ORIGINAL ARTICLE

Roles of Drinking Pattern and Type of Alcohol Consumed in Coronary Heart Disease in Men

Kenneth J. Mukamal, M.D., M.P.H., Katherine M. Conigrave, M.B., B.S., Ph.D., Murray A. Mittleman, M.D., Dr.P.H., Carlos A. Camargo, Jr., M.D., Dr.P.H., Meir J. Stampfer, M.D., Dr.P.H., Walter C. Willett, M.D., Dr.P.H., and Eric B. Rimm, Sc.D.

ABSTRACT

BACKGROUND

Although moderate drinking confers a decreased risk of myocardial infarction, the roles of the drinking pattern and type of beverage remain unclear.

METHODS

We studied the association of alcohol consumption with the risk of myocardial infarction among 38,077 male health professionals who were free of cardiovascular disease and cancer at base line. We assessed the consumption of beer, red wine, white wine, and liquor individually every four years using validated food-frequency questionnaires. We documented cases of nonfatal myocardial infarction and fatal coronary heart disease from 1986 to 1998.

RESULTS

During 12 years of follow-up, there were 1418 cases of myocardial infarction. As compared with men who consumed alcohol less than once per week, men who consumed alcohol three to four or five to seven days per week had decreased risks of myocardial infarction (multivariate relative risk, 0.68 [95 percent confidence interval, 0.55 to 0.84] and 0.63 [95 percent confidence interval, 0.54 to 0.74], respectively). The risk was similar among men who consumed less than 10 g of alcohol per drinking day and those who consumed 30 g or more. No single type of beverage conferred additional benefit, nor did consumption with meals. A 12.5-g increase in daily alcohol consumption over a four-year follow-up period was associated with a relative risk of myocardial infarction of 0.78 (95 percent confidence interval, 0.62 to 0.99).

CONCLUSIONS

Among men, consumption of alcohol at least three to four days per week was inversely associated with the risk of myocardial infarction. Neither the type of beverage nor the proportion consumed with meals substantially altered this association. Men who increased their alcohol consumption by a moderate amount during follow-up had a decreased risk of myocardial infarction.

From the Divisions of General Medicine and Primary Care (K.J.M.) and Cardiology (M.A.M.), Beth Israel Deaconess Medical Center, Boston; the Department of Public Health and Community Medicine and the Department of Medicine, University of Sydney, Sydney, New South Wales, Australia (K.M.C.); the Departments of Epidemiology (M.A.M., C.A.C., M.J.S., W.C.W., E.B.R.) and Nutrition (M.J.S., W.C.W., E.B.R.), Harvard School of Public Health, Boston; the Channing Laboratory, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston (C.A.C., M.J.S., W.C.W., E.B.R.); and the Department of Emergency Medicine, Massachusetts General Hospital, Boston (C.A.C.). Address reprint requests to Dr. Mukamal at the Division of General Medicine and Primary Care, Beth Israel Deaconess Medical Center, 330 Brookline Ave., LY-303, Boston, MA 02215, or at kmukamal@caregroup.harvard.edu.

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Important questions remain about the effect of alcohol consumption on coronary heart disease. Among these are the roles that the type of beverage consumed, the pattern of drinking, and the consumption of alcohol with meals have in modifying the apparent benefits of moderate alcohol consumption.[1] Furthermore, most studies have used single measurements of alcohol use and hence have not assessed the importance of updating alcohol intake or the effect of changes in consumption over time.

Although the consumption of wine in particular has been hypothesized to be associated with a lower risk of cardiovascular disease,[2] systematic reviews differ about the specific effects of beer, wine, and liquor.[2-4] Likewise, an episodic pattern of drinking, with alcohol consumption concentrated over a few days, confers a higher risk of myocardial infarction,[5-7] but few studies have sought to clarify the relative roles of the quantity and frequency of alcohol consumption or consumption with meals.

To address these questions, we extended our analysis of data from the Health Professionals Follow-up Study to 12 years, having previously reported on alcohol use and coronary heart disease after 2 years.[8]

METHODS

The Health Professionals Follow-up Study includes 51,529 U.S. male dentists, veterinarians, optometrists, osteopathic physicians, and podiatrists 40 to 75 years of age who returned a mailed questionnaire regarding diet and medical history in 1986. Participants return follow-up questionnaires every two years to update information on exposures and current illnesses. At base line, we excluded 5528 men who reported a history of myocardial infarction, angina, stroke, transient ischemic attack, claudication, or cancer (other than nonmelanoma skin cancer); 1703 men whose data on alcohol consumption were missing; 202 men whose questionnaires had other technical problems; and 6019 men who currently consumed no alcohol but reported having consumed alcohol in the preceding 10 years. A total of 38,077 men were therefore included in this analysis.

We assessed average alcohol consumption with a semiquantitative food-frequency questionnaire, which included separate questions about beer, white wine, red wine, and liquor. We standardized portions as a 12-oz (355-ml) bottle or can of beer, a 4-oz (118-ml) glass of wine, and a shot of liquor. For each beverage, participants reported their usual average consumption in the preceding year, with nine response categories. We determined alcohol intake by multiplying the consumption of each beverage by its ethanol content (12.8 g for beer, 11.0 g for wine, and 14.0 g for liquor)[9] and summing all beverages. This process was repeated in 1990 and 1994, and a similar question about light beer (containing 11.3 g of ethanol) was added in 1994. We categorized daily ethanol intake in grams into seven categories: none, 0.1 to 4.9, 5.0 to 9.9, 10.0 to 14.9, 15.0 to 29.9, 30.0 to 49.9, and 50.0 g or more.[8]

We assessed the validity of self-reported alcohol consumption by comparing estimates from the food-frequency questionnaire with two seven-day dietary records among 127 participants who returned questionnaires in 1986 and 1987.[10] The Spearman correlation coefficients between alcohol use assessed on the basis of the first and second questionnaires and dietary records were 0.83 and 0.86, respectively.

