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Drinking Patterns and Body Mass Index in Never Smokers

National Health Interview Survey, 1997–2001

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Alcohol could contribute to obesity. The authors examined the relation between drinking patterns and body mass index (BMI) (weight (kg)/height (m)^2) by pooling cross-sectional data from the 1997–2001 National Health Interview Surveys. Weighted analyses included 45,896 adult never smokers who were current alcohol drinkers. Height and weight were self-reported. In adjusted analyses, alcohol quantity and frequency had opposite associations with BMI. As quantity increased from 1 drink/drinking day to ≥4 drinks/drinking day, BMI significantly increased; in men, it increased from 26.5 (95% confidence interval (CI): 26.3, 26.6) to 27.5 (95% CI: 27.4, 27.7), and in women, it increased from 25.1 (95% CI: 25.0, 25.2) to 25.9 (95% CI: 25.5, 26.3). As frequency increased from low quintiles of drinking days/year to high quintiles, BMI significantly decreased; in men, it decreased from 27.4 (95% CI: 27.2, 27.6) to 26.3 (95% CI: 26.2, 26.5), and in women, it decreased from 26.2 (95% CI: 26.0, 26.5) to 24.3 (95% CI: 24.2, 24.5). In stratified analyses of frequency trends within quantity categories, BMI declines were more pronounced in women than in men, but all linear trends were inverse and significant (p trend < 0.001). In all respondents combined, persons who consumed the smallest quantity the most frequently were leanest, and those who consumed the greatest quantity the least frequently were heaviest. Alcohol may contribute to excess body weight among certain drinkers.

alcohol drinking; body mass index; cross-sectional studies; health surveys; obesity

Abbreviations: BMI, body mass index; MET(s), metabolic equivalent(s); MSA, Metropolitan Statistical Area; NHIS, National Health Interview Survey.

An estimated 65 percent of Americans are overweight (body mass index (BMI) ≥25) or obese (BMI ≥30) (1). Excess body weight increases the risk of morbidity from numerous conditions, including hypertension, dyslipidemia, type 2 (non-insulin-dependent) diabetes mellitus, coronary heart disease, gallbladder disease, respiratory problems, osteoarthritis, and certain cancers (2). An estimated 51–67 percent of Americans consume alcoholic beverages (3–5). Ethanol, a source of dietary energy (6.9 kcal/g or 28.8 kJ/g) (6, 7), could contribute to excess body weight.

Although short-term laboratory studies suggest that alcohol consumption increases total energy intake, longer-term trials do not. In short-term studies, healthy volunteers who consumed approximately two drinks during or prior to a meal failed to compensate for the energy by eating less at the meal (8, 9); in fact, their dietary intake was greater. In longer-term 12- and 20-week trials (10, 11), free-living volunteers who consumed 1–2 drinks/day for 6 weeks and 10 weeks, respectively, followed by crossover to abstention (or vice versa), had no change in energy intake or body weight, which suggests that they substituted alcohol for food.

Epidemiologic studies of alcohol consumption and BMI or body weight (12–27) have had inconsistent results. Cross-sectional studies have shown positive (12–14, 21, 23), inverse (19), and null (15–19) associations in men and inverse (12–19, 21) and null (19) associations in women. Cohort studies have shown positive (20–22) and null (13, 17, 18, 24–26) associations in men, positive (21, 22), null (13, 18, 26), and inverse (17) associations in women, and null (27) associations in men and women combined. These

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studies generally defined alcohol intake as average volume, a measure that depends on two components: amount consumed (quantity) and how often consumption occurs (frequency).

Average volume may not fully explain important relations between quantity and frequency of drinking and health outcomes (28–30). In the medical literature, quantity and frequency have been differentially associated with myocardial infarction (31), diabetes (32), high blood pressure (33), and alcohol-related injuries (28). In previous research, we found that studying alcohol in terms of average volume obscured substantially different drinking patterns due to quantity alone or frequency alone (34).

The purpose of the present study was to examine the association between drinking patterns and BMI in a large, nationally representative sample of current drinkers who had never smoked cigarettes. The study was conducted in never smokers to avoid confounding by relations among drinking, smoking, and body weight (14, 16, 35).

