Running header: **Hangover severity and food consumption**

Daily experiences of hangover severity and food consumption in young adults

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Abstract

Aims

Our aim was to determine whether alcohol hangover is associated with eating unhealthy foods (hot chips, soft drink) or healthy foods (fruit, vegetables).

Design

Daily diary study across 13 days (micro-longitudinal design)

Setting

A sample of young adults completed daily diaries in the university community.

Participants

605 young adults (71% women; ages 17 to 25; mean age 19.91 [*SD* 1.86] years) who reported drinking alcohol at least twice during the 13-day study period.

Measurements

Each day, participants reported on their hangover severity, their consumption of fruit, vegetables, hot chips (French fries), and soft drink, and their alcohol consumption from the previous day. Linear mixed models were used to examine within-person associations between hangover severity and food consumption, by gender. Exploratory models also controlled for previous day alcohol consumption to acknowledge potential variability in hangover susceptibility.

Findings

On days when participants reported higher severity of hangovers, they reported consuming more hot chips ($\beta = 0.09, p = 0.001$), more soft drink ($\beta = 0.08, p = 0.001$) and less fruit ($\beta = -0.06, p = 0.05$). In our exploratory model controlling for previous day alcohol consumption, the predictive effect of hangover severity on hot chips ($\beta = 0.08, p = 0.009$) remained and significant interaction effects were observed between gender and previous day alcohol consumption on fruit ($\beta = -0.03, p = 0.003$) and vegetable ($\beta = -0.03, p = 0.03$) servings.

Conclusion

Higher hangover severity may lead to greater intake of some unhealthy foods such as hot chips. Higher alcohol consumption was significantly associated with decreased fruit and vegetable intake the following day for women but not for men. The association between high alcohol intake and poor eating is of concern and merits exploration in other settings.

Keywords: hangover, alcohol, young adults, diet, nutrition, alcohol consumption

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Conflict of Interest Statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Authors contribution

TSC conceived the Daily Life Study and led collection of the behavioural data. KM, BR, WL, SB conceived the paper idea. WL performed the statistical analysis with assistance from SB and BR. KM and SB wrote the article with assistance from WL. All authors read and reviewed the final manuscript.

Author agreement

This material has not been previously published and has not been submitted for publication elsewhere.

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Data Availability Statement

Requests to access the dataset should be directed to Tamlin S. Conner at tamlin.conner@otago.ac.nz

Daily experiences of hangover severity and relationship with food intake in young adults

Introduction

Alcohol use is highly prevalent among young adults [1], who report greater quantity and frequency of alcohol consumption and alcohol-related consequences [2] (such as hangovers [3]) than other age groups. An alcohol-related hangover is defined as the physical and mental symptoms experienced the day after alcohol consumption [4]. Symptoms usually peak about the time blood alcohol concentration (BAC) reaches zero [5] and may have a negative impact on physical and psychological well-being [6, 7]. While there has been growing research on the impact of hangovers on cognitive function, fatigue and task performance [8], there has been little research examining the role of hangovers in relation to dietary choices.

It is well documented that appetite is influenced by alcohol consumption acutely [9]. Studies demonstrate an increase in the urge to snack among individuals administered a priming dose of alcohol [10]. Moderate alcohol consumption before and during meals has been linked with a decrease in satiety and corresponding increases in average meal duration [11], which could be due to the inhibitory effect of alcohol on appetite-regulating hormones [11]. While the hyperphagic effect of alcohol appears to be unrelated to the pleasantness of food, with similar spikes in consumption observed between bland and flavoured foods [12], a preference for foods specifically high in salt and fat has been observed when alcohol is consumed before or during a meal [13]. Experimental research among university students demonstrates that moderate alcohol consumption is acutely associated with a preference for savoury over sweet foods [14].

Chronic alcohol use has been shown to be predictive of a diet low in fruits and vegetables and high in processed meat in European populations [15] and this effect appears to be dose dependent with excessive drinkers reporting the lowest intake of fruit and vegetables [16]. This pattern is mirrored among university students, whereby heavy and excessive drinkers are consistently less likely to consume the recommended intake of fruits and vegetables than moderate drinkers or abstainers [17]. Moreover, this relationship between chronic alcohol use and the consumption of fruit and vegetables may be moderated by gender, with male drinkers being significantly less likely to consume fruit and vegetables than female drinkers [18].