In 1986, men reported the number of days per week that they typically drank any alcohol, with five response categories. The correlation coefficient between drinking frequency with the use of this measure and dietary records was 0.79.[11] To determine the usual quantity of alcohol consumed per drinking day, we divided average weekly alcohol consumption (from the food-frequency questionnaire) by the number of drinking days per week. In 1994, men reported the proportion of their alcohol that was consumed with meals in four response categories.

We confirmed a reported myocardial infarction if it met World Health Organization criteria, including the presence of symptoms and either typical electrocardiographic changes or elevated cardiac enzyme levels.[12] We included probable myocardial infarctions when we could not obtain medical records but the participant required hospitalization and supplementary correspondence corroborated the diagnosis.

We confirmed deaths when reported by families, postal officials, or the National Death Index, with a combined follow-up rate exceeding 98 percent.[13] Fatal coronary heart disease included fatal myocardial infarction that was confirmed by hospital records or, if coronary heart disease was listed as the cause of death on the death certificate, was the most plausible cause and if evidence of previous coronary heart disease was available. We included sudden death from cardiac causes, defined as death within one hour after the onset of symptoms in a man with

no previous serious illness and no other plausible cause. Physicians reviewing medical records were unaware of participants' reported alcohol intake.

We calculated person-years from the date of return of the 1986 questionnaire to the date of the first coronary heart disease event, death, or January 31, 1998. We estimated relative risks with cumulative incidence ratios, adjusted for age in five-year categories and smoking in six categories. In multivariate analyses, we used pooled logistic regression[14] to control for age; smoking status; quintiles of body-mass index (the weight in kilograms divided by the square of the height in meters); use or nonuse of aspirin; physical exertion (in five categories); presence or absence of hypertension, diabetes, and a parental history of premature myocardial infarction; energy intake (in quintiles); and energy-adjusted intakes of vitamin E, folate, saturated fat, trans fatty acids, and dietary fiber (in quintiles). Dietary variables were updated every four years, and other covariates every two years. We assigned missing variables their values from the previous questionnaire.

For base-line alcohol consumption, we assessed the risk of subsequent myocardial infarction according to a single estimate of alcohol consumption. In updated analyses, we prospectively assessed the risk of myocardial infarction in four-year increments, based on alcohol consumption in the preceding questionnaire. We assessed the risk associated with individual types of beverages using updated intake, controlling for standard covariates and the intake of the other beverages. To assess changes in alcohol use, we determined whether the change from 1986 to 1990 predicted the risk of myocardial infarction from 1990 to 1994 and whether the change from 1990 to 1994 predicted the risk from 1994 to 1998.

RESULTS

BASE-LINE CHARACTERISTICS

At base line, increasing alcohol consumption was positively associated with smoking, hypertension, and hypercholesterolemia (Table 1). Among men who drank, the amount consumed per drinking day and the frequency of use were moderately correlated (Spearman correlation coefficient, 0.47; $P<0.001$). Beer and liquor were consumed in greatest quantities and correlated most closely with the frequency of drinking (Spearman correlation coefficient, 0.32 for red wine, 0.39 for white wine, 0.51 for beer, and 0.61 for liquor; $P<0.001$ for all).

AVERAGE ALCOHOL CONSUMPTION

We documented 1418 cases of myocardial infarction during follow-up. We found a graded, inverse relation between updated alcohol consumption and the risk of myocardial infarction (Table 2), with a similar risk among men who abstained and men who were very light drinkers (0.1 to 4.9 g daily). Using base-line alcohol consumption, we found that the relative risks were somewhat weaker although still statistically significant. To minimize the possibility that alcohol consumption had changed in response to subclinical disease, we excluded the first four years of follow-up, which had little effect. Our results were also unchanged when we excluded hypertension as a covariate or restricted the analyses to men who reported no change in their alcohol consumption during the 10 years before enrollment (data not shown).

The association of alcohol consumption with myocardial infarction was similar for fatal and nonfatal events (Table 2). Alcohol consumption was inversely associated with the risk of undergoing a coronary revascularization procedure, with the lowest risk among those who consumed 50 g or more of alcohol daily (adjusted relative risk, 0.59; 95 percent confidence interval, 0.43 to 0.81; P for trend <0.001).

PATTERN OF ALCOHOL CONSUMPTION

The frequency of alcohol consumption was strongly inversely associated with the risk of myocardial infarction (Table 3). To assess the relative effects of the quantity and frequency of alcohol consumption, we subdivided the categories of frequency according to the amount of alcohol consumed per drinking day. We found consistently similar risks within categories of frequency, regardless of the amount of alcohol consumed per drinking day.