MATERIALS AND METHODS

Survey

We pooled data from the 1997–2001 administrations of the National Health Interview Survey (NHIS). The NHIS is an annual, cross-sectional, nationally representative survey of the US noninstitutionalized civilian population that uses a complex, stratified, multistage probability design. Details on NHIS methods (36), including how to pool data from multiple survey years to increase sample size, are available at the NHIS website (http://www.cdc.gov/nchs/nhis/). In brief, the NHIS is conducted continuously throughout each survey year by the National Center for Health Statistics. Each year, data are collected from approximately 33,000 households containing approximately 106,000 persons of all ages; Blacks and Hispanics are oversampled. The Sample Adult Core Questionnaire is administered to one randomly selected adult (aged ≥18 years) from each family within a household; all information is self-reported. The Sample Adult Core Questionnaire includes questions (identical from year to year) on demographic factors, weight and height (without shoes), alcohol consumption, cigarette smoking, physical activity, and pregnancy status. We obtained limited data on daily intake of dietary fiber (grams) and fruits and vegetables (number of servings), as well as percentage of energy derived from total fat, from a Multifactor Dietary Screener in the 2000 NHIS Cancer Module (37); information on dietary intake was not available in 1997–1999 or 2001. NHIS response rates, computed as overall family response rate × sample person response rate, ranged from 69.6 percent (1999) to 80.4 percent (1997); the mean 5-year response rate was 74.0 percent.

Measures

Body mass index. BMI, our dependent variable, was calculated as weight in kilograms divided by height in meters squared.

Alcohol consumption. Alcohol consumption, the independent variable of interest, was determined using the following questions: "In any one year, have you had at least 12 drinks of any type of alcoholic beverage?" "In your entire life, have you had at least 12 drinks of any type of alcoholic beverage?" "In the past year, how often did you drink any type of alcoholic beverage?" "In the past year, on those days that you drank alcoholic beverages, on the average, how many drinks did you have?" Respondents who had consumed at least 12 drinks in any year or their entire life and one or more drinks in the past year were considered current drinkers.

Alcohol consumption was characterized using three variables. First, quantity (number of drinks consumed, on average, on drinking days) was categorized as 1, 2, 3, and ≥4 drinks/drinking day in initial analyses and as 1, 2, and ≥3 drinks/drinking day in stratified analyses. Second, frequency (number of drinking days in the past year) was defined as gender-specific quintiles. In men, quintiles of frequency approximated the following categories: quintile 1, 1–11 drinking days/year; quintile 2, 1–3 days/month; quintile 3, 1 day/week; quintile 4, 2 days/week; and quintile 5, 3–7 days/week. In women, quintiles of frequency approximated the following categories: quintile 1, 1–2 drinking days/year; quintile 2, 3–11 days/year; quintile 3, 1 day/month; quintile 4, 2–4 days/month; and quintile 5, 2–7 days/week. Third, average volume (quantity × frequency/365.25) was categorized as <1, 1, 2, and ≥3 drinks/day. We also created continuous forms of the three variables and log-transformed the data because of positive skewing.

Smoking. Smoking status was determined by asking, "Have you smoked at least 100 cigarettes in your entire life?" Respondents who replied "no" were classified as never smokers.

Covariates. Covariates included continuous age, race (non-Hispanic White, non-Hispanic Black, Hispanic, other), education (less than high school, high school graduation, some college, college graduation or more), marital status (married/cohabiting or not), leisure physical activity, US Census Metropolitan Statistical Area (MSA) (non-MSA, MSA), region (Northeast, Midwest, South, West), and continuous survey year. Leisure physical activity was assessed in terms of frequency and duration of light-to-moderate and vigorous activities, with intensity quantified in metabolic equivalents (METs) (38). For light-to-moderate activities, we assigned an intensity value of 4 METs/minute; for vigorous activities, 8 METs/minute (39). Five levels of leisure physical activity were created: none (referent) and quartiles of MET-minutes/week. For NHIS 2000 dietary data, percentage of energy derived from total fat intake was used as a continuous variable; intakes of fiber, fruits, and vegetables were used as log-transformed continuous variables.

