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Analysis of NHANES 1999-2002 data reveals noteworthy association of alcohol consumption with obesity

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Abstract

Background With the obesity pandemic sweeping the globe and alcohol use on the rise worldwide, there is growing interest in how the two might be linked epidemiologically. The aim of the study was to use data from the NHANES registry from 1999-2002 to analyze the association between obesity and alcohol use.

Methods Multivariate logistic regression was used to assess the relationship between alcohol use and obesity. Risk was assessed separately for men and women.

Results Of the 9,193 individuals (49% males), 26.8% of males and 33.6% of females were obese. About 17% of males and 12% of females were never drinkers (less than 12 drinks in their lifetime). After adjusting for age, race, marital status, highest level of education of the individual and spouse, country of origin, annual household income and duration of physical activity in the past 30 days, the odds of obesity were higher in never drinkers compared to ever drinkers in both men and women. Consumption of alcohol for more than 45 days, binge drinking (>5 drinks/day) for more than 90 days and being "ever binge drinker" were associated with significantly higher odds of obesity (in both genders) than those who drank for shorter duration or were "never binge drinkers". Consumption of alcohol more than the recommended limit for moderate drinking (3 drinks/day in females and 4 drinks/day in males) was associated with increased (OR 1.074, 95% CI 1.072-1.076) and decreased (OR 0.970, 95%CI 0.968-0.972) obesity in females and males respectively.

Conclusion Frequent or heavy alcohol consumption is associated with greater odds of being obese.

Keywords Alcohol, obesity, binge drinking, demographic, education

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Introduction

Alcohol use has been linked to many acute and chronic diseases. With the obesity pandemic sweeping the globe, there is a keen interest in identifying the lifestyle factors that contribute to obesity. In turn, we can remedy unhealthy practices and encourage measures that promote healthy weight. Recently, studies in several countries have examined the impact of alcohol on obesity. In a study among 1,001 Cypriots for instance, alcohol consumption positively correlated and exercise negatively correlated with obesity [1]. Obesity is one of the components of metabolic syndrome (MetS) which has been linked to the development of non-alcoholic fatty liver disease [2]. Alcohol intake is also one of the significant risk factors for MetS [3]. Prior studies have shown that among individuals older than 60 years, increasing age was associated with a trend towards drinking less [4]. The goal of the present study was to investigate whether there was any association between alcohol consumption and obesity in the cohort of individuals included in the NHANES (National Health and Nutrition Examination Survey) between 1999 and 2002. The NHANES program started in the 1960's and is conducted by the National Center for Health Statistics (NCHS), a part of the Centers for Disease Control and Prevention (CDC). Each year, it examines a representative sample of about 5,000 individuals located across 15 different counties of the United States.

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Conflict of Interest: None

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Methods

The data from the NHANES survey 1999-2002 is available for public use from the website maintained by the CDC (http://www.cdc.gov/nchs/nhanes.htm). The subjects

are de-identified and given unique sequence numbers. CDC recommends that to obtain greater statistical reliability one should combine two or more 2-year cycles of continuous NHANES data. It also recommends using the four-year weights, created from the NHANES data during the period 1999-2002. The four-year sample weight is included with the public use data files for individuals included between 1999 and 2002 and this was used for weighing the variables. Mean and standard deviation were estimated for continuous data while frequency in the form of percentage was estimated for categorical data. Two-way ANOVA was used to compare continuous data while the Kruskal Wallis test was used to compare categorical data. Multinomial logistic regression was used to assess the contribution of demographic and socioeconomic factors in addition to alcohol use in the development of obesity. For logistic regression, continuous variables were transformed into categorical variables wherever needed. Age, annual household income, average duration of physical activity in the past 30 days, frequency of alcohol consumption (in days) in the past 12 months, average number of alcoholic drinks per day in the past 12 months and number of days of binge drinking in the preceding 12 months were the continuous variables categorized. A main effects model was used for multinomial regression analysis and forward stepwise method was employed for entering variables into the model. A threshold P-value of 0.05 was used for entry and 0.10 for removal of a variable when building the model in a forward stepwise manner. The -2 log likelihood ratio was compared before and after employing the predictor variables. The chi square statistic was used to measure the difference in likelihood that the regression coefficient for a given variable was "non-zero". The significance was expressed as the P-value.

Missing data was accounted for by including it as a separate variable in the calculations. Obesity was defined per the guidelines given by the CDC, available at http://www.cdc.gov/obesity/adult/defining.html. Thus, a body mass index (BMI) less than 18.5 was considered underweight, 18.5-24.9 healthy, 25.0-29.9 overweight and 30 or more obese. According to the National Institute on Alcohol Abuse and Alcoholism, men and women are at risk for alcohol-related health problems if their alcohol consumption exceeds 4 drinks or 3 drinks per day respectively. It also defines binge drinking as 5 or more drinks on a single day. This usually results in a blood alcohol level of 0.08 mg/dL or higher within 2 h. (http://www.niaaa.nih.gov/alcohol-health/overview-alcohol-consumption/moderate-binge-drinking). The duration of physical activity over the last 30 days was obtained by multiplying the number of days of physical activity in the last 30 days with average duration of physical activity each time in the same time period (recommended: at least 150 min per week or 600 min within a month (Reference: http://www.cdc.gov/physicalactivity/everyone/guidelines/adults.html).

