Fitness/Substance Abuse

Do Alcohol Consumers Exercise More? Findings From a National Survey

Michael T. French, PhD; Ioana Popovici, PhD; Johanna Catherine Maclean, MA

Abstract

Purpose. *Investigate the relationship between alcohol consumption and physical activity because understanding whether there are common determinants of health behaviors is critical in designing programs to change risky activities.*

Design. *Cross-sectional analysis.*

Setting. *United States.*

Subjects. *A sample of adults representative of the U.S. population (N = 230,856) from the 2005 Behavioral Risk Factor Surveillance System.*

Measures. *Several measures of drinking and exercise were analyzed. Specifications included numerous health, health behavior, socioeconomic, and demographic control variables.*

Results. *For women, current drinkers exercise 7.2 more minutes per week than abstainers. Ten extra drinks per month are associated with 2.2 extra minutes per week of physical activity. When compared with current abstainers, light, moderate, and heavy drinkers exercise 5.7, 10.1, and 19.9 more minutes per week. Drinking is associated with a 10.1 percentage point increase in the probability of exercising vigorously. Ten extra drinks per month are associated with a 2.0 percentage point increase in the probability of engaging in vigorous physical activity. Light, moderate, and heavy drinking are associated with 9.0, 14.3, and 13.7 percentage point increases in the probability of exercising vigorously. The estimation results for men are similar to those for women.*

Conclusions. *Our results strongly suggest that alcohol consumption and physical activity are positively correlated. The association persists at heavy drinking levels. (Am J Health Promot 2009;24[1]:2–10.)*

Key Words: Health Behavior, Lifestyle, Alcohol, Exercise, Health Consciousness, Sensation Seeking, Prevention Research. Manuscript format: research, Research purpose: modeling/relationship testing, Study design: nonexperimental, Outcome measure: physical activity, behavioral, Setting: state/national, Health focus: fitness/physical activity, Strategy: skill building/behavior change, Target population age: adult, Target population circumstances: education/income level and race/ethnicity

Michael T. French, PhD, and Ioana Popovici, PhD, are with the Department of Sociology, University of Miami, Coral Gables, Florida. Johanna Catherine Maclean, MA, is with the Department of Policy Analysis and Management, Cornell University, Ithaca, New York.

Send reprint requests to Michael T. French, PhD, Department of Sociology, Department of Epidemiology and Public Health, and Department of Economics, 5202 University Drive, Merrick Building, Room 121F, PO Box 248162, Coral Gables, FL 33124-2030; mfrench@miami.edu.

This manuscript was submitted January 10, 2008; revisions were requested March 25 and May 19, 2008; the manuscript was accepted for publication June 17, 2008.

Copyright © 2009 by American Journal of Health Promotion, Inc.
0890-1171/09/$5.00 + 0

PURPOSE

The epidemiologic literature has firmly established that certain lifestyle health-related choices are associated with an elevated risk of morbidity and mortality.[1–3] Excessive alcohol consumption, physical inactivity, smoking, and unhealthy dietary practices account for a large proportion of preventable chronic diseases and deaths in the United States. However, the precise association between these behaviors is still the subject of longstanding debate. There are reasons to believe that health behaviors may not be independent of each other. One view purports that individuals' motivation to prevent disease or improve health could cause the clustering of health behaviors.[4] In other words, health consciousness could lead an individual with a healthy lifestyle orientation (or an unhealthy tendency) to act similarly toward another health-related behavior. Demographic and socioeconomic characteristics might also lead to different health-related practices.[5] Biologic factors may be yet another influence on the clustering of health behaviors. For example, the co-occurrence of smoking and physical inactivity could be explained by the decline of lung function due to smoking.

Although research has found strong evidence for the association of smoking with a sedentary lifestyle,[6] unhealthy diet,[7] and excessive alcohol use,[8,9] there is considerable disagreement about the links among other health behaviors. Evidence of an association between physical activity and alcohol intake is inconclusive. Studies have found no association,[10–13] a positive relationship,[14–16] or a negative correlation.[17] Others have found very weak correlations[18] or evidence that seems to suggest that moderate drinkers are more likely to adopt physically active lifestyles.[19]

Lack of research consensus on the relationships between alcohol use and exercise could be due to a number of factors, including sample heterogeneity, inconsistent measures for alcohol

use, analysis methods used, and differential statistical powers. For example, although the majority of the published literature used dichotomous measures for alcohol consumption, there is great inconsistency in the categories used, as well as the cut-off points used to construct these. Drinking categories included heavy drinkers,[20–22] risky drinkers,[23,24] binge drinkers,[14] and most frequently light, moderate, and heavy drinkers.[19,25–27]

To provide new and more generalizable information on this important topic, the present study examined the association between drinking and physical activity in a nationally representative sample of the U.S. adult population. Both bivariate and multivariate statistical methods that control for several potentially confounding variables were applied. Moreover, the present analysis considers several different measures for alcohol consumption and physical activity.

METHODS

Design

The main objective of the present analysis was to determine whether the typical number of minutes of physical activity (moderate and vigorous*) in a usual week is significantly related to (1) any alcohol consumption, (2) total quantity/frequency of drinking, (3) drinking types (i.e., abstainer, light, moderate, and heavy), and (4) binge drinking. A secondary objective was to investigate whether alcohol consumption is significantly related to meeting the U.S. Surgeon General's recommendations for physical activity (i.e., $\geq$30 minutes of moderate exercise per day on $\geq$5 days per week or $\geq$20 minutes of vigorous exercise per day on $\geq$3 days per week).[28]

Sample

To investigate the association between alcohol consumption and physical activity, we employed individual-level data from the 2005 cross-section of the Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS is a large, annual, state-administered, cross-sectional telephone survey of the noninstitutionalized adult population. It is an ongoing data collection program designed to measure behavioral risk factors in the U.S. population, ages 18 years and older, living in households. The Centers for Disease Control and Prevention act in collaboration with the states to maintain the BRFSS. The main objective of the survey is to collect uniform, state-level data on preventive health practices and risk behaviors that are linked to chronic diseases, injuries, and preventable infectious diseases in the adult population. Respondents are identified through telephone-based methods. Overall, coverage ranges from 87% to 98% across states and varies for subgroups as well. For instance, individuals in lower socioeconomic groups or minorities have lower telephone coverage. The BRFSS employs poststratification weights to adjust for differences in the probability of selection and nonresponse, as well as noncoverage.