Sample

A total of 165,057 respondents (71,377 men and 93,680 women) completed the 1997–2001 Sample Adult Core Questionnaire. We first excluded 1,948 pregnant women. Next, we excluded 74,582 current and former smokers and 1,452 respondents with unknown smoking status. This left us with 87,075 (32,516 men and 54,559 women) never smokers. Excluding smokers eliminated an important potential confounder and resulted in a more moderate-drinking sample (only 6.8 percent of never smokers consumed ≥5 drinks, on average, on drinking days, as compared with 20.3 percent of smokers). Finally, we excluded 40,021 nondrinkers and 1,158 respondents with unknown drinking status; this resulted in an analytic sample of 45,896 (20,976 men and 24,920 women) current-drinking never smokers. Excluding nondrinkers made it possible to explore dose-response relations between alcohol consumption and BMI.

Although the five survey years contained 20 quarters of data, consistent questions for physical activity were used only in the last 18 quarters. Thus, information on physical activity was considered missing for the first two quarters of 1997. Taking into account missing data for all variables in our multivariable models, we had complete data for 37,103 respondents (17,151 men and 19,952 women).

Statistical analyses

All analyses were performed using SUDAAN, version 8.0 (40), statistical software that takes survey stratification and clustering into account in computation of standard errors.

All analyses were weighted to produce nationally representative results. Analyses were performed in all respondents (current-drinking never smokers) combined and separately in men and women. Unadjusted mean values with standard errors were calculated for BMI according to demographic and lifestyle factors. Multiple linear regression (41) was used to obtain least-squares mean values with standard errors (40) for BMI within alcohol categories, both unadjusted and adjusted for covariates (age, race, education, marital status, leisure physical activity, MSA, region, and survey year (and dietary variables in NHIS 2000)). For multivariable analyses of frequency, we included continuous quantity as a covariate; for quantity, we included continuous frequency. For analyses of all respondents combined, we included gender as a covariate.

We tested the significance of differences in BMI within alcohol categories by *t* tests of beta coefficients comparing the lowest (referent) and highest categories. We also tested linear trends for BMI for each continuous consumption variable using adjusted multiple regression models. In addition, we tested the interaction of gender, continuous quantity, and continuous frequency using product terms in a hierarchical manner (41). Gender interactions were potentially important because of sex differences in alcohol metabolism (42). We began by testing the second-order interaction and moved successively to first-order interactions using reduced models excluding nonsignificant terms. For trends and interactions, we determined significance using *t* tests of beta coefficients. For all analyses, alpha was less than 0.05, two-tailed.

RESULTS

Sample description

The mean BMI of current-drinking never smokers was 26.1 (95 percent confidence interval: 26.0, 26.2). Non-drinking never smokers (excluded from the analyses a priori) had a mean BMI of 26.4 (95 percent confidence interval: 26.3, 26.5).

Current-drinking never smokers were evenly divided by gender; 76.3 percent were non-Hispanic Whites, and 35.7 percent had a college degree. Their mean age was 40.6 years. The mean number of drinking days per year was 58.1 (72.8 for men and 43.5 for women). The mean number of drinks consumed, on average, per drinking day was 2.1 (2.5 for men and 1.7 for women).

Table 1 presents mean BMIs according to selected covariates. BMI was higher ($p < 0.001$) in men versus women, in Blacks and Hispanics versus Whites, and in non-MSA respondents versus MSA respondents. BMI decreased with increasing education and leisure physical activity (p trend < 0.001). BMI increased with age and survey year (p trend < 0.001).

Multivariable models

Quantity. In all respondents combined, consumers of ≥4 drinks/drinking day had a significantly higher BMI than consumers of 1 drink/drinking day—a difference of 1.0 ($p < 0.001$) (table 2). In men, the difference was 1.1 ($p < 0.001$); in women, it was 0.8 ($p < 0.001$). In all respondents combined and in each gender, BMI increased as continuous quantity increased (p trend < 0.001).

Frequency. With the use of gender-specific quintiles, in all respondents combined, the most frequent drinkers (quintile 5) had a significantly lower BMI than the least frequent drinkers (quintile 1)—a difference of –1.5 ($p < 0.001$) (table 2). In men, the difference was –1.1 ($p < 0.001$); in women, it was –1.9 ($p < 0.001$). In all respondents combined and in each gender, BMI decreased as continuous frequency increased (p trend < 0.001).