These definitions were employed in the analysis of data in this study. All statistical analyses were carried out at the 5% level of significance using PASW Statistics 18.0 (SPSS, Hong Kong).

Results

Comparison of demographics, social factors and alcohol use between obese and non-obese individuals

A total of 9,193 individuals were available for analysis. Forty-nine percent were males. Among females, 3% were underweight (BMI <18.5), 35.2% were healthy weight (BMI 18.5-24.9), 27.9% were overweight (BMI 25-29.9) and 33.6% were obese (BMI ≥30). The corresponding percentages in males were 1.2%, 31.1%, 40.8% and 26.8%, respectively.

Individuals were divided into two groups, obese (BMI ≥30) and non-obese (BMI <30). Twenty-seven percent of males and 34% of females were obese. Table 1 compares the characteristics of obese vs. non-obese individuals. Obese individuals were significantly older than their non-obese counterparts (P<0.0001). Whites were the predominant ethnic group among both males and females. The proportion of blacks was higher among obese females (16% vs. 9% in non-obese) but similar in males (9.9% vs. 9.8%). Obese males had a higher proportion of individuals who were either married or living with a partner, had at least high school or higher education, had spouses with at least high school or higher education and had an annual household income of 20,000 US dollars or more. While non-

Table 1 Characteristics of obese vs. non-obese individuals

	Obese	Non-obese
Male (n=4,535)		
Age (years)[a]	46.6±15	43.4±16
Race or ethnicity*		
Non-Hispanic white	75.5%	71.4%
Non-Hispanic black	9.9%	9.8%
Mexican American	7.6%	8.1%
Other races	2.8%	3.9%
Percentage of never drinkers*,[b]	17%	12%
Percentage married or living with partner*	74.4%	65%
Percentage with at least high school education*	79%	78%
Percentage with spouse education at least high school or higher*	45%	38%
Percentage with annual household income >20,000$*	83.4%	82.7%
Female (N=4,658)		
Age (years)[a]	46.1±15	44.5±16.5
Race or ethnicity		
Non-Hispanic white	67%	74%
Non-Hispanic black	16%	9%
Mexican American	7%	6%
Other races	1.4%	5%
Percentage of never drinkers*,[b]	11.5%	8.9%
Percentage married or living with partner	60%	62%
Percentage with at least high school education*	77%	82%
Percentage with spouse education at least high school or higher	33%	38%
Percentage with annual household income >20,000$	76%	82%

*[a]P<0.0001 by one-way ANOVA; *P<0.001 by Kruskal Wallis test; [b]defined as less than 12 alcoholic drinks in their lifetime*

obese female reported a higher proportion of spouses with high school or higher level of education (82% vs. 77%), the other variables were comparable to that in the obese group.

Factors affecting odds of obesity in men and women

By regression analysis, we identified that alcohol use was an independent risk factor for obesity when adjusted for demographic factors (age, race, place of birth), socioeconomic factors (marital status, annual household income, level of education of the individual and their spouse and availability of emotional support) and physical activity. Overall, about 17% of males and 12% of females was never drinkers (i.e. consumed less than 12 alcoholic drinks in their lifetime). The impact of alcohol on obesity was assessed separately in males and females and is discussed below (Table 2 for males and Table 3 for females).

Age: The relationship between age and obesity was bimodal in both genders. Compared to those between 18 and 40 years of age, there were increased odds of obesity in those between 41 and 60 years. However, the odds of obesity decreased in those 61 years or older.

Race: Compared to whites, the odds of obesity were higher in black males and females [OR 2.04 (95% CI 2.04-2.05) and 1.71 (95% CI 1.70-1.71)]. The risk of obesity was also higher in Mexican Americans and other Hispanic races compared to whites. However, non-white, non-black, non-Hispanic individuals of either gender had significantly lower odds of being obese (OR 0.43 95% CI 0.42-0.43 for males and 0.39 95% CI 0.395-0.399 for females respectively, P<0.0001).

Country of origin: Compared to those born in the USA, the odds of obesity were lower in those born outside (either in Mexico or other countries) (Tables 2, 3). This was true for both males and females.

Marital status: The odds of being obese were lower among males who were widowed, divorced, separated or never married compared to those who were married or living with a partner (OR 0.99, 95% CI 0.996-0.999 P<0.0001). Among females, the opposite was true, i.e., odds of obesity was higher in divorced, separated or never married females (OR 1.029, 95% CI 1.028-1.030 P<0.0001).

Income: Odds of obesity were lower in those with an annual household income greater than 20,000 US dollars and this was true for both genders (OR 0.81, 95% CI 0.80-0.81 in males and 0.851, 95% CI 0.850-0.852 in females).

Level of education: Men who had at least high school or higher level of education had lower odds of being obese than those with a lower level of education (OR 0.896, 95% CI 0.894-0.897, P<0.0001). The converse was true for women (OR 1.038, 95% CI 1.036-1.039, P<0.0001).