The 2005 cross-section of the BRFSS included 356,112 respondents. A large percentage (approximately 14%) of the respondents failed to report annual household income. We used gender-specific average values to impute the missing income values. We then deleted all observations with incomplete information (e.g., missing values for any of the other variables [except for income] used in our analysis). The analysis sample for the present study included 230,856 individuals between 21 and 65 years (inclusive). Elderly persons were excluded because there are significant changes in alcohol consumption and the level of physical activity once individuals enter typical retirement age. Respondents under age 21 years were excluded because possession of alcohol among persons under this age is illegal.

Measures

As mentioned above, the primary aim of the present study was to examine the association between physical activity (moderate and vigorous) and alcohol consumption.

Physical Activity Measures. To address this aim, the following core measures of physical activity were used: typical number of minutes of total (moderate and vigorous) exercise in a usual week, typical number of minutes of vigorous exercise in a usual week, and a dichotomous variable equal to one when respondents report engaging in any vigorous physical activities in a typical week. The typical numbers of minutes of exercise in a usual week are provided in the BRFSS data set. Their calculation is based on items in the questionnaire that ask respondents about the number of days per week and the total time per day spent exercising for at least 10 minutes at a time.

About half of the respondents in the sample reported that they typically did not engage in any vigorous physical activity. Thus, to account for the high prevalence of zero values in the dependent variable, we chose a two-part statistical model (described in the Analysis section) that warranted the construction of an additional measure of vigorous physical activity: a dichotomous variable equal to one if the respondent reported engaging in any vigorous exercise and zero otherwise.

The majority of studies examining the association between drinking and exercise used an alternative dichotomous variable: meeting the U.S. Surgeon General's recommendations for physical activity.[21–24,27,29] Nevertheless, we chose the continuous measures described above for our core analysis because we thought the results would provide a more detailed and informative picture of the association between drinking and physical activity.

However, we also followed the literature[21–24,27,29] and used a dichotomous variable equal to one if the respondent's reported level of exercise met the U.S. Surgeon General's recommendations for physical activity (i.e., $\geq$30 minutes of moderate exercise per day on $\geq$5 days per week or $\geq$20 minutes of vigorous exercise per day on $\geq$3 days per week) and zero otherwise. This measure was constructed in the BRFSS data set based on previously reported total time per day and number of days per week spent exercising.

Alcohol Use Measures. The explanatory variables of interest are measures of alcohol consumption. These correspond to the 30 days prior to interview date. We constructed three drinking variables for the core analysis.

First, because previous studies found that current drinkers and abstainers have distinct physical activity behaviors,[26,27] a measure for current drinking was set equal to one when the respondent indicated having at least one drink in the 30 days prior to the interview and zero otherwise.

Second, to assess the presence of a linear association between drinking and exercise, a continuous variable denoting the total number of alcoholic drinks consumed in the previous month was used next. The BRFSS calculated this measure according to respondents' answers to questions about the number of days per week when they had at least one drink and the average number of drinks they had on such days.

Third, previous studies have suggested that moderate drinkers exercise more than abstainers or other drinking categories.[19] To account for different relationships across the drinking continuum, we used the constructed measure of number of drinks and categorized the alcohol use data into four drinking categories: current abstainers (did not consume alcohol within the 30 days prior to interview date), current light drinkers (consumed 1–14 alcoholic drinks if female and 1–29 alcoholic drinks if male within the 30 days prior to interview date), current moderate drinkers (consumed 15–45 alcoholic drinks if female and 30–75 alcoholic drinks if male within the 30 days prior to interview date), and current heavy drinkers (consumed ≥ 46 alcoholic drinks if female and ≥ 76 alcoholic drinks if male within the 30 days prior to interview date). Several published studies that analyzed the clustering of different health risk behaviors[19,26,27] used similarly constructed drinking categories.

Finally, occasional binge drinking may affect exercise choices in a different way than regular moderate drinking, even though total consumption might be similar.[22] Thus, we included two alternative binge drinking measures to be used in sensitivity analyses. First, we used a continuous measure of the number of binge drinking episodes reported by the respondent (provided by the BRFSS). Second, based on this measure, we constructed a dichotomous variable indicating whether the respondent had at least one binge drinking episode per week in the 30 days before interview date. A binge drinking episode was defined as having five or more drinks on one occasion.

Control Variables. The BRFSS provides detailed socioeconomic and demographic information on respondents. Most studies examining the level of physical activity are adjusted for age.[10,16,30] Race and ethnicity have also been identified as important correlates in previous studies.[16,31] The present analysis included dichotomous indicators for race. Because adjustment for urbanization is conventional in the literature,[19] a binary measure of urbanization was included in the analysis. Education is a standard control variable within the literature,[19,30–37] and so educational attainment was characterized with three binary measures. Dichotomous measures of current employment and marital status were also entered as control variables.[19,23,31] Two measures of socioeconomic status (number of people in the household and total equivalent household income in the past year) were included. Current and past smoking status measures were entered into the models as indicators of risky behavior that could also impact physical activity.[20,38] Health indicators were included in all specifications because health limitations may influence an individual's ability to engage in physical activity.[19] Two binary variables captured health status as perceived by the respondents. In addition, we included a dichotomous variable equal to one when respondents reported that they are limited in any way in their activities because of physical, mental, or emotional problems and six dummy variables to capture the lifetime prevalence of various chronic health conditions that are often correlated with the level of physical activity: heart attack, angina, stroke, asthma, diabetes, and high blood pressure.