Results for frequency remained inverse and significant ($p < 0.001$) in all respondents combined and in each gender when categories (<12, 12–51, 52–155, 156–259, and 260–365 drinking days/year) were studied instead of gender-specific quintiles.

Average volume. In all respondents combined and in men and women examined separately, respondents consuming an average volume of ≥3 drinks/day did not have a significantly different BMI than those consuming <1 drink/day (table 2). However, in all respondents combined and in each gender, BMI decreased as continuous average volume increased (p trend < 0.001).

Interaction. We examined interactions between gender, continuous quantity, and continuous frequency (41). The second-order interaction between gender, quantity, and frequency was not significant. When we tested first-order interactions, one significant finding emerged: a negative interaction between gender and frequency ($p < 0.001$) (gender × quantity and quantity × frequency were not significant). Quantity had a positive independent effect ($p < 0.001$); BMI increased as quantity increased.

TABLE 1. Mean body mass indices of never smokers who were current alcohol drinkers, according to selected characteristics, National Health Interview Surveys, 1997–2001

	Body mass index*					
	Total		Men		Women†	
	No.	Mean‡	No.	Mean	No.	Mean
All participants	42,579	26.1	19,709	26.8	22,870	25.3
Race						
White, non-Hispanic	29,481	25.9	13,510	26.8	15,971	25.1
Black, non-Hispanic	4,787	27.5	2,010	27.5	2,777	27.4
Hispanic	6,972	26.7	3,509	27.3	3,463	26.1
Other	1,339	24.5	680	25.4	659	23.3
Education						
Less than high school	4,623	27.3	2,289	27.3	2,334	27.3
High school graduation	9,973	26.8	4,403	27.3	5,570	26.2
Some college	13,136	26.2	5,831	27.0	7,305	25.5
College graduation or more	14,718	25.3	7,120	26.3	7,598	24.1
Married or cohabiting						
Yes	23,749	26.3	11,388	27.2	12,361	25.3
No	18,710	25.8	8,260	26.1	10,450	25.4
Leisure physical activity						
None	10,455	26.9	4,528	27.3	5,927	26.5
First quartile (low)	6,934	26.3	2,677	27.2	4,257	25.7
Second quartile	5,939	25.8	2,533	26.7	3,406	25.0
Third quartile	7,512	25.6	3,608	26.6	3,904	24.5
Fourth quartile (high)	6,898	25.7	4,140	26.5	2,758	24.3
MSA§						
Non-MSA	6,829	26.6	3,239	27.2	3,590	26.0
MSA	35,750	26.0	16,470	26.8	19,280	25.2
Region						
Northeast	8,350	26.0	3,784	26.8	4,566	25.2
Midwest	10,404	26.2	4,678	26.9	5,726	25.6
South	13,678	26.3	6,411	27.0	7,267	25.4
West	10,147	25.8	4,836	26.6	5,311	25.0
Survey year						
1997	9,285	25.8	4,207	26.6	5,078	25.0
1998	8,274	25.9	3,842	26.7	4,432	25.2
1999	7,839	26.2	3,619	27.0	4,220	25.4
2000	8,318	26.2	3,887	26.9	4,431	25.5
2001	8,863	26.3	4,154	27.0	4,709	25.6

* Weight (kg)/height (m)^2.
† Pregnant women were excluded.
‡ Mean values were weighted.
§ MSA, Metropolitan Statistical Area.

Stratified analyses

We performed stratified analyses of gender-specific frequency quintiles within quantity categories because frequency and quantity alone do not provide sufficient information about the relation between drinking patterns and BMI, and interactions are inherently difficult to interpret.