The highest level of education of the spouse was negatively correlated with the odds of being obese in both males and females (correlation coefficient -0.11 and -0.16 in males and females respectively, P<0.0001).

Physical activity: Those who engaged in 600 min or more of physical activity in the past 30 days had a significantly lower odds of obesity compared to less active individuals (OR 0.83 95% CI 0.833-0.836 and 0.81 95% CI 0.806-0.808 in males and females respectively, P<0.0001).

Alcohol use: The odds of being obese were significantly increased if patients reported consuming at least 12 drinks of an alcoholic beverage in any given year.

When stratified by the frequency of alcohol consumption (number of drinking days in the past 12 months), females who consumed alcohol for up to 45 days in the past 12 months had lower odds of being obese than those who did not drink at all during this period (frequency=0). However, consumption of alcohol for longer than that (≥46 days) was associated with a significant increase in the odds of being obese (OR 2.7, 95% CI 2.70-2.75). Among males, drinking for longer than 30 days in the past 12 months was associated with a significant increase in the odds of being obese, with the odds increasing with an increase in the frequency of alcohol consumption (OR 2.79 for ≥46 days of drinking in the past 12 months, 95% CI 2.77-2.82).

Up to 3 drinks per day in females and 4 in males is considered moderate alcohol consumption. Consumption above the limit of moderate drinking was associated with a small but significant increase in the odds of obesity in females (OR 1.07, 95% CI 1.07-1.08) and decreased odds of obesity in males (OR 0.97, 95% CI 0.96-0.97).

Binge drinking (>5 alcoholic drinks/day) for longer than 90 days in the past 12 months was associated with significantly increased odds of obesity in both males and females. Further, those who responded with a "no" to the question "did you binge drink nearly every day at any time in your life" had significantly lower odds of being obese.

Availability of social support: The odds of being obese were significantly higher in those individuals who reported not having a social support system and this held true for both males and females (OR 1.11 95% CI 1.1-1.2 and 1.23 95% CI 1.23-1.24 in males and females respectively, P<0.0001).

Discussion

The goal of the present study was to investigate the influence of frequency of alcohol consumption in the past year and the frequency of binge drinking and daily consumption of alcoholic beverages on the odds of being obese separately in men and women. Overall, we found that ever drinkers (irrespective of gender), who consumed alcohol for longer than 45 days or engaged in binge drinking for more than 180 days in the past 12 months had higher odds of being obese. Those who answered "no" to the question of daily binge drinking at any point in their life had lower odds of being obese than those who answered "yes" to that question. The present study's results suggest that alcohol use is linked to BMI in a representative sample of US adults. Overall, about 27% of males and 34% females were obese as defined by a BMI of 30 or more.

Obesity, alcohol use and smoking are likely linked together and all three constitute unhealthy lifestyle practices. It is estimated that nearly 40 million Americans and 400 million

Table 2 Multinomial regression analysis of factors that affect obesity in males*, €, £

		Male		
	X^2 statistic[κ]	B[ɣ] (SE)	Adjusted OR (95% CI)	P-value
Age	1.01×10^5			
18-40 yrs		Reference		
41-60 yrs		0.042 (0.001)	1.043 (1.042-1.045)	<0.0001
61-80 yrs		−15.235 (0.000)	2.42×10^{-7} (2.42×10^{-7}-2.42×10^{-7})	-
≥81 yrs		−15.752 (0.003)	1.44×10^{-7} (1.43×10^{-7}-1.45×10^{-7})	<0.0001
Race	9.91×10^5			
Non-Hispanic white		Reference		
Non-Hispanic black		0.715 (0.001)	2.044 (2.040-2.048)	<0.0001
Mexican American		0.291 (0.002)	1.338 (1.333-1.342)	<0.0001
Other races including multiracial		−0.843 (0.003)	0.430 (0.428-0.433)	<0.0001
Other Hispanic		0.825 (0.001)	2.344 (2.338-2.350)	<0.0001
Country of origin	3.67×10^5			
USA		Reference	-	
Mexico		−0.350 (0.002)	0.705 (0.702-0.708)	<0.0001
Other countries		−0.758 (0.001)	0.469 (0.467-0.470)	<0.0001
Annual household income	7.67×10^4			
Less than 20,000 $		Reference	-	
More than 20,000$		−0.214 (0.001)	0.807 (0.806-0.809)	<0.0001
Marital status	4.91×10^3			
Married or living with partner		Reference	-	
Widowed, divorced, separated or never married		−0.002 (0.001)	0.998 (0.996-0.999)	0.005
Highest level of education of study subject	3.77×10^4			
Less than high school		Reference	-	
High school or higher		−0.110 (0.001)	0.896 (0.894-0.897)	<0.0001
Highest level of education of spouse	3.35×10^3			
Less than high school		Reference	-	
High school or higher		-0.040 (0.001)	0.960 (0.958-0.963)	<0.0001
Average duration of physical activity (in min) in past 30 days[c]	4.47×10^5			
1-599 min		Reference	-	
≥600 min		−0.181 (0.001)	0.834 (0.833-0.836)	<0.0001
Have you had at least 12 drinks of alcoholic beverage in any one year?	2.72×10^5			
Yes		Reference	-	
No		1.824 (0.004)	6.199 (6.149-6.250)	<0.0001
Have you had at least 12 alcoholic drinks in your lifetime?	1.28×10^5			
Yes		Reference	-	
No		1.399 (0.004)	4.053 (4.020-4.087)	<0.0001
Frequency of alcohol consumption in the past 12 months (in days)	7.45×10^4			
None		Reference	-	
1-15 days		0.066 (0.001)	1.068 (1.065-1.070)	<0.0001
16-30 days		−0.349 (0.003)	0.705 (0.700-0.710)	<0.0001
31-45 days		0.041 (0.011)	1.042 (1.021-1.064)	<0.0001
≥46 days		1.027 (0.004)	2.793 (2.770-2.817)	<0.0001
Average number of alcoholic drinks/day in the past 12 months	753.4			
Up to 4 drinks/day		Reference		
>4 drinks/day		−0.031 (0.001)	0.970 (0.968-0.972)	<0.0001
No. of days of binge drinking in past 12 months[a]	7.01×10^4			
0		Reference	-	
1-90 days		−0.062 (0.001)	0.940 (0.938-0.941)	<0.0001
91-180 days		0.514 (0.005)	1.671 (1.654-1.689)	<0.0001
181-365 days		1.055 (0.007)	2.871 (2.833-2.909)	<0.0001
Did you ever binge drink nearly every day at any time in your life?	882.3			
Yes		Reference	-	
No		−0.037 (0.001)	0.963 (0.961-0.966)	<0.0001
Anyone available to provide emotional support?	8.06×10^4			
Yes		Reference	-	
No		0.103 (0.004)	1.108 (1.100-1.116)	<0.0001
Don't need help		−1.073 (0.010)	0.342 (0.335-0.349)	<0.0001

