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BRIEF ARTICLE

Relationship between alcohol intake and dietary pattern: Findings from NHANES Ⅲ

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Abstract

AIM: To examine the association between macronutrient dietary patterns and alcohol consumption using the Third National Health and Nutritional Examination Survey Ⅲ.

METHODS: A total of 9877 subjects (5144 males) constituted the study cohort. Dietary interviews were conducted with all examinees by a trained dietary interviewer in a mobile examination center (MEC). Subjects reported all foods and beverages consumed except plain drinking water for the previous 24-h time period. Physical examination and history of alcohol consumption were obtained. Pearson correlation coefficients were used to evaluate the association of the levels of alcohol consumption and the percentage of energy derived from macronutrients. Univariate and multivariate regression analyses were performed accounting for the study sampling weight to further explore the relationships between alcohol consumption and calories derived from each macronutrient.

RESULTS: Subjects who drank were younger than non-drinker controls in both genders (P < 0.01). Alcohol intake was inversely associated with body mass index and body weight in women. Of all macronutrients, carbohydrate intake was the first to decrease with increasing alcohol consumption. In the multivariate analyses, the level of alcohol consumption was found to be an independent predictor associated with lower intake of other macronutrients.

CONCLUSION: Our results show that there is an alteration in the daily dietary pattern with increasing alcohol consumption and that energy derived from alcoholic beverages substitutes that from other macronutrients such as carbohydrate, protein, and fat.

Key words: Alcohol; Macronutrients; National Health and Nutritional Examination Survey Ⅲ

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INTRODUCTION

Aside from fat, ethanol is the macronutrient with the highest energy density. Though alcohol can serve as the energy source, how the body processes and utilizes the energy from alcohol is very complex. Because of additional energy supplementation from alcohol, we might anticipate many drinkers to be obese. In fact, data have shown that drinkers are no more obese than non-drinkers, despite higher caloric intake[1,2]. Moreover, weight loss and malnutrition are common clinical presentations among drinkers. Alcohol intake may be associated with altered patterns of food intake resulting in the replacement of alcohol for other nutrients[1]. We hypothesized that energy derived from alcoholic beverages might substitute energy from other macronutrients such as carbohydrate, protein, and fat. In this study, we examined an association between the macronutrient dietary patterns and alcohol consumption using the Third National Health and Nutritional Examination Survey (NHANES Ⅲ).

MATERIALS AND METHODS

Study population

NHANES Ⅲ was conducted in the United States from 1988 through 1994 by the National Center for Health Statistics of the Centers for Disease Control and Prevention. The NHANES Ⅲ survey used complex, multi-stage, stratified, clustered samples of civilian, non-institutionalized populations of age 2 mo and older to collect information about the health and diet of people residing in the United States. A detailed description of the survey and its sampling procedures is available elsewhere[3]. This study was approved by the CDC Institutional Review Board and all participants provided written informed consent.

During the survey period, 18 162 subjects underwent physical examination and laboratory assessment at a mobile examination center (MEC). Exclusion criteria for this study included minors (age < 20 years old), breast feeding or pregnant women, and those with missing values of specific variables (hepatitis B and C serologies, body mass index, aspartate aminotransferase (AST), alanine aminotransferase (ALT), serum creatinine, and drinking history). Additionally, subjects with history of diabetes, congestive heart failure/heart disease, renal insufficiency were also excluded. History of diabetes was defined by self-report and/or taking diabetes medications and/or the subjects having been told by his/her physicians that he/she has diabetes or sugar diabetes. Subjects with history of congestive heart failure/heart disease were defined by self-report of prior myocardial infarction and/or they had been told by their physicians that they have congestive heart failure. For study purposes, we defined subjects with renal insufficiency as those with creatinine ⩾ 2.5 mg/dL. Subjects with diabetes, congestive heart failure and renal insufficiency were excluded from this study because of the possibilities of dietary restrictions due to underlying diseases. Thus, our analytic population included 5144 men and 4733 women.

NHANES Ⅲ dietary data

Dietary interviews were conducted with all examinees by a trained dietary interviewer in the MEC. Subjects reported all foods and beverages consumed except plain drinking water for the previous 24-h time period (midnight to midnight). An automated, microcomputer-based dietary interview and coding system known as the Dietary Data Collection (DDC) System was used to collect all dietary recall data. The detailed method for data collection is described elsewhere[3].