We next compared a frequency of alcohol use of less than three times per week with a weekly frequency of three or more times within narrow categories of average alcohol consumption. Among men who consumed 0.1 to 4.9, 5.0 to 9.9, 10.0 to 14.9, 15.0 to 29.9, or 30.0 to 49.9 g of alcohol per day on average, more frequent use consistently predicted a reduced risk, with adjusted relative risks of 0.66 (95 percent confidence interval, 0.37 to 1.18), 0.77 (95 percent confidence interval, 0.57 to 1.03), 0.72 (95 percent confidence interval, 0.52 to 1.01), 0.74 (95 percent confidence interval, 0.44 to 1.23), and 0.76 (95 percent confidence interval, 0.18 to 3.21), respectively. The inclusion of both the fre-

Table 1. Base-Line Characteristics of 38,077 U.S. Male Health Professionals, 40 to 75 Years of Age, According to Alcohol Consumption.

Characteristic*	Alcohol Consumption†						
	0 g/day (N=4521)	0.1–4.9 g/day (N=10,568)	5.0–9.9 g/day (N=6390)	10.0–14.9 g/day (N=5594)	15.0–29.9 g/day (N=5827)	30.0–49.9 g/day (N=3831)	≥50.0 g/day (N=1346)
Mean age (yr)	52.9	53.0	52.9	54.2	53.6	55.4	55.2
Mean body-mass index	25.0	25.0	24.8	24.8	24.7	24.9	25.0
Mean no. of days per week alcohol consumed	0	0.9	2.3	3.9	5.0	6.2	6.6
Amount of ethanol consumed (g/day)							
As beer	0	0.6	2.4	4.3	5.8	13.0	26.9
As red wine	0	0.4	0.8	1.3	2.6	2.4	5.6
As white wine	0	0.7	1.5	2.4	4.1	3.8	6.9
As liquor	0	0.5	2.4	4.3	7.4	18.8	30.8
Current cigarette smoker (%)	5	8	9	10	10	19	24
Past cigarette smoker (%)	19	37	42	46	50	51	51
Physical activity (MET/week)‡	17	20	22	22	23	21	19
Hypertension (%)	18	18	19	19	21	24	27
Diabetes (%)	3.0	2.5	1.9	1.7	1.4	1.5	2.4
Hypercholesterolemia (%)	9	11	10	11	11	11	12
Parental history of myocardial infarction (%)§	10	12	13	12	11	13	13
Mean daily intake							
Total energy (kcal)	1951	1926	1960	1965	2080	2153	2433
Folate (μg)¶	459	487	488	480	481	449	419
Trans fats (g)¶	3.1	2.9	2.9	2.8	2.7	2.5	2.2
Saturated fats (g)¶	25.8	25.1	24.9	24.6	24.0	23.1	20.6
Dietary fiber (g)¶	21.7	21.9	21.2	20.7	20.0	17.4	15.2
Vitamin E (mg)¶	78.4	94.1	96.8	96.2	97.2	91.6	86.2

* Except for age, all variables have been adjusted by direct standardization to the age distribution of the entire study population.
† A single alcoholic beverage contains 11.0 to 14.0 g of alcohol.
‡ MET denotes metabolic equivalents.
§ A parental history of myocardial infarction was defined as a myocardial infarction that occurred at or before the age of 60 years in either parent.
¶ Vitamin, fat, and fiber intakes were adjusted for total energy intake.

quency and average quantity of consumption (in seven categories) in a single model did not change the relative risks associated with the frequency of use, but it markedly attenuated the estimated effect of the quantity of consumption, with relative risks for myocardial infarction ranging from 1.06 to 1.20.

The inverse association between the frequency of alcohol consumption and the risk of myocardial infarction was similar among men in 10-year age groups from 40 to 49 years to 70 to 79 years (data not shown), including men 40 to 49 years of age who reported no change in their alcohol consumption in the 10 years before enrollment. The use or nonuse of aspirin and the body-mass index also did not modify the association of the frequency of alcohol use with the risk of myocardial infarction.

TYPE OF BEVERAGE

We found inverse relations between the risk of myocardial infarction and consumption of the four types of beverage, with similar relative risks at levels of consumption of at least 15.0 g of alcohol daily (Table 4). The associations were strongest for beer and liquor, intermediate for white wine, and weakest for red wine. Multivariate adjustment weakened the association of myocardial infarction with wine consumption but strengthened the associations with beer and liquor consumption.

TIMING OF ALCOHOL INTAKE WITH RESPECT TO MEALS

Of the 20,986 eligible men who reported their alcohol intake with respect to meals in 1994, 43 percent

Table 2. Relative Risk of Nonfatal, Fatal, and Any Myocardial Infarction among 38,077 U.S. Male Health Professionals, According to Updated or Base-Line Alcohol Consumption.