**Reference group is non-obese; [€]for 1227 (43%) of cases, information on body mass index was missing. Hence, 1426 cases were included in the analysis; [£]the chi-square statistic for the model (comparing the -2 log likelihood ratio before and after the final step of the model) was 3.31×10^6 and the P-value was<0.0001 suggesting that the model was significantly improved by addition of the variables. The overall accuracy of the final model was 69.9%; [κ]this chi square statistic is the difference in -2 log likelihood ratios between the final model and a reduced model formed by omitting one variable from the final mode. The null hypothesis is that all parameters of that model are zero; [ɣ]this is the estimated multinomial regression coefficient; SE (standard error); OR (odds ratio); [a]defined as≥5 drinks/day; [c]obtained by multiplying the number of days of physical activity in the last 30 days with average duration of physical activity each time in the same time period (recommended: at least 150 min per week or 600 min in a month. Reference: http://www.cdc.gov/physicalactivity/everyone/guidelines/adults.html)*

Table 3 Multinomial regression analysis of factors that affect obesity in Females*, €, £

	Female			
	X^2 statistic[κ]	B (SE)	Adjusted OR (95% CI)	P-value
Age	6.15×10^5			<0.001
18-40 yrs		Reference	-	
41-60 yrs		0.25 (0.001)	1.294 (1.293-1.295)	<0.001
61-80 yrs		−1.36 (0.007)	0.257 (0.253-0.261)	<0.001
≥81 yrs		−2.51 (0.008)	0.082 (0.080-0.083)	<0.001
Race	1.24×10^6			<0.001
Non-Hispanic white		Reference	-	
Non-Hispanic black		0.53 (0.001)	1.709 (1.706-1.711)	<0.001
Mexican American		0.32 (0.001)	1.374 (1.371-1.378)	<0.001
Other races including multiracial		−0.93 (0.002)	0.397 (0.395-0.398)	<0.001
Other Hispanic		0.66 (0.001)	1.926 (1.921-930)	<0.001
Country of origin	5.79×10^5			<0.001
USA		Reference	-	
Mexico		−0.48 (0.002)	0.624 (0.622-0.626)	
Other countries		−0.75 (0.001)	0.473 (0.472-0.474)	
Annual household income	5.40×10^4			<0.001
Less than 20,000 $		Reference	-	
More than 20,000$		−0.16 (0.001)	0.851 (0.850-0.852)	<0.001
Marital status	4.43×10^3			<0.001
Married or living with partner		Reference	-	
Widowed, divorced, separated or never married		0.018 (0.001)	1.029 (1.028-1.030)	<0.001
Highest level of education of study subject	3.53×10^3			<0.001
Less than high school		Reference	-	
High school or higher		0.037 (0.001)	1.038 (1.036-1.039)	<0.001
Highest level of education of spouse	1.21×10^5			<0.001
Less than high school		Reference		
High school or higher		−0.354 (0.001)	0.702 (0.701-0.704)	<0.001
Average duration of physical activity (in min) in past 30 days[c]	7.93×10^5			<0.001
1-599 min		Reference		
≥600 min		−0.215 (0.001)	0.807 (0.806-0.808)	<0.001
Have you had at least 12 drinks of alcoholic beverage in any one year?	2.37×10^5			<0.001
Yes		Reference		
No		1.83 (0.004)	6.235 (6.185-6.286)	<0.001
Have you had at least 12 alcoholic drinks in your lifetime?	2.12×10^5			<0.001
Yes		Reference		
No		2.295 (0.005)	9.902 (9.800-10.006)	<0.001
Frequency of alcohol consumption in the past 12 months (in days)	8.75×10^4			<0.001
None		Reference		
1-15 days		0.041 (0.001)	1.042 (1.040-1.044)	<0.001
16-30 days		−0.447 (0.003)	0.639 (0.635-0.644)	<0.001
31-45 days		−0.523 (0.001)	0.592 (0.581-0.604)	<0.001
≥46 days		1.002 (0.004)	2.725 (2.702-2.748)	<0.001
Average number of alcoholic drinks/day in the past 12 months	6.29×10^3			<0.001
Up to 3 drinks/day		Reference	-	
>3 drinks/day		0.071 (0.001)	1.074 (1.072-1.076)	<0.001
No. of days of binge drinking in past 12 months[a]	1.67×10^5			<0.001
0		Reference	-	
1-90 days		−0.112 (0.001)	0.894 (0.893-0.896)	<0.001
91-180 days		0.400 (0.005)	1.491 (1.476-1.506)	<0.001
181-365 days		1.06 (0.007)	2.898 (2.860-2.937)	<0.001
Did you ever binge drink nearly every day at any time in your life?	2.86×104			<0.001
Yes		Reference		
No		−0.093 (0.001)	0.911 (0.909-0.913)	<0.001
Anyone available to provide emotional support?	6.66×104			<0.001
Yes		Reference		
No		0.210 (0.003)	1.234 (1.228-1.240)	<0.001
Don't need help		−0.538 (0.007)	0.584 (0.576-0.592)	<0.001