Analysis

We began with a bivariate analysis of the association between drinking and exercise. Given the non-normal distributions, we conducted nonparametric Kruskal-Wallis[39] rank-sum tests to identify statistically significant differences ($p < .05$) in physical activity measures across four alcohol use groups: current abstainers and light, moderate, and heavy drinkers. As with any bivariate analysis, finding statistically significant differences among groups could be the result of confounding factors. For example, certain chronic diseases could discourage respondents from drinking, as well as keep them from being physically active. To incorporate these potential confounders, we used multivariate regression analysis. Our empirical model took the following form.

$$Exercise = f(\alpha_0 + \alpha_1 Alcohol + X\alpha_2) \quad (1)$$

in which *Exercise* was a measure of moderate or vigorous physical activity, *Alcohol* denoted one of the alcohol consumption measures, X was a vector of exogenous control variables, and α_1 and α_2 were coefficient estimates. The function f was either linear or a probit, depending on whether the dependent variable, *Exercise*, was continuous or dichotomous. We ran all of the models separately for men and women because of gender differences in alcohol consumption and exercise.

We considered employing a two-part model to estimate the association between drinking and exercise. Two-part models are generally used to analyze continuous non-negative outcome measures with a large number of zero values. If many respondents reported no exercise in a usual week, we could first model the effect of drinking on the choice to engage in any exercise. The second part of the model would estimate the association between alcohol consumption and the typical number of minutes engaged in exercise during a week for those with a positive number of physical activity. Because only about 12% of the sample reported no moderate or vigorous exercise during a typical week, we decided against a two-part model for the aggregate measure of exercise.

Using the full sample, ordinary least squares (OLS) was employed to estimate models with the number of

minutes of total physical activity in a usual week as the dependent variable. Three specifications were estimated with the following alcohol consumption measures as the independent variables: (1) current drinker, (2) total number of alcoholic drinks consumed in the previous month, and (3) binary measures of light, moderate, and heavy drinking (with current abstainers as the comparison group).

Unlike the high prevalence rate for any physical activity, a large percentage of the respondents in the sample (56% for women and 42% for men) reported that they typically did not engage in vigorous physical activity. Therefore, as the zero values for this variable are too common to be ignored statistically, we estimated the effect of drinking on vigorous physical activity with a two-part model. First, we estimated probit regressions to determine the effect of alcohol consumption on the probability of engaging in any vigorous physical activity. In the second part of the model, we used OLS to estimate the effect of drinking on the number of minutes of vigorous physical activity in a usual week but only for respondents who reported exercising vigorously. We estimated three two-part models corresponding to each of the drinking measures/groups specified above.

The final statistical issue concerned the possible endogeneity of alcohol use. It is possible, for example, that variables correlated with both drinking and exercise are unintentionally omitted from the outcome equations or that alcohol use is directly influenced by physical activity (i.e., reverse causality). If one or both of these situations exist, then estimates generated from such models will be biased. One way to overcome this endogeneity problem is to employ an instrumental variables technique. We discuss our attempt to address this issue in the Results section.

RESULTS

Bivariate Analysis

Tables 1A (women) and 1B (men) present summary statistics for all variables used in the analysis. The means and standard deviations were computed using the BRFSS sampling weights so that the data are representative of the U.S. adult population. Because several authors have established gender differences in alcohol consumption[40,41] and levels of physical activity,[42] we conducted separate analyses for each gender.

Table 1A reports weighted variable means for 140,925 women by drinking category. All control variables revealed statistically significant differences ($p < .01$) in median values (Kruskal-Wallis[39] rank-sum tests) across the drinking groups. Of particular interest were the statistically significant differences in median values for physical activity measures across groups. The mean number of minutes of total physical activity in a usual week was 70.29 minutes for current abstainers, 78.30 minutes for light drinkers, 84.56 minutes for moderate drinkers, and 95.99 minutes for heavy drinkers. The same linear relationship was observed for the number of minutes of vigorous physical activity in a usual week.

Table 1B reports weighted variable means and standard deviations for 89,931 men by drinking category. Nonparametric Kruskal-Wallis[39] rank-sum tests showed statistically significant differences ($p < .01$) between drinking groups for all variables. The typical weekly number of minutes of total (vigorous) physical activity was 95.75 (38.11) minutes for current abstainers, 101.4 (43.44) minutes for light drinkers, 110.8 (46.47) minutes for moderate drinkers, and 128.4 (53.38) minutes for heavy drinkers.

Multivariate Analysis

Although we found significant differences in the typical weekly minutes of exercise between the drinking categories, these differences could be attenuated by confounding factors. Tables 2A (women) and 2B (men) present the results of the multivariate analyses. The estimates revealed that alcohol consumption was positively associated with total minutes of any physical activity in all specifications ($p < .01$). Reviewing Table 2A first, current female drinkers exercised about 7.2 more minutes per week on average compared with abstainers (approximately 10% of the mean weekly number of minutes of total physical activity for women). Viewed from a different angle, 10 extra drinks per month were associated with an average of 2.2 more minutes per week of total physical activity. When compared with current abstainers, light, moderate, and heavy drinkers exercised approximately 5.7, 10.1, and 19.9 minutes more per week (approximately 8%, 14%, and 27% of the mean weekly number of minutes of total physical activity for women), respectively. The results for vigorous physical activity for women indicated that drinking was associated with a 10.1 percentage point increase in the probability of exercising vigorously (about 23% of the mean probability of engaging in any vigorous exercise for women). Ten extra drinks per month was associated with a 2.0 percentage point increase in the probability of engaging in any vigorous physical activity. Light, moderate, and heavy drinking were associated with 9.0, 14.3, and 13.7 percentage point increases, respectively, in the probability of exercising vigorously (approximately 21%, 33%, and 31% of the mean probability of engaging in any vigorous exercise for women). However, when only women who exercised vigorously were taken into account (i.e., conditional on any vigorous exercise), the OLS coefficient estimates were not always statistically significant and some of the signs changed. These results suggest that although drinking was significantly related to the decision to exercise vigorously, conditional physical activity intensity was not correlated with alcohol consumption.