In all respondents and within each gender, in each quantity stratum, BMI was significantly lower among the most frequent drinkers (quintile 5) as compared with the least frequent drinkers (quintile 1) (p = 0.002 for women, p < 0.001 for men) (figure 1 and table 3). The largest reduction in BMI (quintile 5 – quintile 1, a difference of –2.2) was seen in women who consumed 1 drink/drinking day; the smallest

TABLE 2. Adjusted least-squares mean body mass indices of never smokers who were current alcohol drinkers, according to drinking patterns, National Health Interview Surveys, 1997–2001

	Body mass index*		
	No. of subjects	Mean†	95% CI‡
Quantity (average no. of drinks consumed on drinking days)			
All participants§			
1	16,223	25.8	25.7, 25.9
2	11,875	26.1	26.0, 26.2
3	4,600	26.5	26.3, 26.6
≥4	4,405	26.8	26.7, 27.0
Difference (≥4 – 1) and *p* value		1.0	<0.001
p for linear trend			<0.001
Men			
1	5,437	26.5	26.3, 26.6
2	5,661	26.8	26.7, 26.9
3	2,769	27.1	26.9, 27.3
≥4	3,284	27.5	27.4, 27.7
Difference (≥4 – 1) and *p* value		1.1	<0.001
p for linear trend			<0.001
Women			
1	10,786	25.1	25.0, 25.2
2	6,214	25.5	25.3, 25.6
3	1,831	25.9	25.6, 26.1
≥4	1,121	25.9	25.5, 26.3
Difference (≥4 – 1) and *p* value		0.8	<0.001
p for linear trend			<0.001
Frequency (no. of drinking days in the past year)			
All participants (gender-specific)			
Q‡1	6,402	26.8	26.7, 27.0
Q2	8,658	26.5	26.4, 26.7
Q3	7,730	26.2	26.0, 26.3
Q4	8,091	25.7	25.5, 25.8
Q5	6,222	25.3	25.2, 25.4
Difference (Q5 – Q1) and *p* value		–1.5	<0.001
p for linear trend			<0.001
Men			
Q1 (1–11/year)	3,143	27.4	27.2, 27.6
Q2 (1–3/month)	4,460	27.0	26.8, 27.1
Q3 (1/week)	4,091	26.8	26.7, 27.0

Table continues

TABLE 2. Continued

	Body mass index*		
	No. of subjects	Mean†	95% CI
Q4 (2/week)	2,500	26.7	26.5, 26.9
Q5 (3–7/week)	2,957	26.3	26.2, 26.5
Difference (Q5 – Q1) and *p* value		–1.1	<0.001
p for linear trend			<0.001
Women			
Q1 (1–2/year)	3,259	26.2	26.0, 26.5
Q2 (3–11/year)	4,198	26.1	26.0, 26.3
Q3 (1/month)	3,639	25.5	25.3, 25.7
Q4 (2–4/month)	5,591	24.8	24.7, 25.0
Q5 (2–7/week)	3,265	24.3	24.2, 24.5
Difference (Q5 – Q1) and *p* value		–1.9	<0.001
p for linear trend			<0.001
Average daily volume (quantity × frequency/365.25)			
All participants			
<1	28,726	26.2	26.1, 26.3
1	6,415	25.7	25.6, 25.9
2	1,227	26.0	25.7, 26.2
≥3	735	26.1	25.7, 26.4
Difference (≥3 – 1) and *p* value		–0.1	0.48
p for linear trend			<0.001
Men			
<1	11,397	26.9	26.8, 27.0
1	4,154	26.7	26.6, 26.8
2	956	26.9	26.6, 27.1
≥3	644	27.0	26.6, 27.4
Difference (≥3 – 1) and *p* value		0.1	0.59
p for linear trend			<0.001¶
Women			
<1	17,329	25.5	25.4, 25.6
1	2,261	24.6	24.4, 24.8
2	271	24.9	24.2, 25.5
≥3	91	24.9	23.9, 25.9
Difference (≥3 – 1) and *p* value		–0.6	0.25
p for linear trend			<0.001

* Weight (kg)/height $(m)^2$.
† Mean values were weighted and adjusted for age, race, education, marital status, leisure physical activity, Metropolitan Statistical Area, region, and survey year and as appropriate for quantity, frequency, and gender.
‡ CI, confidence interval; Q, quintile.
§ Pregnant women were excluded.
¶ Negative continuous linear trend.

reduction (–0.9) was seen in men who consumed ≥3 drinks/drinking day. All linear trends for frequency within each quantity stratum were negative and significant (*p* trend < 0.001). Examining linear trends in more detail, we observed that the decline in BMI with increasing frequency was more pronounced in women than in men. These findings are consistent with our earlier reported interaction between frequency and gender. In analyses of all respondents combined, the leanest persons (BMI = 24.9, 95 percent confidence interval: 24.7, 25.0) were those who consumed the smallest quantity the most frequently, while the heaviest persons (BMI = 27.2, 95 percent confidence interval: 26.8,