Variable*	Alcohol Consumption†							P Value‡
	0 g/day	0.1–4.9 g/day	5.0–9.9 g/day	10.0–14.9 g/day	15.0–29.9 g/day	30.0–49.9 g/day	≥50.0 g/day	
Nonfatal myocardial infarction								
No. of cases	167	300	140	116	132	82	23	
Relative risk	1.00	1.03	0.82	0.69	0.76	0.64	0.55	<0.001
95% CI	—	0.85–1.25	0.65–1.02	0.54–0.88	0.60–0.96	0.48–0.85	0.35–0.85	
Multivariate relative risk	1.00	1.04	0.84	0.73	0.80	0.64	0.50	0.003
95% CI	—	0.86–1.26	0.67–1.05	0.57–0.93	0.63–1.02	0.48–0.84	0.31–0.79	
Fatal myocardial infarction								
No. of cases	93	142	73	57	61	57	15	
Relative risk	1.00	0.87	0.80	0.60	0.62	0.74	0.53	0.01
95% CI	—	0.67–1.14	0.59–1.08	0.43–0.84	0.44–0.86	0.53–1.05	0.29–0.96	
Multivariate relative risk	1.00	0.89	0.84	0.61	0.71	0.62	0.39	0.01
95% CI	—	0.67–1.17	0.61–1.15	0.43–0.87	0.50–1.01	0.43–0.89	0.21–0.71	
Any myocardial infarction								
Updated alcohol consumption								
No. of cases	255	430	206	167	189	133	38	
Person-yr	60,663	106,842	63,369	55,890	59,084	37,095	12,391	
Relative risk	1.00	0.97	0.80	0.65	0.71	0.67	0.55	<0.001
95% CI	—	0.83–1.13	0.66–0.96	0.54–0.80	0.58–0.86	0.53–0.83	0.39–0.78	
Multivariate relative risk	1.00	0.98	0.83	0.69	0.79	0.64	0.48	<0.001
95% CI	—	0.84–1.15	0.68–1.00	0.57–0.85	0.64–0.96	0.51–0.80	0.33–0.69	
1986 alcohol consumption								
No. of cases	177	449	225	180	188	146	53	
Person-yr	47,062	110,273	66,572	58,025	60,823	38,866	13,707	
Relative risk	1.00	1.02	0.86	0.68	0.73	0.76	0.75	<0.001
95% CI	—	0.86–1.22	0.70–1.05	0.55–0.85	0.59–0.91	0.60–0.97	0.54–1.05	
Multivariate relative risk	1.00	1.06	0.93	0.77	0.81	0.72	0.68	<0.001
95% CI	—	0.89–1.27	0.76–1.14	0.62–0.95	0.66–1.01	0.57–0.92	0.49–0.95	
1986 alcohol consumption, 1990 cases forward								
No. of cases	115	296	150	119	120	97	31	
Person-yr	28,690	67,755	41,081	35,860	37,368	23,760	8,246	
Relative risk	1.00	1.02	0.87	0.68	0.70	0.75	0.67	<0.001
95% CI	—	0.82–1.27	0.68–1.12	0.52–0.90	0.54–0.92	0.56–1.01	0.44–1.03	
Multivariate relative risk	1.00	1.06	0.94	0.77	0.79	0.74	0.62	<0.001
95% CI	—	0.85–1.33	0.73–1.20	0.59–1.01	0.60–1.03	0.55–0.98	0.41–0.95	

* The relative risk was directly adjusted for age and smoking status (in six categories). The multivariate relative risk was adjusted for age; smoking status; body-mass index; the presence or absence of diabetes, hypertension, hypercholesterolemia, and a parental history of myocardial infarction; use or nonuse of aspirin; physical activity; intake of energy; and energy-adjusted intake of folate, vitamin E, saturated fat, trans fat, and dietary fiber. CI denotes confidence interval.

† A single alcoholic beverage contains 11.0 to 14.0 g of alcohol.

‡ P values were derived from tests of linear trend across increasing categories of alcohol consumption by treating the midpoint of consumption in each category as a continuous variable.

consumed less than 25 percent of their overall intake with meals, 22 percent consumed 25 to 74 percent with meals, 24 percent consumed 75 to 100 percent with meals, and 11 percent did not drink. Among men who consumed 5.0 to 29.9 g of alcohol daily, drinking 25 to 74 percent of the total with meals and drinking at least 75 percent of the total with meals were associated with relative risks of 0.66 (95 percent confidence interval, 0.40 to 1.09) and 1.21 (95 percent confidence interval, 0.81 to

Table 3. Relative Risks of Myocardial Infarction among 38,077 U.S. Male Health Professionals According to the Base-Line Frequency of Alcohol Consumption and the Quantity of Ethanol Consumed per Drinking Day.

Variable*	<1 Drinking Day/Wk	1–2 Drinking Days/Wk	3–4 Drinking Days/Wk	5–7 Drinking Days/Wk	P Value†
Cases of myocardial infarction	411	428	188	388	
Person-yr	97,913	118,794	65,689	112,114	
Relative risk‡	1.00	0.84	0.63	0.63	<0.001
95% CI	—	0.73–0.96	0.53–0.75	0.55–0.73	
Multivariate relative risk‡	1.00	0.88	0.68	0.63	<0.001
95% CI	—	0.77–1.01	0.55–0.84	0.54–0.74	
Multivariate relative risk§	1.00	0.83	0.66	0.62	0.001
95% CI	—	0.70–0.99	0.50–0.85	0.48–0.78	

	<1 Drinking Day/Wk	1–2 Drinking Days/Wk			3–4 Drinking Days/Wk			5–7 Drinking Days/Wk		
		<10.0 g/ drinking day	10.0–29.9 g/ drinking day	≥30.0 g/ drinking day	<10.0 g/ drinking day	10.0–29.9 g/ drinking day	≥30.0 g/ drinking day	<10.0 g/ drinking day	10.0–29.9 g/ drinking day	≥30.0 g/ drinking day
No. of cases	411	82	195	151	10	118	60	8	185	195
Person-yr	97,913	19,658	54,096	45,039	2,818	41,749	21,122	2,193	56,940	52,982
Relative risk‡	1.00	0.84	0.86	0.79	0.65	0.61	0.65	0.57	0.61	0.65
95% CI	—	0.66–1.06	0.73–1.02	0.65–0.95	0.34–1.22	0.50–0.75	0.50–0.86	0.28–1.15	0.51–0.73	0.55–0.78
Multivariate relative risk‡	1.00	0.85	0.93	0.84	0.63	0.67	0.71	0.68	0.68	0.63
95% CI	—	0.67–1.08	0.78–1.10	0.70–1.02	0.33–1.19	0.55–0.83	0.54–0.93	0.33–1.37	0.57–0.82	0.52–0.76