With a few exceptions, the estimation results for men were qualitatively identical to those for women. Turning to Table 2B, current drinking men exercised about 5.5 more minutes per week on average when compared with current abstainers (approximately 6% of the mean weekly number of minutes of total physical activity for men). Ten extra drinks per month was associated with an average of 1.1 more minutes per week of total physical activity. When compared with current abstainers, light, moderate, and heavy drinkers exercised approximately 2.2, 9.5, and 22.9 minutes more per week (approximately 2%, 10%, and 23% of the mean weekly number of minutes of total physical activity for men). The results for vigorous physical activity for men indicated that drinking was associated with a 5.9 percentage point

Table 1A

Mean Values for All Analysis Variables, Female Respondents, 21–64 Years

Variables	Current Abstainers† (n = 71,856)	Current Light Drinkers† (n = 50,431)	Current Moderate Drinkers† (n = 15,029)	Current Heavy Drinkers† (n = 3609)
Physical activity, past 30 d				
Weekly min of total physical activity‡*	70.29 (92.29)	78.30 (85.26)	84.56 (87.29)	95.99 (113.3)
Weekly min of vigorous physical activity*	21.71 (46.40)	27.74 (44.13)	32.57 (47.17)	34.77 (57.59)
Any vigorous physical activity, %*	37.40	52.49	59.01	55.28
Alcohol use, past 30 d				
Total number of alcoholic drinks consumed	—	4.65 (3.54)	24.67 (8.26)	84.08 (63.36)
Other explanatory variables				
Age, y*	42.45 (12.44)	40.91 (11.91)	41.26 (12.40)	41.70 (13.03)
Hispanic, %*	17.32	10.66	7.11	8.12
White, %*	74.17	83.19	88.71	85.12
African-American, %*	14.11	8.92	5.67	7.73
Asian, %*	3.09	2.24	1.61	1.57
Other nonwhite race, %*	8.63	5.65	4.01	5.58
Not in MSA, %*	21.37	15.01	13.04	17.80
Less than high school education, %*	14.31	4.65	3.63	6.73
High school education, %*	31.36	22.50	19.74	25.11
Some postsecondary education, %*	27.59	29.66	28.70	29.64
University education, %*	26.74	43.19	47.92	38.52
Currently employed, %*	58.26	72.41	73.21	70.06
Currently unemployed, %*	6.04	4.51	4.98	5.19
Currently out of the labor force, %*	35.70	23.08	21.81	24.75
Married or living as married, %*	68.38	69.43	65.43	56.20
Divorced/separated/widowed, %*	18.60	15.28	15.14	18.96
Never married, %*	13.02	15.29	19.43	24.83
Household size*	3.37 (1.66)	3.18 (1.46)	2.97 (1.43)	2.90 (1.70)
Equivalent household income (dollars)§*	9677 (15,179)	13,957 (20,171)	17,261 (23,101)	16,528 (22,625)
Excellent/very good self-reported health, %*	48.62	66.02	71.60	64.94
Good self-reported health, %*	31.20	25.33	22.44	24.52
Fair/poor self-reported health, %*	20.18	8.65	5.96	10.55
Activity limitation due to health problem, %*	20.93	13.72	11.85	15.29
Smoker, %*	18.98	19.11	27.52	43.34
Former smoker, %*	17.41	21.06	26.92	26.17
Heart attack, %*	2.40	1.08	0.59	1.69
Angina, %*	3.23	1.43	1.02	1.58
Stroke, %*	2.19	1.16	0.64	1.06
Asthma, %*	10.90	9.87	8.15	9.20
Diabetes, %*	8.68	3.28	1.80	2.14
High blood pressure, %*	23.69	15.73	14.20	18.22

MSA indicates metropolitan statistical area. Standard deviation are reported in parentheses for continuous variables.

† Current abstainer, woman who did not consume alcohol during the 30 days prior to the interview date; current light drinker, woman who consumed 1–14 alcoholic drinks during the 30 days prior to the interview date; current moderate drinker, woman who consumed 15–45 alcoholic drinks during the 30 days prior to the interview date; current heavy drinker, woman who consumed ≥46 alcoholic drinks during the 30 days prior to the interview date.

‡ Measure includes minutes of moderate and vigorous physical activity.

§ Household equivalent income was calculated using the Luxembourg income study measure of equivalent income: household income/(household size)^2.

* Statistically significant difference in variable medians across the alcohol use categories; $p < 0.01$, Kruskal-Wallis[39] equality of populations rank test.

increase in the probability of exercising vigorously (about 10% of the mean probability of engaging in any vigorous exercise for men). Ten extra drinks per month was associated with a 0.2 percentage point increase in the probability of engaging in any vigorous physical activity. Light, moderate, and heavy drinking were associated with 6.1, 6.7, and 4.7 percentage point increases in the probability of exercising vigorously (about 11%, 12%, and 8% of the mean probability of engaging in any vigorous exercise for men). When only men who exercised vigorously were taken into account (i.e., conditional minutes of vigorous exercise), the coefficient estimates de-