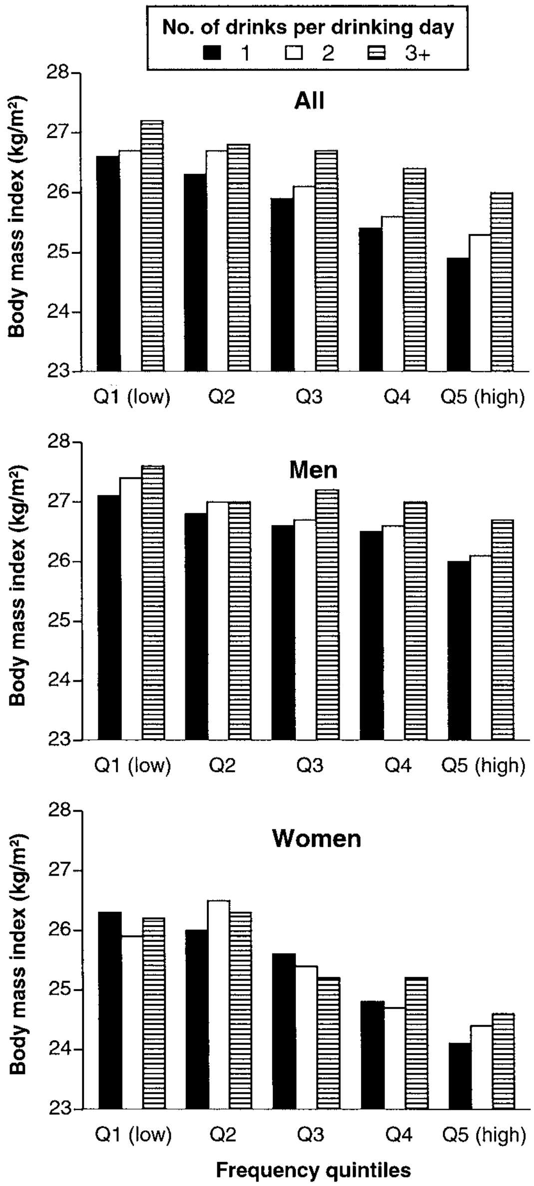

FIGURE 1. Association between alcohol consumption and body mass index (weight (kg)/height (m)^2) in stratified analyses of gender-specific frequency quintiles within quantity categories, National Health Interview Surveys, 1997–2001. Q, quintile.

27.6) were those who consumed the greatest quantity the least frequently—a difference of 2.4. Stratified results are presented in figure 1.

Additional analyses

Using data from NHIS 2000 (n = 7,507 current-drinking never smokers with complete data for all covariates), we added intake of dietary fiber, intake of fruits and vegetables, and percentage of energy derived from total fat to our multivariable models; results were unchanged. The quantity trend for BMI remained positive and significant (p trend < 0.001), the frequency trend remained negative and significant (p trend < 0.001), and the average volume trend remained negative and significant (p trend < 0.001). Interactions were not evaluated in our analysis of NHIS 2000 data.

DISCUSSION

In this study, we found strong independent associations between alcohol drinking patterns and BMI in a nationally representative sample of more than 37,000 current drinkers who had never smoked.

Men and women who consumed the smallest quantity of alcohol per drinking day had the lowest BMIs; those who consumed the greatest quantity had the highest BMIs. The positive association is biologically plausible, for several reasons. Alcohol is a source of dietary energy (6, 7). Alcohol drinking may stimulate food intake (8, 9). Ethanol is the least satiating dietary macronutrient (8). Liquids may fail to trigger physiologic satiety mechanisms (43–45), although the relation is complex, involving other factors such as timing of intake and social context (43). In short-term studies of healthy volunteers, persons who consumed approximately two drinks during or prior to a meal failed to compensate by reducing dietary intake at the next meal (8, 9). In one study (9), healthy volunteers consumed one half drink or two drinks before lunch; those who consumed two drinks had higher energy intakes at lunch and failed to compensate for the added energy obtained from alcohol or food by eating less at dinner. A positive association between alcohol quantity and BMI is also plausible from a behavioral perspective. Both drinking and eating are socially facilitated (46). De Castro (46) reported that the number of people present at a meal correlated positively with the quantity eaten. “Social correlation” was stronger when alcohol accompanied meals.