**Reference group is non-obese; [€]for 2242 (43%) of cases, information on body mass index was missing. Hence, 2607 cases were included in the analysis;. [£]the chi-square statistic for the model (comparing the -2 log likelihood ratio before and after the final step of the model) was 5.58X10[6] and the P value was<0.0001 suggesting that the model was significantly improved by addition of the variables. The overall accuracy of the final model was 67.6%; %. [κ]this Chi square statistic is the difference in -2 log likelihood ratios between the final model and a reduced model formed by omitting one variable from the final mode. The null hypothesis is that all parameters of that model are zero; [ɣ]this is the estimated multinomial regression coefficient; SE (standard error); O.R. (odds ratio);. [a]defined as ≥5 drinks/day; [c]obtained by multiplying the number of days of physical activity in the last 30 days with average duration of physical activity each time in the same time period (recommended: at least 150 min per week or 600 min in a month. Reference: http://www.cdc.gov/physicalactivity/everyone/guidelines/adults.html)*

people worldwide are obese. Worldwide, obesity, excessive alcohol consumption and viral hepatitis are the three leading causes of chronic liver disease [5]. Obesity is associated with increase in both healthcare expenses and incidence of co-morbidities including malignancies. In one study, moderate (BMI 30-35) and morbid obesity (BMI >35) were associated with a 11% and 23% increase in annual health care expenditure in 40-50-year-old adults (compared to those with BMI <30). The increase in expenditure was even higher in those between 54-69 years old (21% and 51% respectively). However, neither obesity nor heavy alcohol consumption was independently associated with healthcare expenditure [6]. Alcohol and obesity have been shown to work synergistically to increase the risk of hepatocellular carcinoma in at least one study after adjusting for age, gender, smoking habit, liver enzymes, hepatitis B and C status and diabetes [7].

The results of our study corroborate previous studies by Flores and Arif among others [8,9]. Flores and co-workers found that the incidence of obesity was higher in Mexican American men and women. They had also noted that Mexican American men (but not women) were more likely to be heavy or binge drinkers of alcohol [8]. Arif and Rohrer reported that current drinkers had lower odds of obesity. Similar to our observation, they reported that the odds of obesity were higher in binge drinkers than non-binge drinkers. Overall (males and females combined), the odds of obesity was lower in those who consumed 1-2 alcoholic drinks daily compared to those with higher daily alcohol consumption [9].

The relationship between binge drinking and obesity has been previously investigated from different angles. In one study among young men aged 12-18 years, it was found that those who had concerns about being muscular were more likely to use supplements and other products to enhance their physique and also to binge drink frequently [10]. In another, it was found that women (but not men) who felt that they needed to lose weight had a greater tendency to indulge in binge drinking [11]. In a study among young college enrolled Mexican American women (mean age 19.4±1.4 years), it was found that alcohol use (including heavy alcohol use) was not related to disorders of eating (either binge eating, purging, diet restriction, fasting or excessive exercise) or to BMI. The only factors that significantly predicted BMI were calorie restriction, binge eating and tobacco use [12]. In a review article, Yeomans discuss how in the short-term alcohol consumption before or with meals increases food intake, probably by stimulating the rewarding effects of food. However, at the same time, moderate alcohol consumption is associated with a lower risk of obesity particularly in women [13]. We noted too that women who consumed more than 3 drinks a day (recommended limit for moderate alcohol consumption) had higher odds of obesity.