Table 1B

Mean Values for All Analysis Variables, Male Respondents, 21–64 Years

Variables	Current Abstainers† (n = 33,438)	Current Light Drinkers† (n = 39,922)	Current Moderate Drinkers† (n = 12,057)	Current Heavy Drinkers† (n = 4514)
Physical activity, past 30 d				
Weekly min of total physical activity‡*	95.75 (114.1)	101.4 (106.5)	110.8 (117.2)	128.4 (150.7)
Weekly min of vigorous physical activity*	38.11 (62.79)	43.44 (59.91)	46.47 (66.27)	53.38 (85.04)
Any vigorous physical activity, %*	52.10	64.80	65.04	59.23
Alcohol use, past 30 d				
Total number of alcoholic drinks consumed	—	9.64 (7.58)	44.71 (12.35)	147.3 (90.26)
Other explanatory variables				
Age, y*	42.96 (12.22)	40.91 (11.80)	40.86 (12.37)	39.46 (12.74)
Hispanic, %*	15.43	13.52	12.21	17.65
White, %*	74.01	80.79	85.18	78.55
African-American, %*	12.19	8.53	6.77	8.77
Asian, %*	4.45	3.43	1.64	1.36
Other nonwhite race, %*	9.35	7.24	6.41	11.33
Not in MSA, %*	21.47	15.10	16.18	18.62
Less than high school education, %*	12.95	7.49	7.09	14.49
High school education, %*	32.23	23.45	26.24	35.03
Some postsecondary education, %*	25.10	25.95	25.86	26.94
University education, %*	29.72	43.10	40.82	23.54
Currently employed, %*	75.69	85.31	84.83	79.35
Currently unemployed, %*	6.18	4.57	4.22	8.14
Currently out of the labor force, %*	18.14	10.12	10.94	12.52
Married or living as married, %*	70.68	72.55	67.44	56.16
Divorced/separated/widowed, %*	11.40	9.33	11.00	16.01
Never married, %*	17.92	18.12	21.56	27.82
Household size*	3.29 (1.71)	3.22 (1.52)	3.06 (1.46)	3.12 (1.60)
Equivalent household income (dollars)§*	11,763 (18,910)	15,348 (22,899)	17,392 (24,871)	14,478 (23,519)
Excellent/very good self-reported health, %*	49.61	63.68	62.01	51.52
Good self-reported health, %*	31.28	27.64	28.06	32.79
Fair/poor self-reported health, %*	19.11	8.68	9.93	15.69
Activity limitation due to health problem, %*	20.73	12.39	11.85	15.60
Smoker, %*	22.08	21.21	29.67	49.60
Former smoker, %*	23.99	23.65	29.28	22.87
Heart attack, %*	4.77	2.41	2.15	2.61
Angina, %*	4.63	2.89	2.46	3.08
Stroke, %*	2.17	1.00	1.19	1.25
Asthma, %*	5.73	5.23	5.13	5.82
Diabetes, %*	10.12	4.88	2.70	3.45
High blood pressure, %*	26.49	20.72	21.67	24.53

MSA indicates metropolitan statistical area. Standard deviation are reported in parentheses for continuous variables.

† Current abstainer, man who did not consume alcohol during the 30 days prior to the interview date; current light drinker, man who consumed 1–29 alcoholic drinks during the 30 days prior to the interview date; current moderate drinker, man who consumed 30–75 alcoholic drinks during the 30 days prior to the interview date; current heavy drinker, man who consumed ≥76 alcoholic drinks during the 30 days prior to the interview date.

‡ Measure includes minutes of moderate and vigorous physical activity.

§ Household equivalent income was calculated using the Luxembourg income study measure of equivalent income: household income/(household size)^2.

* Statistically significant difference in variable medians across the alcohol use categories; $p < 0.01$, Kruskal-Wallis[39] equality of populations rank test.

clined in magnitude, sometimes turned negative, and were not always statistically significant. Like with women, the association between drinking and vigorous physical activity worked primarily through participation in vigorous exercise rather than conditional intensity.

Sensitivity Tests

All of the models in Tables 2A and 2B were re-estimated with different subsets of control variables to examine

Table 2A

Selected Estimation Results for Average Weekly Minutes of Physical Activity, Women†

Explanatory Variables	Average Weekly Minutes of Total Physical Activity‡	Any Vigorous Physical Activity§	Conditional Average Weekly Minutes of Vigorous Physical Activity‡
N	140,925	140,925	61,638
Baseline mean	73.24	0.44	55.71
Current drinker	7.215* (1.171)	0.101* (0.006)	−1.251 (1.057)
Total number of alcoholic drinks	0.226* (0.050)	0.002* (0.0002)	0.054** (0.020)
Current light drinker	5.749* (0.954)	0.090* (0.005)	−2.074** (0.931)
Current moderate drinker	10.088* (0.954)	0.143* (0.009)	−0.062 (1.608)
Current heavy drinker	19.866* (5.323)	0.137* (0.025)	3.944 (2.433)

† Analyses used the sampling weights provided within the Behavioral Risk Factor Surveillance System. Standard errors corrected for clustering at the state level and are reported in parentheses. All specifications control for age, age^2, ethnicity, race, urbanicity, educational attainment, employment, marital status, health status, activity limitation due to health problems, smoking status, household size, household equivalent income, and six chronic conditions.
‡ Estimated with ordinary least squares.
§ Estimated with probit. Marginal effects are reported.
* Statistically significant at $p \leq 0.01$.
** Statistically significant at $p \leq 0.05$.

the robustness of our findings. The key coefficient estimates were similar in magnitudes, signs, and statistical significance under different specifications. Moreover, the results were robust even when controlling for body mass (i.e., dichotomous variables for overweight and underweight were included as controls, with normal weight as the reference group). We also re-estimated the models separately for two age subgroups, below and above 45 years. Again, results were consistent with the aggregate sample results. Because studies indicated that the probability of a physically active lifestyle increases from abstinence to moderate drinking but decreases with heavy drinking,[19] we estimated a quadratic model with the total number of alcoholic drinks and its square. Although the negative coefficient on the quadratic term indicated that the relationship between physical activity and alcohol consumption becomes negative at some point (the linear and quadratic terms are jointly significant [$p < .01$]), the turning point occurs at a very high value and sometimes outside the range of actual data. This result suggests a linear relationship between drinking and exercise over a plausible range of alcohol consumption.