* CI denotes confidence interval.
† P values were derived from tests of linear trend across increasing categories of frequency of alcohol use by treating the midpoint of frequency in each category as a continuous variable.
‡ Relative risks and multivariate relative risks were adjusted for the covariates listed in Table 2.
§ Multivariate relative risks were adjusted for the covariates listed in Table 2 as well as for the estimated quantity of alcohol consumed in 1986, with use of the seven categories of alcohol consumption given in Tables 1 and 2.

1.82), respectively, as compared with drinking less than 25 percent of the total with meals (P for trend, 0.51). The relative effect of alcohol was similar among men with different patterns of consumption with meals (Table 5).

CHANGE IN CONSUMPTION OVER TIME

Among men who were free of cardiovascular disease or cancer in 1994, mean daily alcohol consumption declined from 13.1 g in 1986 to 12.0 g in 1994 (Pearson r = 0.69, P<0.001). Men who substantially decreased their consumption had a higher prevalence of diabetes and symptoms triggering a visit to a physician, and men who substantially increased consumption had a lower prevalence of hypercholesterolemia (Table 6).

As compared with consumption that remained constant or increased by less than 5.0 g, an increase of 5.0 to 9.9 g was not associated with a decreased risk of myocardial infarction (relative risk, 1.05; 95 percent confidence interval, 0.72 to 1.55), but an increase of at least 10.0 g was (relative risk, 0.55; 95 percent confidence interval, 0.33 to 0.91). Among men whose consumption remained stable or increased, a 12.5-g increase in daily alcohol consumption (as a linear variable) was associated with a relative risk of myocardial infarction of 0.78 (95 percent confidence interval, 0.62 to 0.99). Conversely, among men whose consumption was stable or decreased during follow-up, a 12.5-g decrease in daily alcohol intake was associated with a nonsignificant trend toward a higher risk of infarction (relative risk, 1.10; 95 percent confidence interval, 0.92 to 1.31), with similar risks among men whose

Table 4. Relative Risks of Myocardial Infarction (MI) among 38,077 U.S. Male Health Professionals, According to the Type of Alcoholic Beverage Consumed.

Variable*	0 g/day	0.1–9.9 g/day	10.0–14.9 g/day	≥15.0 g/day		P Value†
Red wine						
No. of cases of MI	814	560	36	8		
Person-yr	211,361	171,979	8,952	4,681		
Relative risk	1.00	0.94	1.14	0.48		0.14
95% CI	—	0.84–1.05	0.81–1.59	0.24–0.97		
Multivariate relative risk	1.00	1.06	1.48	0.64		0.34
95% CI	—	0.95–1.19	1.05–2.09	0.32–1.29		
White wine						
No. of cases of MI	671	709	26	12		
Person-yr	168,438	214,784	8,346	5,404		
Relative risk	1.00	0.93	0.82	0.62		0.04
95% CI	—	0.83–1.03	0.55–1.21	0.35–1.10		
Multivariate relative risk	1.00	1.04	0.98	0.74		0.87
95% CI	—	0.93–1.17	0.65–1.46	0.41–1.32		
	0 g/day	**0.1–9.9 g/day**	**10.0–14.9 g/day**	**15.0–49.9 g/day**	**≥50.0 g/day**	
Beer						
No. of cases of MI	747	574	72	21	4	
Person-yr	184,927	173,592	26,914	9,657	1883	
Relative risk	1.00	0.91	0.74	0.58	0.45	<0.001
95% CI	—	0.81–1.01	0.58–0.94	0.38–0.90	0.17–1.22	
Multivariate relative risk	1.00	0.93	0.78	0.57	0.34	<0.001
95% CI	—	0.83–1.04	0.61–1.01	0.37–0.89	0.12–0.92	
Liquor						
No. of cases of MI	646	515	156	87	14	
Person-yr	186,506	142,782	41,587	22,390	3706	
Relative risk	1.00	1.02	0.80	0.73	0.67	<0.001
95% CI	—	0.91–1.15	0.67–0.96	0.58–0.92	0.39–1.14	
Multivariate relative risk	1.00	1.03	0.79	0.67	0.54	<0.001
95% CI	—	0.91–1.16	0.66–0.95	0.53–0.84	0.31–0.92	

* Relative risks were directly adjusted for age and smoking status. Multivariate relative risks were adjusted for all other types of beverage and the covariates listed in Table 2. CI denotes confidence interval.

† P values were derived from tests of linear trend across increasing categories of alcohol consumption by treating the midpoint of consumption in each category as a continuous variable.

consumption decreased by 5.0 to 9.9 g per day and those with a decrease of 10.0 g or more per day.