Estimation of alcohol consumption

The amount of alcohol consumed was determined based on the responses to two survey queries that questioned the number of days of drinking over the past 12 mo and the number of drinks per day on a given drinking day. To avoid any arbitrariness in the choice of a cutoff point, we further stratified the extent of alcohol consumption in subjects who reported a history of alcohol use into four groups using quartiles.

Estimation of physical activity

Physical activity assessment was part of the comprehensive interview in NHANES Ⅲ. In brief, subjects were asked to identify specified exercises in which they participated during their free time (jogging or running; riding a bicycle or exercise bicycle; swimming; aerobic dancing; other dancing; calisthenics or floor exercises; gardening or yard work; and weight lifting). They were requested to specify the number of times they participated in an identified activity during the past month. Responses were standardized as “times per week” using the conversion factors 4.3 wk/mo and 30.4 d/mo, then rounded to the nearest whole number. The frequency of performance of other reported exercises, sports or physically active hobbies was also recorded. The physical activity was specified as the sum of intensity rating multiplied by times (of each activity) per month[4].

Laboratory measurements

All venous blood samples were immediately centrifuged and shipped weekly at -20℃ to a central laboratory. The laboratory procedures followed in the NHANES Ⅲ are described in detail elsewhere[3].

Statistical analysis

Descriptive statistics such as means, SD, ranges, and percentages were used to characterize the study patients. Comparisons among groups were made using Analysis of Variance for the continuous and χ^2 test for the categorical variables. Pearson correlation coefficients were used to evaluate the association of the levels of alcohol consumption and the percentage of energy derived from macronutrients. Multivariate regression analyses were performed accounting for the study sampling weight. All statistical analyses and database management were performed using SAS-callable SUDANN software accounting for stratification, sample weight, and clustering. This analysis method also takes into account the different sample weights and the effects of the complex sample design on variance estimation.

Table 1 Clinical characteristics and dietary patterns in male cohorts (n = 5144)

	Levels of alcohol consumption (g/d)					P value
	Non-drinkers (n = 3557)	< 16 (n = 372)	16-35 (n = 465)	36-64 (n = 353)	> 64 (n = 397)	
Age (yr)	48.8 ± 19.5	46.4 ± 19.3	45.4 ± 17.8	42.9 ± 16.2	39.5 ± 14.1	< 0.01
Body mass index (kg/m^2)	26.3 ± 4.1	25.5 ± 3.7	25.7 ± 3.6	25.9 ± 3.7	26.0 ± 3.9	0.87
Body weight (kg)	79.3 ± 14.3	76.9 ± 12.7	78.3 ± 12.3	79.1 ± 13.6	79.4 ± 14.0	0.82
Cigarette smoking (%)	24.8	25.5	37	41.9	50.6	< 0.01
Waist to hip ratio	0.96 ± 0.07	0.95 ± 0.07	0.95 ± 0.07	0.94 ± 0.07	0.94 ± 0.07	0.94
AST (U/L)	22.8 ± 12.7	22.6 ± 8.3	24.1 ± 11.9	26.4 ± 18.7	29.7 ± 26.1	< 0.01
ALT (U/L)	19.7 ± 15.2	19.1 ± 12.8	20.1 ± 13.4	21.6 ± 16.5	25.5 ± 23.2	< 0.01
Physical activity	76.7 ± 109.2	91.6 ± 108.4	91.2 ± 113.8	71.6 ± 98.1	71.5 ± 105.5	< 0.01
Total energy from food (kcal/d)	2 213 ± 838	2432 ± 850	2500 ± 848	2606 ± 857	3155 ± 1018	< 0.01
kcal from alcohol (%)	0	3.5 ± 2.1	8.0 ± 3.9	13.6 ± 6.2	24 ± 11.3	< 0.01
kcal from carbohydrate (%)	50.8 ± 10.7	47.7 ± 10.6	44.4 ± 9.8	42.2 ± 9.1	36.6 ± 8.4	< 0.01
kcal from protein (%)	16.1 ± 5.1	15.9 ± 4.6	15.5 ± 4.4	14.6 ± 4.1	12.9 ± 4.1	< 0.01
kcal from fat (%)	34.6 ± 9.0	34.1 ± 9.1	33.2 ± 9.2	30.7 ± 8.3	27.2 ± 9.2	< 0.01
kcal from monosaturated fat (%)	13.1 ± 4.0	13.0 ± 4.1	12.7 ± 4.1	11.7 ± 3.8	10.4 ± 3.8	< 0.01
kcal from polysaturated fat (%)	7.3 ± 3.4	7.0 ± 3.2	7.1 ± 3.5	6.2 ± 2.8	5.7 ± 3.3	< 0.04

AST: Aspartate aminotransferase; ALT: Alanine aminotransferase.