Men and women who consumed alcohol most frequently had the lowest BMI; those who consumed alcohol least frequently had the highest BMI. The association was stronger in women. Frequent drinkers may compensate for energy derived from ethanol by eating less. In longer-term 12- to 20-week trials (10, 11), free-living volunteers consumed two glasses of wine (approximately 200 kcal) (47) daily or abstained in a crossover design. The volunteers reported similar total energy intakes during wine treatment and abstention and maintained body weight throughout the study, suggesting (assuming reasonably valid dietary assessment) that they substituted alcohol for other dietary intake. Respondents with intermediate drinking frequencies may have been influenced to varying degrees by shorter-term effects of drinking, which may promote alcohol-related food consumption, and longer-term effects, which may promote dietary compensation.

A case could be made that the least frequent drinkers in our study drank so infrequently (1–11 days/year) that their BMI could not have been related to alcohol consumption. On the other hand, they may have been special-occasion drinkers who consumed additional food when they drank, perhaps because of social facilitation (46). Even infrequent alcohol-related overeating could lead to weight gain over time (48).

Results of our stratified analyses highlight the importance of carefully examining drinking patterns. When we exam-

TABLE 3. Adjusted least-squares mean body mass indices* of never smokers who were current alcohol drinkers, according to frequency of drinking within quantity categories, National Health Interview Surveys, 1997–2001

Frequency (no. of drinking days)	Quantity (no. of drinks consumed, on average, on drinking days)								
	1 drink/drinking day			2 drinks/drinking day			≥3 drinks/drinking day		
	No. of subjects	Mean†	95% CI‡	No. of subjects	Mean†	95% CI	No. of subjects	Mean†	95% CI
Men									
Q‡1 (1–11/year)	1,679	27.1	26.9, 27.4	827	27.4	27.1, 27.8	637	27.6	27.2, 28.0
Q2 (1–3/month)	1,487	26.8	26.6, 27.1	1,642	27.0	26.8, 27.2	1,331	27.0	26.7, 27.2
Q3 (1/week)	1,024	26.6	26.4, 26.9	1,272	26.7	26.5, 26.9	1,795	27.2	27.0, 27.4
Q4 (2/week)	410	26.5	26.1, 27.0	902	26.6	26.3, 26.9	1,188	27.0	26.8, 27.2
Q5 (3–7/week)	837	26.0	25.8, 26.3	1,018	26.1	25.9, 26.4	1,102	26.7	26.4, 26.9
Difference (Q5 – Q1) and *p* value		–1.1	<0.001		–1.3	<0.001		–0.9	<0.001
p for linear trend			<0.001			<0.001			<0.001
Women§									
Q1 (1–2/year)	2,365	26.3	26.1, 26.6	601	25.9	25.4, 26.3	293	26.2	25.3, 27.0
Q2 (3–11/year)	2,657	26.0	25.8, 26.2	1,095	26.5	26.1, 26.9	446	26.3	25.8, 26.9
Q3 (1/month)	2,083	25.6	25.3, 25.8	1,119	25.4	25.1, 25.8	437	25.2	24.7, 25.7
Q4 (2–4/month)	2,242	24.8	24.7, 25.0	2,189	24.7	24.4, 24.9	1,160	25.2	24.9, 25.5
Q5 (2–7/week)	1,439	24.1	23.9, 24.3	1,210	24.4	24.1, 24.6	616	24.6	24.3, 25.0
Difference (Q5 – Q1) and *p* value		–2.2	<0.001		–1.5	<0.001		–1.5	0.002
p for linear trend			<0.001			<0.001			<0.001

* Weight (kg)/height (m)^2.

† Mean values were weighted and adjusted for age, race, education, marital status, leisure physical activity, Metropolitan Statistical Area, region, and survey year.

‡ CI, confidence interval; Q, quintile.