DISCUSSION

Among these 38,077 men, alcohol consumption was consistently associated with a lower risk of coronary heart disease, regardless of the type of beverage, the proportion consumed with meals, or the type of coronary outcome. The drinking pattern had an important effect, with the lowest relative risks among men who consumed alcohol three or more days per week, even if the amount consumed per drinking day was small to moderate.

Episodic consumption of large amounts of alcohol has been associated with a high risk of coronary heart disease in several studies.[5-7,15,16] For example, in the Australian World Health Organization MONICA (Monitoring of Trends and Determinants in Cardiovascular Disease) project, men who consumed nine or more drinks per drinking day, as compared with those who did not drink at all, had odds ratios for acute myocardial infarction of approximately 2 even if they drank only one to two days per week, whereas men who consumed one to two drinks on five to six drinking days per week had an odds ratio of 0.36.[6] In contrast, our results emphasize the frequency of alcohol consumption as the primary determinant of its inverse association with the risk of myocardial infarction. Our results concur with the findings of one meta-analysis of alcohol consumption and nonfatal myocardial infarction[17]: an average consumption of more than a single drink every two days offered only a small

Table 5. Multivariate Relative Risk of Myocardial Infarction (MI) among 20,986 U.S. Male Health Professionals, According to Alcohol Consumption and the Proportion of Alcohol Consumed with Meals in 1994.*

Variable	0.1–4.9 g/day	5.0–29.9 g/day	≥30.0 g/day	P Value†
<25% of total alcohol intake consumed with meals				
No. of cases of MI	45	70	22	
Relative risk	1.00	0.67	0.57	0.05
95% CI	—	0.45–0.99	0.32–1.03	
25–74% of total alcohol intake consumed with meals				
No. of cases of MI	6	21	8	
Relative risk	1.00	0.78	0.51	0.28
95% CI	—	0.29–2.07	0.15–1.77	
≥75% of total alcohol intake consumed with meals				
No. of cases of MI	20	41	3	
Relative risk	1.00	0.92	0.33	0.16
95% CI	—	0.52–1.63	0.09–1.27	

* The analysis includes cases of myocardial infarction that occurred from 1994 to 1998. Multivariate relative risks were adjusted for the same variables listed in Table 2. Only subjects with information on the consumption of alcohol with meals are included.

† P values were derived from tests of linear trend across increasing categories of alcohol consumption by treating the midpoint of consumption in each category as a continuous variable.

incremental benefit. The inverse association between recent alcohol exposure and the risk of myocardial infarction,[6,18] though debated,[19] also offers evidence in support of a benefit of frequent consumption.

Studies differ on whether the drinking pattern modifies high-density lipoprotein cholesterol levels.[5,20,21] The drinking pattern does not clearly influence fibrinogen levels,[22] but it may have an important effect on blood pressure.[23-25] The Intersalt study found that a highly variable pattern of alcohol consumption predicted a high mean blood-pressure level among heavy drinkers, regardless of the amount of alcohol consumed in the 24 hours before measurement.[26] Likewise, platelet aggregability appears to be lower among moderate drinkers than among those who did not drink[27] but higher during withdrawal among heavy users of alcohol.[28]

When we used two methods of assessing alcohol consumption — at base line and updated every four years during follow-up — we found a stronger association with myocardial infarction for the updated reports. Because alcohol use changes over time, updating this information should improve the accuracy of assessment during the follow-up period, an important feature for exposures with short-term effects on risk.

We found the strongest associations between alcohol consumption and the risk of myocardial infarction for beer and liquor, the predominant types of alcoholic beverages consumed by this population. Our findings support the hypothesis that the beverage most widely consumed by a given population is the one most likely to be inversely associated with the risk of myocardial infarction in that population.[29] This may occur because heavily consumed beverages are more likely to be consumed frequently, as confirmed by their closer correlation with the frequency of drinking in our analyses. The fact that multivariate adjustment strengthened the inverse associations of myocardial infarction with beer and liquor but weakened the associations with red wine and white wine suggests that uncontrolled confounding may explain the greater benefits attributed to red wine in some studies.[30,31]

Few studies have assessed increases in alcohol consumption and the risk of myocardial infarction. In three studies, increased consumption over time was associated with a decrease in the risk of subsequent cardiovascular events of a magnitude similar to that in our study,[32-34] although one study found no significant difference in the rate of death from coronary or cardiovascular causes.[34] Since advising patients at high risk for myocardial infarction to drink moderately is controversial, the finding that a moderate increase in consumption over time appears beneficial may inform this debate.

Recent reviews suggest that alcohol consumption is mainly associated with a decreased risk of myocardial infarction among men over 45 years of age and women over 55 years of age.[35] We found that frequent drinking was associated with a decreased risk even among men 40 to 49 years of age who had previously had stable levels of consumption, implying that this association is not limited to adults over a specific age. However, the absolute benefits of moderate drinking will be most apparent among older adults at increased risk for myocardial infarction, whereas many of the risks of alcohol consumption, such as trauma, are of paramount concern for younger persons. For example, among the middle-aged healthy men in our study, the incidence of myocardial infarction among those who abstained was 420 cases per 100,000 person-years, yielding a difference in risk associated with frequent alcohol use of approximately 145 cases per 100,000 person-years. In younger populations

Table 6. Characteristics of 25,692 U.S. Male Health Professionals, According to Average Alcohol Consumption in 1986 and 1994.*