Alcohol use has also been linked to stress, particularly that associated with occupation. For instance, in one study among firefighters, participants in departmental wellness programs had a lower incidence of obesity and better physical fitness than those without such programs. However, both groups had a higher prevalence of binge drinking suggesting the possible influence of the high-stress environment that the firemen work in [14]. Jezewska, in another article, discussed how excessive consumption of processed foods, alcohol and fat and disorders of eating (such as binge drinking), coupled with decreased physical activity and increased stress promote obesity among seafarers [15]. Long-work hours can place significant physical stress on the body. In a study among Korean adult workers, Jang and colleagues noted that male manual workers (but not non-manual workers or females) who worked longer than 60 h per week had higher odds of being obese (OR 1.65, 95% CI 1.26-2.15)[16]. Psychological disorders can influence appetite and promote alcohol consumption and therefore influence obesity. In a study of over 20,000 patients with post-traumatic stress disorder (PTSD) in the United States, it was found that after adjusting for other factors including alcohol use, PTSD was an independent predictor of obesity [17]. Social support is well known as an important component of treatment of psychological illnesses. It is possible that psychological disorders like stress, peer pressure and depression among others influence eating, drinking and physical activity and in turn promote obesity. For instance, a study among over 700,000 non-pregnant women aged between 18-44 years living in the United States found that compared to the period from 2003-2006, there was an increase in the incidence of binge drinking and associated co-morbidities (including obesity, hypertension and diabetes mellitus) between 2007 and 2010. This was despite there being overall improvements in any alcohol use and intensity of physical activity [18]. There is a growing concern that today's youth are spending more and more time indoors watching television and playing video games. A study of 12-19-year-olds in Canada found that watching frequent television was associated with a significant increase in the odds of getting obese (adjusted OR 1.10). However it was associated with lower odds of binge alcohol drinking and alcohol dependence [19].

Population studies investigating the relationship between obesity and alcohol use in non-US populations have been few. Lee reported in an analysis of the Korean NHANES IV data that there were gender-specific associations between alcohol consumption and the occurrence of MetS. He noted that the odds of MetS were significantly higher in men who consumed ≥7 alcoholic drinks on a typical occasion. For women, the corresponding number of drinks was ≥3. Binge drinking for one week or longer resulted in significantly higher odds of MetS in both genders when compared to men and women who consumed 1 or 2 drinks and did not indulge in binge drinking. Men with hypertension and abdominal obesity and women with hyperglycemia were more likely to engage in binge drinking. Notably, there was no significant association between the frequency of alcohol consumption and prevalence of MetS in this cohort [20]. In another study among Italian subjects aged between 50-74 years aimed primarily to investigate the role of psychological problems with obesity, it was found that BMI was associated with age, education, socioeconomic status and smoking in both genders. However, psychological factors influencing obesity differed between men and women [21].

Obesity is the net result of an imbalance between calorie consumption and utilization. The CDC recommends at least 150 min of physical activity in a week (or 600 min a month). We noted that individuals who engaged in 600 min or longer duration of physical activity in a month had 20-30% lower odds of obesity. We hypothesize that the low likelihood of getting the recommended amount of daily physical activity together with the higher frequency of alcohol consumption and binge drinking over the course of the last year contributed to obesity in these individuals.

Alcohol use and obesity are social diseases. In one study, obesity and its associated diseases accounted for nearly 16% of all health costs while alcohol use and its associated health problems accounted for 26% of all national health costs in the NHS in the UK for the years 2006-2007 [22]. Further, being obese has previously been linked to reduced health-related quality of life [23]. Social support is also known to be key to treating alcohol abuse [34]. We noticed that being a Mexican American or black was a risk factor for obesity in both genders. Further, reporting the lack of someone to provide emotional support was also associated with greater odds of obesity in both genders. It is well known that there are racial differences in the relative importance given to exercise and social acceptance of alcohol use. Cultural and dietary factors could play a role too as individuals who were born outside USA were less likely to be obese. A strong social support mechanism would provide the much needed encouragement and emotional support needed to promote alcohol cessation and adopt other healthy measures like exercise and healthy dietary practices and thus decrease the risk of obesity.

Marital status emerged as a key determinant of obesity as being divorced, widowed or separated was an independent risk factor for obesity in women while married women tend to be more obese. Our observations support previous studies that report that married men are more likely to be obese [26,27]. Being unmarried, male and overweight or obese has been reported to be associated with a higher risk of pre-hypertension among Ugandan adults of 40 years and over [28]. In another study however, female gender and age between 60 and 69 years, but not marital status, level of education or wealth were significantly associated with risk factors for non-communicable diseases (including alcohol use and overweight/obesity) [29]. In a study of 13,889 Scottish men and women without a prior history of cardiovascular disease, Molloy and colleagues found that the risk of cardiovascular mortality was highest in never married men and separated/divorced women compared to those who were married. They concluded that health behavior (including alcohol use and physical activity), psychological stress and metabolic dysregulation (including obesity, hypertension and diabetes) interact in a complex way to contribute to the relationship between cardiovascular disease and unmarried state in this cohort [30].