Table 2 Multivariate linear regression analysis of total daily food energy and other macronutrients adjusting for covariates by level of alcohol intake[1]

	Levels of alcohol consumption (g/d)					P value
Male subjects	Non-drinkers (n = 3557)	< 16 (n = 372)	16-35 (n = 465)	36-64 (n = 353)	> 64 (n = 397)	
Total energy from food (kcal/d)	2228.5 ± 818	2419.6 ± 850	2454.5 ± 847	2559.6 ± 857	3052.1 ± 1018	< 0.05
kcal from carbohydrate (%)	50.2 ± 10.6	47.0 ± 10.6	44.1 ± 9.8	41.9 ± 9.0	36.5 ± 8.3	< 0.01
kcal from protein (%)	16.1 ± 5.1	16.0 ± 4.5	15.5 ± 4.4	14.7 ± 4.1	13.1 ± 4.1	< 0.05
kcal from fat (%)	34.8 ± 9.0	34.4 ± 9.1	33.3 ± 9.2	30.7 ± 9.3	27.1 ± 9.2	< 0.05
kcal from monosaturated fat (%)	13.1 ± 4.0	13.1 ± 4.0	12.7 ± 4.1	11.8 ± 3.9	10.4 ± 3.8	< 0.05
kcal from polysaturated fat (%)	7.2 ± 3.3	6.9 ± 3.2	7.1 ± 3.4	6.1 ± 2.7	5.6 ± 3.3	< 0.05
Female subjects	Non-drinkers (n = 4062)	< 13 (n = 161)	13-21 (n = 169)	22-38 (n = 172)	> 38 (n = 169)	
Total energy from food (kcal/d)	1683 ± 668	1794 ± 612	1881 ± 735	1838 ± 651	2256 ± 861	< 0.01
kcal from carbohydrate (%)	51.5 ± 10.8	48.0 ± 10.3	45.4 ± 10.1	43.4 ± 10.1	38.2 ± 8.4	< 0.01
kcal from protein (%)	15.8 ± 5.1	15.7 ± 4.5	15.1 ± 4.4	14.8 ± 4.3	12.4 ± 3.9	< 0.01
kcal from fat (%)	34.1 ± 9.4	33.8 ± 9.1	34.0 ± 10.1	31.5 ± 9.0	27.2 ± 9.0	< 0.01
kcal from monosaturated fat (%)	12.7 ± 4.0	12.7 ± 4.0	13.0 ± 4.5	12.1 ± 4.1	10.1 ± 3.4	< 0.05
kcal from polysaturated fat (%)	7.3 ± 3.7	7.1 ± 3.2	7.0 ± 3.6	6.8 ± 3.6	5.9 ± 3.3	< 0.05

[1]Adjusted for age, body weight, physical activity, and smoking status.

RESULTS

Relationship between dietary pattern and alcohol consumption in males

Among male participants (n = 5144), 69% reported no history of alcohol use (Table 1).

There were no differences in waist-to-hip ratio among groups. In this study cohort, only subjects who drank < 16 g of alcohol/d weighed less than non-drinker controls. The percentage of subjects who smoked increased in accordance with the level of alcohol consumption. As expected, markers of hepatic inflammation, AST and ALT, were increased with the level of alcohol consumption. The total energy consumption per day increased with the level of alcohol consumption. The increment in such energy was mainly due to the calories provided by alcohol. In the univariate analysis (Table 1), we found that the percentage of energy derived from carbohydrate, protein, and fat decreased with increasing alcohol consumption. Carbohydrate intake started to decrease at a daily consumption of ≤ 35 g/d. When the daily levels of alcohol consumption continued to increase (> 35 g/d), subjects consumed less protein and fat. In those who drank alcohol at a level of > 64 g/d, the energy intake which was derived from protein and fat was reduced by 4% and 7%, respectively. In the multivariate linear regression analyses adjusting for covariates (such as age, body weight, smoking status and physical activity), the level of alcohol consumption was found to be an independent predictor associated with lower percent calories derived from macronutrients. The adjusted calories from macronutrients stratified by alcohol consumption are shown in Table 2. In the correlation analyses, the amount of alcohol consumed per day was inversely associated with the percentage of calories derived from each macronutrient (Figure 1A-C).