Characteristic†	Alcohol Consumption in 1986 and 1994‡								
	Light in 1986 and 1994 (N=8534)	Light in 1986 and Moderate in 1994 (N=1812)	Light in 1986 and Heavy in 1994 (N=53)	Moderate in 1986 and Light in 1994 (N=2626)	Moderate in 1986 and 1994 (N=8229)	Moderate in 1986 and Heavy in 1994 (N=1130)	Heavy in 1986 and Light in 1994 (N=248)	Heavy in 1986 and Moderate in 1994 (N=1143)	Heavy in 1986 and 1994 (N=1917)
Mean age at base line (yr)	52.3	50.9	53.4	53.2	52.4	52.9	53.4	54.4	54.2
Mean alcohol intake in 1986 (g/day)	1.5	2.9	2.3	10.1	13.5	18.0	47.5	42.2	47.9
Mean alcohol intake in 1994 (g/day)	1.1	9.9	42.0	2.1	13.9	41.1	0.7	18.5	48.7
Full-time or part-time work status in 1994 (%)	78	78	74	78	78	75	75	77	73
No physical examination within 2 yr preceding 1994 (%)	23	19	31	20	20	23	24	23	26
Physical examination for symptoms within 2 yr preceding 1994 (%)	16	14	12	16	14	12	21	15	13
Current smoker in 1994 (%)	4	4	18	7	5	11	15	10	16
Hypertension in 1994 (%)	19	20	27	22	20	25	31	25	26
Diabetes in 1994 (%)	4.2	2.1	4.7	3.7	2.0	2.0	7.1	3.2	2.6
Hypercholesterolemia in 1994 (%)	23	26	16	24	25	27	29	30	26
Aspirin use in 1994 (%)	29	36	32	31	36	42	34	37	38

* This subgroup of men in the Health Professionals Follow-up Study comprised men who reported their alcohol consumption in both 1986 and 1994 and who were free of cardiovascular disease and cancer at both time points.
† Except for age, all variables have been adjusted by direct standardization to the age distribution of the entire study population.
‡ Light, moderate, and heavy refer to an average daily consumption of less than 5.0, 5.0 to 29.9, and 30.0 or more g of alcohol, respectively.

at decreased risk for myocardial infarction, the difference in risk associated with frequent alcohol use would be smaller.

Although differences among participants in factors other than alcohol consumption could influence our findings, we found little additional confounding by diet, exercise, body-mass index, family history, aspirin use or nonuse, or the presence or absence of hypertension and diabetes after we controlled for age and smoking status, and our population was homogeneous, by design, with respect to occupational class and sex. In order to have produced these results, any uncontrolled confounder would need to be associated with both exposure and the outcome and unrelated to the covariates included. Our exclusion of former drinkers, the elimination of myocardial infarctions that occurred early in the follow-up period, and the similarity in risk among those who abstained and those who were very light drinkers argue against the "sick quitter" hypothesis[36] as an explanation for our findings.

Our ability to separate the associations of the quantity and the frequency of alcohol consumption with the risk of myocardial infarction was limited, because the two were correlated. Also, only 3.5 percent of study participants reported consumption of 50 g or more of alcohol daily, a fact that limited our ability to study the detrimental effects of heavy drinking.

National guidelines recommend caution when applying the results of epidemiologic studies of alcohol consumption to individual patients, since clinical care requires consideration of the myriad health effects of alcohol and of individual susceptibility to those effects.[35,37] We encourage adults to discuss alcohol use with their physicians and together make individualized decisions about appropriate consumption.