We then re-estimated all models with the binge drinking measures described in Methods. The results indicated that women (men) who had at least one episode of binge drinking per week engaged in 17.0 (13.4) more minutes of total exercise (23% [14%] of the mean weekly number of minutes of total physical activity) and 10.0 (5.6) more minutes of vigorous exercise in a typical week (41% [14%] of the mean weekly number of minutes of vigorous physical activity). Also, an extra episode of binge drinking increased the number of minutes of total and vigorous physical activity per week for both women and men. All the results were statistically significant at $p < .01$.

Table 2B

Selected Estimation Results for Average Weekly Minutes of Physical Activity, Men†

Explanatory Variables	Average Weekly Minutes of Total Physical Activity‡	Any Vigorous Physical Activity§	Conditional Average Weekly Minutes of Vigorous Physical Activity‡
N	89,931	89,931	51,883
Baseline mean	99.70	0.58	70.31
Current drinker	5.537* (1.602)	0.059* (0.009)	−0.706 (1.195)
Total number of alcoholic drinks	0.111* (0.023)	0.0002 (0.0001)	0.072* (0.024)
Current light drinker	2.191 (2.052)	0.061* (0.007)	−2.299 (1.187)
Current moderate drinker	9.450* (1.602)	0.067* (0.015)	0.536 (1.553)
Current heavy drinker	22.925* (3.501)	0.047* (0.015)	11.774* (2.604)

† Analyses used the sampling weights provided within the Behavioral Risk Factor Surveillance System. Standard errors corrected for clustering at the state level and are reported in parentheses. All specifications control for age, age^2, ethnicity, race, urbanicity, educational attainment, employment, marital status, health status, activity limitation due to health problems, smoking status, household size, household equivalent income, and six chronic conditions.
‡ Estimated with ordinary least squares.
§ Estimated with probit. Marginal effects are reported.
* Statistically significant at $p \leq 0.01$.

Finally, we re-estimated our models with an alternative measure of our dependent variable (i.e., meeting the U.S. Surgeon General's recommendations for physical activity). Again, these results were consistent with our core models in that any amount of drinking, and particularly moderate or heavy drinking, was positively associated with meeting the Surgeon General's recommendations for exercise.

DISCUSSION

Although the exact relationship between exercise and drinking is ambiguous in the published literature,[18] there are reasons why physical inactivity and alcohol consumption might be positively correlated. Numerous studies in the literature have explored the clustering of health risk behaviors such as smoking, physical inactivity, unhealthy dietary practices, and heavy alcohol consumption, and have concluded that behavioral risk factors tend to concentrate within individuals. Health consciousness might encourage a person who is physically active to avoid heavy drinking as well.

Conversely, for some individuals, heavy drinking is part of a sensation-seeking lifestyle. Heavy drinkers scored high on sensation-seeking measures such as the Minnesota Multiphasic Personality Inventory[32] or Zuckerman Sensation-Seeking Scale.[33] Also, certain physical activities such as skiing, mountaineering, kayaking, or deep-sea diving are considered high-risk activities. It is possible to observe the co-occurrence of heavy drinking and high levels of physical exercise in risk-loving individuals who are predisposed to choose such sensation-seeking behaviors as part of a risk-taking lifestyle. A positive correlation between physical activity and alcohol consumption could also be the result of people socializing and drinking after participating in organized group sports. Moreover, individuals who drink heavily may engage in frequent physical exercise to compensate for the extra calories gained through drinking or to counterbalance the negative health effects of drinking. This would explain a surprising finding of several epidemiologic studies.[34–36] These studies recognized that calories from alcohol are added to the energy intake from other foods rather than substituted, but they found no evidence of a positive correlation between alcohol intake and body weight. It is plausible that the additional energy intake through alcohol is offset by the extra energy consumed through physical activity.

Although it is not possible to directly test any of the mechanisms noted above, our results provide evidence that, in a nationally representative sample of U.S. adults, alcohol consumption and physical activity are positively correlated for both women and men. Moreover, this association persists at moderate as well as heavy drinking levels. Finding that exercise and alcohol consumption are positively related contradicts the view that risk behaviors are clustered within individuals. On average, current heavy drinkers exercise about 10 more minutes per week than current moderate drinkers and about 20 more minutes per week than current abstainers. Given the extremely large analysis samples from the BRFSS, even relatively small coefficient estimates can sometimes be statistically different than zero. Indeed, some of the statistically significant estimates for the drinking variables in this study corresponded to small absolute differences in minutes of exercise, raising questions about practical significance. As presented in Results, however, what appeared to be relatively small absolute differences actually corresponded to fairly large percentage increases when they were compared with baseline mean values for weekly minutes of exercise.

In conclusion, these results point to a complex set of relationships between health behaviors that do not always follow expected patterns. Similar to an unhealthy diet and cigarette smoking, heavy drinking and physical inactivity are two behavioral practices that are strongly discouraged by health professionals because they significantly contribute to preventable chronic disease morbidity and mortality.[1–3] For the reasons discussed earlier, individuals may be making behavioral decisions based on aggregate risk rather than incremental risk. If this is the case, then perhaps health professionals and policy makers should consider aggregate risks as well as individual risks when they advise patients and formulate health promotion, disease prevention, and alcohol abuse programs.