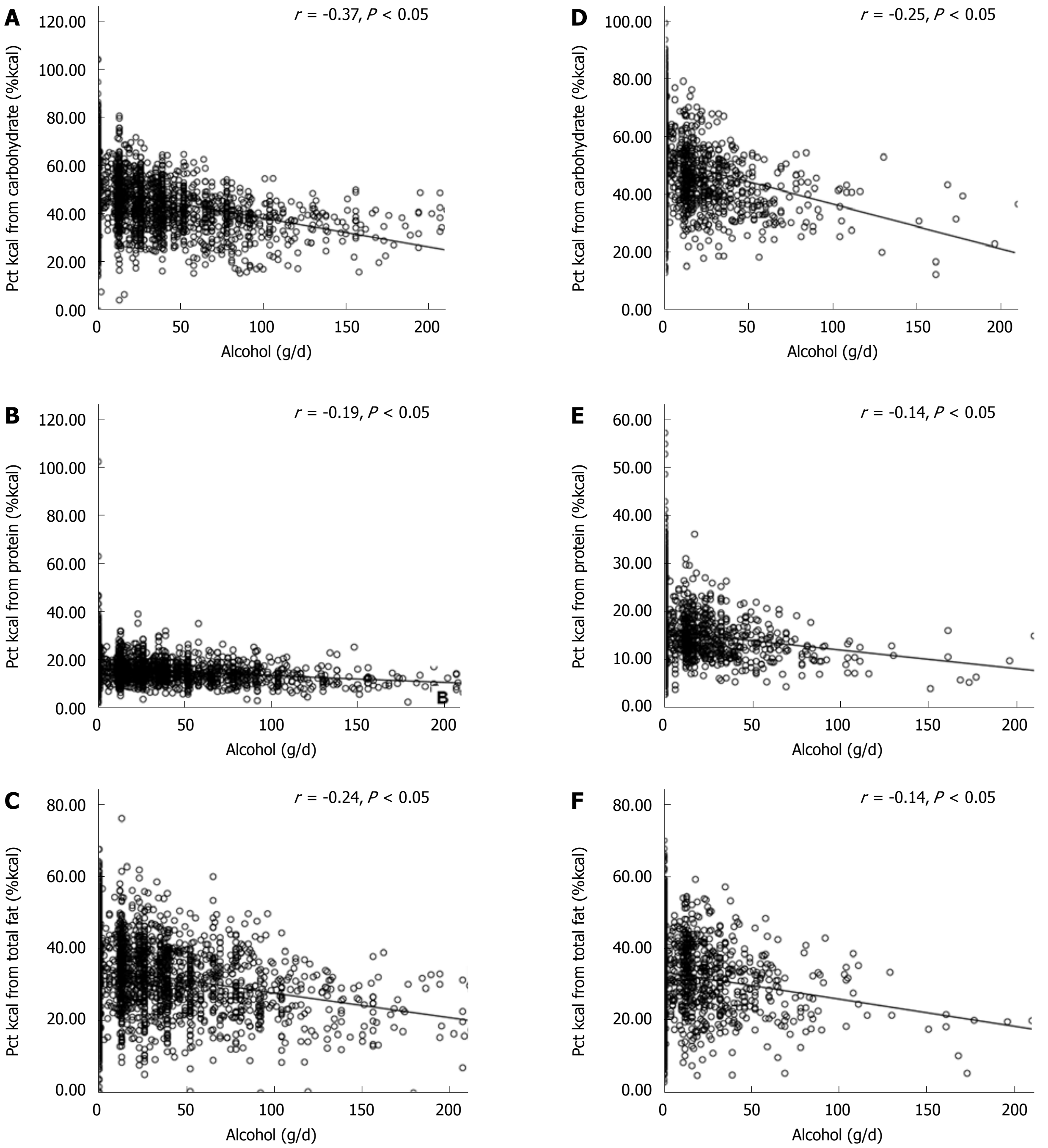

Figure 1 Relationship between the levels of alcohol consumption and the percentage of calories derived from each macronutrient in males (A-C) and females (D-F).