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REFERENCES

1. Rimm E. Alcohol and coronary heart disease: can we learn more? Epidemiology 2001;12:380-2.
2. Di Castelnuovo A, Rotondo S, Iacoviello L, Donati MB, De Gaetano G. Meta-analysis of wine and beer consumption in relation to vascular risk. Circulation 2002;105:2836-44.
3. Rimm EB, Klatsky A, Grobbee D, Stampfer MJ. Review of moderate alcohol consumption and reduced risk of coronary heart disease: is the effect due to beer, wine, or spirits? BMJ 1996;312:731-6.
4. Cleophas TJ. Wine, beer and spirits and the risk of myocardial infarction: a systematic review. Biomed Pharmacother 1999;53:417-23.
5. Gruchow HW, Hoffmann RG, Anderson AJ, Barboriak JJ. Effects of drinking patterns on the relationship between alcohol and coronary occlusion. Atherosclerosis 1982;43:393-404.
6. McElduff P, Dobson AJ. How much alcohol and how often? Population based case-control study of alcohol consumption and risk of a major coronary event. BMJ 1997;314:1159-64.
7. Kauhanen J, Kaplan GA, Goldberg DE, Salonen JT. Beer binging and mortality: results from the Kuopio ischaemic heart disease risk factor study, a prospective population based study. BMJ 1997;315:846-51.
8. Rimm EB, Giovannucci EL, Willett WC, et al. Prospective study of alcohol consumption and risk of coronary disease in men. Lancet 1991;338:464-8.
9. Nutrient Data Laboratory. USDA nutrient database for standard reference, release 13. Beltsville, Md.: Department of Agriculture, Agricultural Research Service, 1999. (Accessed November 15, 2002, at http://www.nal.usda.gov/fnic/foodcomp.)
10. Giovannucci E, Colditz G, Stampfer MJ, et al. The assessment of alcohol consumption by a simple self-administered questionnaire. Am J Epidemiol 1991;133:810-7.
11. Feskanich D, Rimm EB, Giovannucci EL, et al. Reproducibility and validity of food intake measurements from a semiquantitative food frequency questionnaire. J Am Diet Assoc 1993;93:790-6.
12. Rose GA, Blackburn H. Cardiovascular survey methods. WHO monograph series no. 58. Geneva: World Health Organization, 1982.
13. Stampfer MJ, Willett WC, Speizer FE, et al. Test of the National Death Index. Am J Epidemiol 1984;119:837-9.
14. D'Agostino RB, Lee ML, Belanger AJ, Cupples LA, Anderson K, Kannel WB. Relation of pooled logistic regression to time dependent Cox regression analysis: the Framingham Heart Study. Stat Med 1990;9:1501-15.
15. Shaper AG, Phillips AN, Pocock SJ, Walker M. Alcohol and ischaemic heart disease in middle aged British men. Br Med J (Clin Res Ed) 1987;294:733-7.
16. Rehm J, Greenfield TK, Rogers JD. Average volume of alcohol consumption, patterns of drinking, and all-cause mortality: results from the US National Alcohol Survey. Am J Epidemiol 2001;153:64-71.
17. Maclure M. Demonstration of deductive meta-analysis: ethanol intake and risk of myocardial infarction. Epidemiol Rev 1993;15:328-51.
18. Jackson R, Scragg R, Beaglehole R. Does recent alcohol consumption reduce the risk of acute myocardial infarction and coronary death in regular drinkers? Am J Epidemiol 1992;136:819-24.
19. Wouters S, Marshall R, Yee RL, Jackson R. Is the apparent cardioprotective effect of recent alcohol consumption due to confounding by prodromal symptoms? Am J Epidemiol 2000;151:1189-93.
20. Taskinen MR, Valimaki M, Nikkila EA, Kuusi T, Ylikahri R. Sequence of alcohol-induced initial changes in plasma lipoproteins (VLDL and HDL) and lipolytic enzymes in humans. Metabolism 1985;34:112-9.
21. Rakic V, Puddey IB, Dimmitt SB, Burke V, Beilin LJ. A controlled trial of the effects of pattern of alcohol intake on serum lipid levels in regular drinkers. Atherosclerosis 1998;137:243-52.
22. Dimmitt SB, Rakic V, Puddey IB, et al. The effects of alcohol on coagulation and fibrinolytic factors: a controlled trial. Blood Coagul Fibrinolysis 1998;9:39-45.
23. Wannamethee G, Shaper AG. Alcohol intake and variations in blood pressure by day of examination. J Hum Hypertens 1991;5:59-67.
24. Rakic V, Puddey IB, Burke V, Dimmitt SB, Beilin LJ. Influence of pattern of alcohol intake on blood pressure in regular drinkers: a controlled trial. J Hypertens 1998;16:165-74.
25. Abe H, Kawano Y, Kojima S, et al. Biphasic effects of repeated alcohol intake on 24-hour blood pressure in hypertensive patients. Circulation 1994;89:2626-33.
26. Marmot MG, Elliott P, Shipley MJ, et al. Alcohol and blood pressure: the INTERSALT study. BMJ 1994;308:1263-7.
27. Renaud SC, Beswick AD, Fehily AM, Sharp DS, Elwood PC. Alcohol and platelet aggregation: the Caerphilly Prospective Heart Disease Study. Am J Clin Nutr 1992;55:1012-7.
28. Mikhailidis DP, Barradas MA, Jeremy JY. The effect of ethanol on platelet function and vascular prostanoids. Alcohol 1990;7:171-80.
29. Rimm EB. Alcohol consumption and coronary heart disease: good habits may be more important than just good wine. Am J Epidemiol 1996;143:1094-8.
30. Mortensen EL, Jensen HH, Sanders SA, Reinisch JM. Better psychological functioning and higher social status may largely explain the apparent health benefits of wine: a study of wine and beer drinking in young Danish adults. Arch Intern Med 2001;161:1844-8.
31. Tjonneland A, Gronbaek M, Stripp C, Overvad K. Wine intake and diet in a random sample of 48763 Danish men and women. Am J Clin Nutr 1999;69:49-54.
32. Goldberg RJ, Burchfiel CM, Reed DM, Wergowske G, Chiu D. A prospective study of the health effects of alcohol consumption in middle-aged and elderly men: the Honolulu Heart Program. Circulation 1994;89:651-9.
33. Sesso HD, Stampfer MJ, Rosner B, Hennekens CH, Manson JE, Gaziano JM. Seven-year changes in alcohol consumption and subsequent risk of cardiovascular disease in men. Arch Intern Med 2000;160:2605-12.
34. Wannamethee SG, Shaper AG. Taking up regular drinking in middle age: effect on major coronary heart disease events and mortality. Heart 2002;87:32-6.
35. Nutrition and your health: dietary guidelines for Americans. 5th ed. Washington, D.C.: Department of Agriculture, 2000. (Home and garden bulletin no. 232.) (Accessed December 13, 2002, at http://www.usda.gov/cnpp/DietGd.pdf.)
36. Shaper AG, Wannamethee G, Walker M. Alcohol and mortality in British men: explaining the U-shaped curve. Lancet 1988;2:1267-73.
37. Alcohol & cancer. Atlanta: American Cancer Society, February 2002. (Accessed December 13, 2002, at http://www.cancer.org/downloads/PRO/alcohol.pdf.)