Although considerable research has been conducted to develop an understanding of the acute and chronic effects of alcohol on food preference and diet, there is considerably less data regarding the impact of alcohol hangover on next day food consumption. The physiological, neurocognitive and psychological changes that occur following alcohol metabolism may be relevant to regulating food choice and impact diet in the long term, such as reductions in executive functioning and increased impulsivity and depression [19]. One previous study examined the relationship between alcohol use and eating habits of 143 university students that drank alcohol within the last month. These authors observed that moderate-risk drinkers were more likely than low-risk drinkers to report increases in appetite after drinking, with nearly half of students reporting overeating and making unhealthy food choices following drinking episodes [20]. However, this was a cross-sectional study comparing groups of categorised low-risk and moderate-risk drinkers that utilised data from surveys of eating behaviours collected retrospectively in the previous month which may be subject to recall bias and does not adequately allow for the study of dynamic within-subject processes [21]. An alternative explanation for these findings is that underlying personality or health risk taking accounts for both high risk alcohol use and food selection. Moreover, the role of the alcohol hangover severity following the drinking episode was not explored.

Accordingly, the objective of the present study was to further develop our understanding of the factors that contribute to diet among young adults by examining food preference on days people reported hangovers from alcohol consumption. Employing a micro-longitudinal design with daily survey data across 13 days, we aimed to evaluate the relationship between hangover severity and consumption of various food types (hot chips, soft drink, fruit and vegetables) using a within-subject design. Previous work suggests that individual drinkers differ with respect to hangover liability at a constant level of alcohol exposure [22, 23]. We thus also conducted exploratory models controlling for previous day alcohol consumption to acknowledge potential variability in hangover susceptibility and to determine whether any relationships between hangover severity and food servings were independent of alcohol consumption.

Method

Participants

Participants were 605 young adults aged between 17 and 25 ($M = 19.91$ $SD, = 1.86$) who took part in the 2011 2012, 2013, and 2014 waves of the Daily Life Study (previously described [24, 25]). The study was run at a university setting in New Zealand where the drinking age in New Zealand is 18 years of age. Remuneration depended on the individual's method of recruitment: course credits if recruited as part of undergraduate psychology requirement or a one-time cash payment if recruited by other means, which included flyers, word of mouth or the university's human nutrition program. For the present study, we only included participants who reported drinking alcohol at least twice during the 13-day study period (i.e., those who could experience a hangover), which reflected 605 participants who completed the daily diary procedure. All procedures were approved by the Human Ethics Committee (10/777).

Procedure

Participants completed an initial laboratory session which included providing informed written consent, a computerised demographic survey, and training on how to engage with the online survey platform. Participants were informed that the survey was for the purpose of understanding lifestyle factors that contribute to the health of young adults. Starting the next day, participants then completed a daily diary questionnaire for 13 days which included a number of self-report measures on diet, physical activity, sleep and mood at 24-hour intervals during a 5-hour period between 3pm and 8pm. The timing was chosen to coincide with the end of the day before the advent of night-time behaviours. Hangover severity was measured the day following alcohol use in the usual reporting window.

Measures

Demographics: Age, gender, ethnicity

Dietary servings: The current analysis included the following measures of diet from the New Zealand National Nutrition Survey [24]: (1) hot chips (fries, wedges or sweet potato); (2) soft

drink (sugary drinks, including powerade) (3) fruit (fresh, frozen, canned or stewed excluding dried fruit or juice; (4) vegetables (fresh, frozen or canned excluding juice and chips).

Serving sizes were described according to the protocol set out in the 1997 New Zealand National Nutrition Survey (i.e., one serving was about one handful) [26]. Six serving options were provided in the questionnaire (none, <1 serving, 1 serving, 2 servings, 3 servings $\geq$ 4 servings).

In order to better examine the role of hangovers on dietary choices, we also collated a ‘typical food pattern’ control variable calculated by the mean number of servings from each food type from non-drinking days.

Hangover: Hangover was subjectively reported each day using a single face-valid item in which participants rated the extent to which they “had a hangover or felt sick from alcohol today” on a four-point scale ranging from 0 (not at all), 1 (a little), 2 (somewhat), 3 (moderately), or 4 (very). Thus hangover severity scores ranged from 0 (no hangover) to 4 (severe hangover).

Alcohol: Participants recorded the number of alcohol drinks they consumed the previous day with one serving representing one standard drink (10 grams of pure alcohol). Participants were given a standard drink guide for a range of commonly consumed beverages.

Data Analysis

Generalized linear mixed models using lme4 [27] in R software (Version 4.0.3) were conducted to predict the number of daily servings for each food category from hangover severity. In the first models, we predicted the number of servings of food groups in four separate models (‘hot chips’, ‘fruit’, ‘vegetables’, ‘soft drink’) with hangover severity as the main predictor, gender as a covariate, and the interaction between gender and hangover severity, and typical food servings as a control.