Relationship between dietary pattern and alcohol consumption in females

As observed with male participants, women who drank higher amounts of alcohol were younger than non-drinker controls ($P < 0.05$). Alcohol intake was inversely associated with body mass index and body weight in women. Again, no differences in waist-to-hip ratio were observed among groups (Table 3). As with male subjects, we found a higher prevalence of cigarette smokers in those who drank higher amounts of alcohol. Because of the energy provided from alcohol, the total energy consumed per day was higher in those who drank any amount of alcohol when compared to controls. We again found that female drinkers started to consume less carbohydrate even when they drank < 13 g/d. The calories derived from protein and fat were reduced once the subjects drank > 21 g of alcohol/d. In the multivariate linear regression analyses, the level of alcohol consumption was found to be an independent predictor associated with lower percent calories derived from macronutrients (Table 2). In the correlation analyses, the amount of alcohol consumption per day was inversely associated with the percentage of calories derived from each macronutrient, as observed in male subjects (Figure 1D-F).

Table 3 Clinical characteristics and dietary patterns in female cohorts (*n* = 4733)

	Levels of alcohol consumption (g/d)					*P* value
	Non-drinkers (*n* = 4062)	< 13 (*n* = 161)	13-21 (*n* = 169)	22-38 (*n* = 172)	> 38 (*n* = 169)	
Age (yr)	49.1 ± 19.5	45.6 ± 18.4	45.4 ± 17.6	41.9 ± 15.2	41.3 ± 14.3	< 0.01
Body mass index (kg/m^2)	26.3 ± 5.0	25.1 ± 4.5	24.9 ± 4.9	24.8 ± 4.5	24.8 ± 4.5	< 0.05
Body weight (kg)	67.3 ± 13.9	64.8 ± 11.8	65.7 ± 14.1	66.3 ± 11.9	66.4 ± 13.0	< 0.05
Cigarette smoking (%)	19	25	30.1	35.4	44.9	< 0.01
Waist to hip ratio	0.87 ± 0.08	0.85 ± 0.07	0.86 ± 0.08	0.86 ± 0.11	0.86 ± 0.08	0.94
AST (U/L)	19.8 ± 12.1	18.9 ± 6.7	23.4 ± 30.9	20.9 ± 11.5	20.5 ± 9.4	< 0.01
ALT (U/L)	14.6 ± 13.8	13.8 ± 8.8	15.1 ± 14.2	14.6 ± 10.5	14.6 ± 10.7	< 0.01
Physical activity	56.9 ± 90.9	78.6 ± 105.7	81.6 ± 107.3	70.5 ± 94.8	70.7 ± 104.3	< 0.01
Total energy from food (kcal/d)	1667 ± 667	1816 ± 646	1903 ± 735	1895 ± 651	2316 ± 860	< 0.01
kcal from alcohol (%)	0	3.7 ± 2.2	6.8 ± 3.4	11.6 ± 4.4	23.2 ± 11.4	< 0.01
kcal from carbohydrate (%)	52.4 ± 10.8	48.9 ± 10.5	46.1 ± 10.1	43.8 ± 10.1	38.4 ± 8.7	< 0.01
kcal from protein (%)	15.8 ± 5.0	15.6 ± 4.5	15.0 ± 4.4	14.7 ± 4.2	12.3 ± 3.9	< 0.01
kcal from fat (%)	33.4 ± 9.4	33.2 ± 9.2	33.6 ± 10.1	31.4 ± 9.0	27.3 ± 9.3	< 0.01
kcal from monosaturated fat (%)	12.3 ± 4.0	12.4 ± 4.1	12.8 ± 4.4	11.9 ± 4.1	10.1 ± 3.8	< 0.01
kcal from polysaturated fat (%)	7.3 ± 3.6	7.1 ± 3.3	7.1 ± 3.5	6.9 ± 3.6	6.0 ± 3.4	< 0.04

AST: Aspartate aminotransferase; ALT: Alanine aminotransferase.