Limitations

One potential limitation of the present study is the unknown reliability of self-reported data in the BRFSS, especially for measures such as alcohol consumption or physical activity. It is sometimes hypothesized that individuals tend to over-report exercise and under-report drinking.[43] Such measurement error, if present and systematic, could bias our estimates. Nevertheless, the standard measures of physical activity and alcohol consumption used in the BRFSS are thought to have high reliability.[25,44] A second limitation directly pertains to the exercise and drinking measures reported in the BRFSS data set. Namely, these health behaviors are reported only for the past 30 days instead of the past year or longer. If the past 30 days is atypical of drinking and/or exercise for some respondents and the measurement error is systematic, then our results could be biased. Although it is not possible to rigorously explore this possibility, we have no reasons to believe that any misreporting or atypical behavior is systematic across the drinking groups.

Another limitation is related to the interpretation of our findings. If alcohol use is strictly exogenous, our estimates represent unbiased and causal effects of alcohol consumption on physical activity. However, it is possible that alcohol use is endogenous in some specifications whereby key unobserved or unavailable explanatory variables in the exercise equations (e.g., motivation, discipline) are significantly correlated with the alcohol use measures. Moreover, alcohol use could be directly influenced by physical activity (i.e., reverse causality). In the absence of panel data (the BRFSS draws a new sample every year), we attempted to address this endogeneity issue by employing instrumental variables techniques.[45] The exhaustive list of possible instruments included state-specific alcohol taxes,[46] alcohol prices,[47] and alcohol policies.[48] Unfortunately, we were unable to find a common set of valid and reliable instrumental variables for all specifica-

tions. Thus, we cautiously view the reported findings as evidence of associations between alcohol use and exercise rather than causal effects.

SO WHAT? Implications for Health Promotion Practitioners and Researchers

The results of this study strongly suggest that alcohol consumption and exercise are positively associated and that this correlation persists even at heavy drinking levels, a finding that contradicts the view advanced by numerous previous studies that health risk behaviors tend to cluster within individuals. According to these studies, the correlation between different health behaviors point toward the development of complementary programs that can address overall lifestyle improvements. Moreover, they suggest that individuals with multiple risk behaviors could be identified by primary care clinicians by simply examining one behavioral risk factor.[49] In addition, health researchers are encouraged by the authors of these studies to conduct evaluations of interventions targeting clustered risk behaviors. In contrast, the findings of our study signal the need for independent strategies addressing specific behaviors. Clinicians and health promotion professionals should be cautious and consider this new knowledge when screening for health risk behaviors. For example, taking into account only the patients' levels of physical activity and perhaps diet would overlook potential alcohol use problems that could be detected and treated. Physically active individuals who engage in problematic drinking are often "healthy looking," because alcohol use consequences are sometimes delayed. This could lead to undetected alcohol-related problems with critical consequences for the individual, as well as negative externalities for society as a whole.

Footnote

*Moderate exercise denotes activities that cause small increases in breathing and heart rate (e.g., brisk walking, vacuuming, or gardening). Vigorous exercise denotes activities that cause large increases in breathing and heart rate (e.g., running, aerobics, or heavy yard work).

Acknowledgments

Financial assistance for this study was provided by the National Institute on Alcohol Abuse and Alcoholism (R01 AA015695 and R01 AA13167). The authors are entirely responsible for the research and results reported in this paper, and their position or opinions do not necessarily represent those of the University of Miami, Cornell University, or the National Institute on Alcohol Abuse and Alcoholism.

