, 29) or ischemic stroke (30) has also been suggested. Therefore, the protective effect of light-to-moderate alcohol intake on atherosclerotic cardiovascular risk should also be included in the overall consideration of the influence of alcohol drinking on human health.



The present study has several limitations. First, in the interview used to assess alcohol intake habits, each participant chose the category most applicable to his or her habit among the five categories on the basis of his or her own judgement. It is possible that some participants who occasionally consume alcoholic beverages choose "never drinker," and this might have underestimated the true proportion of individuals with alcohol-induced hypertension among total hypertensives, because even such drinkers are likely to be at risk for hypertension (10). Second, we did not take the type of alcoholic beverages consumed into consideration in our analysis, because this information was not available. However, Okamura *et al.* (31) reported that the effect of alcohol consumption on blood pressure does not depend on the type of alcoholic beverages consumed. Thus, information on the type of alcoholic beverages consumed may have little effect on the results of the present study. Third, blood pressure-related social factors (*e.g.*, stress, irregular lifestyle) and dietary factors (*e.g.*, sodium intake, potassium intake) were not adjusted in the analysis, because these data were also not available. However, Choudhury *et al.* (32) reported that there was little difference in sodium and potassium intake between Japanese male drinkers and never drinkers. Finally, our results are based on data from the survey conducted in 1990. The latest nationwide survey (the Fifth National Survey on Circulatory Disorders, Japan in 2000) (33) shows that the prevalences of alcohol drinkers (including ex-drinkers) and hypertensives are 62.4% (daily drinkers, 53.6%; ex-drinkers, 8.8%) and 57.1% for men, and 10.7% (daily drinkers, 9.3%; ex-drinkers, 1.5%) and 45.3% for women, respectively. We still observed a high prevalence of alcohol drinkers and hypertensives in men in 2000. Therefore, we believe that the proportion of individuals with alcohol-induced hypertension among total hypertensives remains quite high in the general Japanese male population.

In conclusion, alcohol consumption plays an important role in the high prevalence of hypertension in the Japanese male population. Thus, in any public health approach to combating hypertension, attention should be paid to alcohol consumption. This is also applicable to other countries where the prevalence of alcohol consumption remains high or is increasing.

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### Appendix

#### List of the NIPPON DATA90 Research Group

NIPPON DATA90: National Integrated Project for Prospective Observation of Non-communicable Disease And its Trends in the Aged.

*Chairman:* Hirotsugu Ueshima (Department of Health Science, Shiga University of Medical Science, Otsu, Shiga).

*Consultants:* Osamu Iimura (Hokkaido JR Sapporo Hospital, Sapporo, Hokkaido), Teruo Omae (Health C&C Center, Hisayama, Kasuya, Fukuoka), Kazuo Ueda (Murakami Memorial Hospital, Nakatsu, Oita), Hiroshi Yanagawa (Saitama Prefectural University, Koshigaya, Saitama), Hiroshi Horibe (Aichi Medical University, Nagakute, Aichi).

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