DISCUSSION

In this large population-based study, we found that (1) alcohol consumption was inversely related to body mass index and body weight, primarily in women; (2) energy derived from alcohol replaced that from macronutrients in both genders; and (3) carbohydrate was the foremost macronutrient in which the energy was replaced by that from alcohol. With increasing alcohol consumption, we found a significant reverse relationship between alcohol and all macronutrient intakes.

Although alcohol is an energy source, how the body processes and uses the energy from alcohol is more complex than can be explained by a simple calorie conversion value. Energy derived from alcohol has been consider as "empty calories" because alcohol contains no beneficial nutrients. Additionally, it can also replace the energy derived from other macronutrients. As shown in this study, particularly in female subjects, alcohol provides an average of 23% of the calories when intake is > 38 g/d (Table 2). Despite higher caloric intake from alcohol, females who drank at this level were less obese than non-drinkers. It is postulated that chronic drinking triggers the microsomal ethanol-oxidizing system (MEOS)[1,5,6], an inefficient system of alcohol metabolism. Much of the energy from MEOS-driven alcohol metabolism is lost as heat rather than used to supply the body with energy. The association between gender, body weight, and alcohol intake is debatable. Though our results are consistent with those reported by Colditz *et al*[1], there have been previous reports that men who drank weighed more than non-drinkers[7,8]. The inconsistency in these results is likely due to the study design and data collection.

We observed that the major difference in nutrient intake for both genders was a significantly lower intake of carbohydrates by drinkers (r = -0.37 and -0.25, in male and female subjects, respectively). Our findings are similar to those reported by Thompson *et al*[9], where they observed a decreased absolute intake of carbohydrate, protein, and fat with increasing alcohol intake.

Several limitations in using NHANES datasets deserve discussion. First, the cross-sectional design in NHANES does not enable us to truly address potential temporal associations between significant alcohol consumption and the variables of interest. Second, the accuracy of the alcohol consumption data, as with other retrospective study designs, is unknown. Since the extent of alcohol consumption will be derived from self-report questionnaires, it is vulnerable to a recall bias in each participant.

In summary, our results showed that there is an alteration in the daily dietary pattern with increasing alcohol consumption and that energy derived from alcoholic beverages substitutes that from other macronutrients such as carbohydrate, protein, and fat. Female drinkers were less obese than non-drinkers, suggesting that alcohol calories may be less utilized in female subjects. However, further research is needed to explore the role of gender and body weight in alcoholics.

COMMENTS

Background

Aside from fat, ethanol is the macronutrient with the highest energy density. Though alcohol can serve as the energy source, how the body processes and utilizes the energy from alcohol is very complex. Because of additional energy supplementation from alcohol, the authors might anticipate many drinkers to be obese. In fact, data have shown that drinkers are no more obese than non-drinkers, despite higher caloric intake. Moreover, weight loss and malnutrition are common clinical presentations among drinkers. Alcohol intake may be associated with altered patterns of food intake resulting in the replacement of alcohol for other nutrients. In this study, the authors examined the association between the macronutrient dietary patterns and alcohol consumption using the Third National Health and Nutritional Examination Survey (NHANES Ⅲ).

Research frontiers

In this large population-based study, the authors found alterations in the daily dietary pattern with increasing alcohol consumption and that energy derived from alcoholic beverages substitutes that from other macronutrients such as carbohydrate, protein, and fat.

Innovations and breakthroughs
To the best of the authors' knowledge, this is the first population-based study to address the relationship between alcohol consumption and dietary pattern. The authors found that alcohol consumption was inversely related to body mass index and body weight, primarily in women. With increasing alcohol consumption, they found a significant reverse relationship between alcohol and all macronutrient intakes.

Applications
Energy derived from alcohol has been considered as "empty calories" because alcohol contains no beneficial nutrients. In this study, the authors also found that energy derived from alcohol consumption can replace that from other macronutrients.

Peer review
Dr. Liangpunsakul describes in his manuscript the relationship between alcohol consumption and the macronutrient dietary patterns using data from the NHANES 1988-1994. He found that increasing alcohol intake is associated with an altered daily dietary pattern and that the energy of alcoholic beverages substitutes that from carbohydrates, protein and fat.

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