§ Pregnant women were excluded.

ined frequency within quantity strata, the striking patterns shown in figure 1 emerged. Overall patterns were similar in both genders, but in gender-specific analyses the decrease in BMI with increasing frequency at each quantity stratum was more pronounced in women than in men. There are well-known gender differences in ethanol metabolism, and women typically drink less than men (42). However, the relation of these factors to BMI is unknown.

Previous studies of alcohol and body weight (12–27) generally examined only average volume. In our analyses of average volume, there were no significant differences between the highest and lowest categories of consumption in men or women. However, significant inverse linear trends were apparent when continuous data were considered, perhaps because of greater statistical power. Our average volume results are best compared with those from previous nationally representative surveys (16, 19). Gruchow et al. (19) found a significant inverse linear trend in men but no association in women in the First National Health and Nutrition Examination Survey, while Williamson et al. (16) found the opposite (no association in men but an inverse association in women) in data from the Behavioral Risk Factor Surveys. Comparisons between the three studies are limited by differences in inclusion criteria, interview modes, recall periods, measures of body weight, and referent groups. From our perspective, more important than reconciling differences between studies is the fact that average volume does not adequately explain the association between alcohol and BMI.

For decades, alcohol epidemiologists have been aware of the importance of drinking patterns (29). Average volume may obscure relations between the components of alcohol drinking (quantity and frequency) and health outcomes. A given average volume can be achieved through a number of different drinking patterns with biologic relevance. For example, an average volume of 2 drinks/day can be achieved by consuming two drinks every day, four drinks on 3–4 days/week, 14 drinks on 1 day/week, or 30 drinks on 2 days/month. The design of alcohol epidemiologic studies, from both measurement and analytic perspectives, should be guided by biologic considerations (28, 30). Our results suggest that drinking patterns, not average volume, should be evaluated when BMI is the outcome of interest.

Our study had several limitations. BMI was determined using self-reported height, which is generally overestimated, and self-reported weight, which is generally underestimated, especially at higher body weights (49). Analytic adjustment for diet and physical activity had virtually no effect on the findings. However, lifestyle cannot be completely ruled out as an explanatory factor, because the data, particularly the data on diet, were incomplete. Cause-and-effect cannot be inferred from our cross-sectional data. For example, the fact that more frequent drinking of lower quantity was associated with lower BMI does not mean that drinking caused the lower BMI.

Our study had several strengths. It was performed in a nationally representative sample of the US population. To our knowledge, ours is the first study that had a sample size sufficient to study drinking patterns and BMI in current-drinking never smokers. Although most investigators have considered smoking by adjustment or stratification (12–18, 20–27), imprecise measurement or unaccounted factors related to smoking could have resulted in residual confounding. The most practical way to avoid the problem of smoking-related confounding is to study current-drinking never smokers. Restricting analyses to never smokers resulted in a more moderate-drinking sample. This is important because studies in which participants consumed more than 25 percent of their total energy intake as ethanol (approximately six drinks or 625 kcal per day, assuming a 2,500-kcal/day diet) showed weight loss, possibly attributable to metabolism of alcohol by an alternate pathway, resulting in “energy wastage” (6, 50). Of greater relevance to our more moderate-drinking sample, a controlled feeding study of drinkers who consumed only 5 percent of total daily energy intake as ethanol (1–2 drinks) showed no energy wasting (6).

Is alcohol consumption contributing to obesity among individuals in the United States? It appears likely. In our study, some drinking patterns were associated with higher BMI while others were not. Alcohol may contribute to excess body weight in certain types of drinkers by serving as an energy source and by facilitating food consumption. Is alcohol consumption contributing to the high prevalence of obesity in the US population? It appears unlikely. Over the past 20 years, trends in US apparent per capita alcohol consumption and obesity have moved in opposite directions. Per capita alcohol consumption declined 22 percent between 1980 and 1999 (51), while the age-adjusted prevalence of obesity more than doubled between the second (1976–1980) and the 1999–2000 administrations of the National Health and Nutrition Examination Survey (1).

Alcohol is consumed by over half of US adults. In our study, drinking patterns were strongly associated with BMI, a finding of potential public health significance. Average volume, the summary measure of alcohol consumption commonly used in epidemiologic studies, obscured these results. Prospective studies are needed to determine whether certain drinking patterns constitute risk factors for overweight and obesity.

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