References

1. Davis MA, Neuhaus JM, Moritz DJ, et al. Health behaviors and survival among middle-aged and older men and women in the NHANES I Epidemiologic Follow-up Study. *Prev Med.* 1994;23:369–376.
2. McGinnis JM, Foege WH. Actual causes of death in the United States. *JAMA.* 1993;270:2207–2212.
3. Mokdad AH, Marks JS, Stroup DF, Gerberding JL. Actual causes of death in the United States, 2000. *JAMA.* 2004;291:1238–1245.
4. Taylor SE. *Health Psychology.* 5th ed. New York, NY: McGraw Hill; 2003.
5. Gottlieb NH, Green LW. Ethnicity and lifestyle health risk: some possible mechanisms. *Am J Health Promot.* 1987;2(summer):37–45.
6. Kvaavik E, Meyer HE, Tverdal A. Food habits, physical activity and body mass index in relation to smoking status in 40–42 year old Norwegian women and men. *Prev Med.* 2004;38:1–5.
7. Serdula MK, Byers T, Mokdad AH, et al. The association between fruit and vegetable intake and chronic disease risk factors. *Epidemiology.* 1996;7:161–165.
8. Bien TH, Burge R. Smoking and drinking: a review of the literature. *Int J Addict.* 1990;25:1429–1454.
9. Shiffman S, Balabanis M. Associations between alcohol and tobacco. In: Fertig JB, Allen JP, eds. *Alcohol and Tobacco: From Basic Science to Clinical Practice.* Bethesda, Md: National Institutes of Health; 1995:17–36.
10. Laaksonen M, Luoto R, Helakorpi S, Uutela A. Associations between health-related behaviors: a 7-year follow-up of adults. *Prev Med.* 2002;34:162–170.
11. Blair SN, Jacobs DR, Powell KE. Relationships between exercise or physical activity and other health behaviors. *Public Health Rep.* 1985;100:172–180.
12. Wankel LM, Sefton JM. Physical activity and other life style behaviors. In: Bouchard C, Shephard RJ, Stephens T, eds. *Physical Activity, Fitness, and Health: International Proceedings and Consensus Statement.* Champaign, Ill: Human Kinetics; 1994:530–550.
13. Haraldsdóttir J, Andersen LB. Dietary factors related to fitness in young men and women. *Prev Med.* 1994;23:490–497.
14. Dunn MS, Wang MQ. Effects of physical activity on substance use among college students. *Am J Health Studies.* 2003;18:126–132.
15. Gutgesell ME, Timmerman M, Keller A. Reported alcohol use and behavior in long-distance runners. *Med Sci Sports Exerc.* 1996;28:1063–1070.
16. Pate RR, Heath GW, Dowda M, Trost SG. Associations between physical activity and other health behaviors in a representative sample of US adolescents. *Am J Public Health.* 1996;86:1577–1581.
17. Raitakari OT, Leino M, Räikkönnen K, et al. Clustering of risk habits in young adults: the Cardiovascular Risk in Young Finns Study. *Am J Epidemiol.* 1995;142:36–43.
18. Newsom JT, McFarland BH, Kaplan MS, et al. The health consciousness myth: implications of the near independence of major health behaviors in the North American population. *Soc Sci Med.* 2005;60:433–437.
19. Smothers B, Bertolucci D. Alcohol consumption and health-promoting behavior in a U.S. household sample: leisure-time physical activity. *J Stud Alcohol.* 2001;62:467–476.
20. Laaksonen M, Prättälä R, Karisto A. Patterns of unhealthy behavior in Finland. *Eur J Public Health.* 2001;11:294–300.
21. Poortinga W. The prevalence and clustering of four major lifestyle risk factors in an English adult population. *Prev Med.* 2007;44:124–128.
22. Pronk NP, Anderson LH, Crain AL, et al. Meeting recommendations for multiple healthy lifestyle factors. Prevalence, clustering, and predictors among adolescent, adult, and senior health plan members. *Am J Prev Med.* 2004;27(2S):25–33.
23. Rosal MC, Ockene JK, Hurley TG, Reiff S. Prevalence and co-occurrence of health risk behaviors among high-risk drinkers in a primary care population. *Prev Med.* 2000;31:140–147.
24. Fine LJ, Philogene GS, Gramling R, et al. Prevalence of multiple chronic disease factors in the United States: results from the 2001 National Health Interview Survey. *Am J Prev Med.* 2004;27(2S):18–24.
25. Williams E, Klesges RC, Hanson CL, Eck LH. A prospective study of the reliability and convergent validity of three physical activity measures in a field research trial. *J Clin Epidemiol.* 1989;42:1161–1170.
26. Naimi TS, Brown DW, Brewer RD, et al. Cardiovascular risk factors and confounders among nondrinking and moderate-drinking U.S. adults. *Am J Prev Med.* 2005;28:369–373.
27. Mukamal KJ, Ding EL, Djoussé L. Alcohol consumption, physical activity, and chronic disease risk factors: a population-based cross-sectional survey. *BMC Public Health.* 2006;6:118.
28. *Physical Activity and Health: A Report of the Surgeon General.* Atlanta, Ga: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996.
29. Poortinga W. Do health behaviors mediate the association between social capital and health? *Prev Med.* 2006;43:488–493.
30. Westerterp KR, Meijer EP, Goris AHC, Kester ADM. Alcohol energy intake and habitual physical activity in older adults. *Br J Nutr.* 2004;91:149–152.
31. Johnson MF, Nichols JF, Sallis JF, et al. Interrelationships between physical activity and other health behaviors among university women and men. *Prev Med.* 1998;27:536–544.
32. Hathaway SR, McKinley JC. *The Minnesota Multiphasic Personality Inventory Manual* (revised). New York, NY: Psychological Corporation; 1951.
33. Zuckerman M. *Sensation Seeking: Beyond the Optimal Level of Arousal.* Hillsdale, NJ: Lawrence Erlbaum Associates Inc; 1979.
34. Williamson DF, Forman MR, Binkin NJ, et al. Alcohol and body weight in United States adults. *Am J Public Health.* 1987;77:1324–1330.
35. Gruchow HW, Sobocinski KA, Barboriac JJ, Sheller JG. Alcohol consumption, nutrient intake and relative body weight among US adults. *Am J Clin Nutr.* 1985;42:289–295.
36. Fisher M, Gordon T. The relation of drinking and smoking habits to diet: the Lipid Research Clinics Prevalence Study. *Am J Clin Nutr.* 1985;41:623–630.
37. Schneider D, Greenberg MR. Choice of exercise: a predictor of behavioral risks? *Res Q Exerc Sport.* 1992;63:231–237.
38. Burke V, Milligan RA, Beilin LJ, et al. Clustering of health-related behaviors among 18-year-old Australians. *Prev Med.* 1997;26:724–733.
39. Kruskal WH, Wallis WA. Use of ranks in one-criterion variance analysis. *J Am Stat Assoc.* 1952;47:583–621.
40. Dawson DA, Archer L. Gender differences in alcohol consumption: effects of measurement. *Br J Addict.* 1992;87:119–123.
41. Wilsnack RW, Vogeltanz ND, Wilsnack SC, Harris TR. Gender differences in alcohol consumption and adverse drinking consequences: cross-cultural patterns. *Addiction.* 2000;95:251–265.
42. Michaud PA, Jeannin A, Suris JC. Correlates of extracurricular sport participation among Swiss adolescents. *Eur J Pediatr.* 2006;165:546–555.
43. Midanik L. The validity of self-reported alcohol consumption and alcohol problems: a literature review. *Br J Addict.* 1982;77:357–382.
44. Hilton ME. A comparison of a prospective diary and two summary recall techniques for recording alcohol consumption. *Addiction.* 1989;84:1085–1092.
45. Greene William H. *Econometric Analysis.* 5th ed. Upper Saddle River, NJ: Prentice Hall; 2003.
46. The Beer Institute: Brewer's Almanac 2005. Available at: http://www.beerinstitute.org/statistics.asp?bid=200. Accessed August 7, 2007.
47. *ACCRA: Cost of Living Index.* Arlington, Va: Council for Community and Economic Research; 2004.
48. *Adams Liquor Handbook.* Norwalk, Conn: Adams Beverage Group; 2005.
49. Chiolero A, Wietlisbach V, Ruffieux C, et al. Clustering of risk behaviors with cigarette consumption: a population-based survey. *Prev Med.* 2006;42:348–353.

Copyright of American Journal of Health Promotion is the property of American Journal of Health Promotion and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.