An annual household income of more than 20,000 dollars was associated with lower odds of obesity in both men and women. This could be due to greater awareness or motivation to engage in healthy activities, including exercise, potentially contributing to lower incidence of obesity in well to do families. In a study among 13,262 Italian subjects, it was noted that those in the higher income group were more likely to adhere to a Mediterranean diet comprising vegetables and olive oil and thus less likely to be obese (20% compared to 36% in the lower income group, $P<0.0001$) [32]. In another study, the prevalence of obesity was higher among women (but not men) in the lower income group [33].

From the preceding discussion it is apparent that the interplay of alcohol and obesity is complex and in many situations gender specific. The next question that comes to mind is: how do we tackle the problem? Apart from counseling and social support, pharmacologic measures that treat alcohol dependence and curb appetite are being investigated. Promising targets include agonists of the gamma amino butyric acid system like naloxone and naltrexone and baclofen; pharmacologic measures to control binge eating have been reviewed previously [35].

Like any retrospective study that relies on questionnaires, the NHANES too has unavoidable pitfalls, particularly recall bias. Further, the NHANES results cannot be directly applied to people outside the USA due to the same socioeconomic and cultural differences that emerged as predictors of obesity in our analysis. Despite this, as numerous studies have shown, population registries like NHANES allow us an important cumulative view of factors influencing health that can be extrapolated to the general population.

In conclusion, obesity appears to be significantly associated with the pattern and duration of alcohol use in both genders. In general, the odds of obesity were higher in

Summary Box

What is already known:

- Alcohol use and obesity together with smoking comprise unhealthy lifestyle practices
- Binge drinking is associated with higher incidence of obesity
- Compared to those who drink more, those consuming 1-2 alcoholic drinks daily have a lower incidence of obesity

What the new findings are:

- Never users of alcohol have higher odds of being obese than ever users and this is true for both males and females
- Consumption of alcoholic drinks for more than 45 days in the past 12 months, or binge drinking for longer than 90 days is associated with higher odds of obesity in both males and females
- Drinking above the recommended limit of moderate alcohol consumption (i.e. >3 drinks/day in females or >4 drinks/day in males) is associated with increased odds of obesity in females but lower odds in males

never drinkers of both genders. Among ever drinkers, the odds of obesity were higher in individuals of either gender who consumed alcohol for longer than 45 days in the past 12 months. "Ever binge drinkers" had a significantly higher odds of being obese than "never binge drinkers". Binge drinking for longer than 90 days in the preceding 12 months was associated with significant odds of obesity. Drinking above the recommended limit for moderate alcohol consumption led to lower odds of obesity in males but higher odds in females.

References

1. Andreou E, Hajigeorgiou P, Kyriakou K, et al. Risk factors of obesity in a cohort of 1001 Cypriot adults: An epidemiological study. *Hippokratia* 2012;**16**:256-260.
2. Wang Y, Li YY, Nie YQ, et al. Association between metabolic syndrome and the development of non-alcoholic fatty liver disease. *Exp Ther Med* 2013;**6**:77-84.
3. Garcia-Cruz E, Leibar-Tamayo A, Romero J, et al. Metabolic syndrome in men with low testosterone levels: relationship with cardiovascular risk factors and comorbidities and with erectile dysfunction. *J Sex Med* 2013;**10**:2529-2538.
4. Breslow RA, Smothers B. Drinking patterns of older Americans: National Health Interview Surveys, 1997-2001. *J Stud Alcohol* 2004;**65**:232-240.
5. Zakhari S. Bermuda triangle for the liver: alcohol, obesity, and viral hepatitis. *J Gastroenterol Hepatol* 2013;**28**(Suppl):118-125.
6. Sturm R, An R, Maroba J, et al. The effects of obesity, smoking, and excessive alcohol intake on healthcare expenditure in a comprehensive medical scheme. *S Afr Med J* 2013;**103**:840-844.
7. Atashili J, Kaufman JS. RE: Synergism between obesity and alcohol in increasing the risk of hepatocellular carcinoma: a prospective cohort study. *Am J Epidemiol* 2013;**178**:1010-1011.
8. Flores YN, Yee HF, Jr., Leng M, et al. Risk factors for chronic liver disease in Blacks, Mexican Americans, and Whites in the United States: results from NHANES IV, 1999-2004. *Am J Gastroenterol* 2008;**103**:2231-2238.
9. Arif AA, Rohrer JE. Patterns of alcohol drinking and its association with obesity: data from the Third National Health and Nutrition Examination Survey, 1988-1994. *BMC Public Health* 2005;5126.
10. Field AE, Sonneville KR, Crosby RD, et al. Prospective associations of concerns about physique and the development of obesity, binge drinking, and drug use among adolescent boys and young adult men. *JAMA Pediatr* 2014;**168**:34-39.
11. Antin TM, Paschall MJ. Weight perception, weight change intentions, and alcohol use among young adults. *Body Image* 2011;**8**:149-156.
12. Stein KF, Chen DG, Corte C, et al. Disordered eating behaviors in young adult Mexican American women: prevalence and associations with health risks. *Eat Behav* 2013;**14**:476-483.
13. Yeomans MR. Alcohol, appetite and energy balance: is alcohol intake a risk factor for obesity? *Physiol Behav* 2010;**100**:82-89.
14. Poston WS, Haddock CK, Jahnke SA, et al. An examination of the benefits of health promotion programs for the national fire service. *BMC Public Health* 2013;13805.
15. Jezewska M, Babicz-Zielinska E, Leszczynska I, et al. Promotion of healthy nutrition of seafarers. *Int Marit Health* 2009;**60**:48-50.
16. Jang TW, Kim HR, Lee HE, et al. Long work hours and obesity in Korean adult workers. *J Occup Health* 2014;**55**:359-366.
17. Pagoto SL, Schneider KL, Bodenlos JS, et al. Association of post-traumatic stress disorder and obesity in a nationally representative sample. *Obesity (Silver Spring)* 2012;**20**:200-205.
18. Xaverius PK, Salas J. Surveillance of preconception health indicators in behavioral risk factor surveillance system: emerging trends in the 21st century. *J Womens Health (Larchmt.)* 2013;**22**:203-209.
19. Casiano H, Kinley DJ, Katz LY, et al. Media use and health outcomes in adolescents: findings from a nationally representative survey. *J Can Acad Child Adolesc Psychiatry* 2012;**21**:296-301.
20. Lee K. Gender-specific relationships between alcohol drinking patterns and metabolic syndrome: the Korea National Health and Nutrition Examination Survey 2008. *Public Health Nutr* 2012;**15**:1917-1924.
21. Marcellini F, Giuli C, Papa R, et al. Obesity and body mass index (BMI) in relation to life-style and psycho-social aspects. *Arch Gerontol Geriatr* 2009;**49**(Suppl):1195-206.
22. Scarborough P, Bhatnagar P, Wickramasinghe KK, et al. The economic burden of ill health due to diet, physical inactivity, smoking, alcohol and obesity in the UK: an update to 2006-07 NHS costs. *J Public Health (Oxf)* 2011;**33**:527-535.
23. Dey M, Gmel G, Mohler-Kuo M. Body mass index and health-related quality of life among young Swiss men. *BMC Public Health* 2013;**13**:1028.
24. Brodov Y, Mandelzweig L, Boyko V, et al. Is immigration associated with an increase in risk factors and mortality among coronary artery disease patients? A cohort study of 13,742 patients. *Isr Med Assoc J* 2002;**4**:326-330.
25. Klatsky AL, Armstrong MA. Cardiovascular risk factors among Asian Americans living in northern California. *Am J Public Health* 1991;**81**:1423-1428.
26. Hanson KL, Sobal J, Frongillo EA. Gender and marital status clarify associations between food insecurity and body weight. *J Nutr* 2007;**137**:1460-1465.
27. Woo J, Leung SS, Ho SC, et al. Influence of educational level and marital status on dietary intake, obesity and other cardiovascular risk factors in a Hong Kong Chinese population. *Eur J Clin Nutr* 1999;**53**:461-467.
28. Nuwaha F, Musinguzi G. Pre-hypertension in Uganda: a cross-sectional study. *BMC Cardiovasc Disord* 2013;**13**:101.
29. Phaswana-Mafuya N, Peltzer K, Chirinda W, et al. Sociodemographic predictors of multiple non-communicable disease risk factors among older adults in South Africa. *Glob Health Action* 2013;**6**:20680.
30. Molloy GJ, Stamatakis E, Randall G, et al. Marital status, gender and cardiovascular mortality: behavioural, psychological distress and metabolic explanations. *Soc Sci Med* 2009;**69**:223-228.
31. Aitsi-Selmi A, Chen R, Shipley MJ, et al. Education is associated with lower levels of abdominal obesity in women with a non-agricultural occupation: an interaction study using China's four provinces survey. *BMC Public Health* 2013;**13**:769.
32. Bonaccio M, Bonanni AE, Di CA, et al. Low income is associated with poor adherence to a Mediterranean diet and a higher prevalence of obesity: cross-sectional results from the Moli-sani study. *BMJ Open* 2012;**2**:e001685.
33. Tanaka T, Gjonca E, Gulliford MC. Income, wealth and risk of diabetes among older adults: cohort study using the English longitudinal study of ageing. *Eur J Public Health* 2012;**22**:310-317.
34. Groh DR, Jason LA, Davis MI, et al. Friends, family, and alcohol abuse: an examination of general and alcohol-specific social support. *Am J Addict* 2007;**16**:49-55.
35. Berner LA, Bocarsly ME, Hoebel BG, et al. Pharmacological interventions for binge eating: lessons from animal models, current treatments, and future directions. *Curr Pharm Des* 2011;**17**:1180-1187.