In the second models, we conducted exploratory analyses to determine whether any significant relationships between hangover severity and food servings were independent of alcohol consumption the previous day (i.e., does hangover severity predict food servings over and above alcohol use) and interactions between gender and both hangover and alcohol consumption.

Results

Descriptive statistics

Table 1 shows the characteristics of the sample. The average daily servings of fruit and vegetables was approximately 1.24 and 1.35, respectively. Unhealthy foods were consumed at a lower level, with an average daily consumption of 0.25 and 0.28 servings of chips and soft drink, respectively. The average number of drinks per drinking day was 6.56 (+/- 4.39) and the average number of drinking sessions during the study was 2 (range 1-10). The intraclass correlation coefficients (ICC) were all below 0.5, which indicated more within-person variability than between-person variability in the daily variables.

Insert Table 1 here

Insert Figure 1 here

Association of hangover severity with food consumption

Figure 1 depicts the descriptive violin plots and density figures of each food type for each level of hangover severity for all participants. Table 2 shows the results from the first generalised linear mixed modelling of within-person associations between hangover severity and changes in food consumption according to gender and controlled for typical servings of each food type from non-drinking days. As seen in Table 1, we found a main effect of severity of hangover for hot chips ($\beta = 0.09$, $p = 0.0000475$) and soft drink ($\beta = 0.08$, $p = 0.00037$), with participants reporting more servings of chips or soft drinks on days with more severe hangovers. We also found a main effect of severity of hangover for fruit ($\beta = -0.06$, $p = 0.05$), with participants reporting eating fewer servings of fruit on days with more severe hangovers. There were no associations between hangover severity and consumption of vegetables ($p = 0.98$) but there was an interaction between gender and hangover on vegetables ($\beta = -0.10$, $p = 0.037$) suggesting that for females, on days when more severe hangovers are reported, they reported fewer servings of vegetables.

Table 3 shows the exploratory model, which included the previous day alcohol consumption, and associated interactions. The main effect of hot chips was retained ($\beta = 0.08$, $p = 0.009$). However, the main effect of hangover severity on predicting servings of soft drink ($p = 0.108$) or fruit ($p = 0.307$) was not retained. Interestingly, servings of fruit

was predicted by an interaction between gender and previous day alcohol consumption ($\beta = -0.03, p = 0.003$), suggesting that in the days after female participants reported higher alcohol consumption, they reported lower servings of fruit, whereas this relationship was not observed for males. A similar gender pattern was found for vegetables, which was predicted by an interaction between gender and previous day alcohol consumption ($\beta = -0.03, p = 0.030$), suggesting that following days when females reported higher alcohol consumption, they reported fewer servings of vegetables, whereas this relationship was not observed for males.

Insert Table 3 here

Discussion

Employing a micro-longitudinal design to daily survey data, we aimed to evaluate the relationship between hangover severity and consumption of various food types (chips, soft drink, fruits and vegetables). We observed that on days when participants reported higher severity of hangovers, they reported more servings of hot chips, softdrinks and fewer of fruit. Interestingly, the predictive role of hangover severity on hot chips was retained even when considering alcohol consumption levels the previous day. For women, higher levels of alcohol consumption the previous night appears to be associated with less fruit and vegetable consumption.

This is the first prospective report using a micro-longitudinal design demonstrating a relationship between reported greater severity of hangovers and higher servings of unhealthy foods such as hot chips and soft drink. Interestingly, the relationship between hangover and servings of hot chips was retained when considering the previous alcohol consumption, suggesting that the observed associations may not be merely a function of the amount of alcohol consumed but also individual susceptibility to experience of hangover. It has previously been demonstrated that individual drinkers differ with respect to hangover liability at a constant level of alcohol exposure [22, 23]. Variability in hangover susceptibility in survey research can be acknowledged by utilising hangover scores after covarying alcohol consumption patterns [28]. In the current analysis, patterns of alcohol consumption was included to explore the degree to which food choices are uniquely linked to individual differences in hangover severity. While our initial analyses suggest that hangover symptoms predict subsequent servings of high fat and salt foods (i.e. hot chips), our sensitivity analyses

indicate that this relationship held when considering previous alcohol consumption, suggesting that the individual experience of hangover severity (e.g. due to alcohol metabolism or subjective experience) may be driving this association.

We also observed that severity of hangover was predictive of lower servings of healthy foods. When considering the previous day's alcohol consumption we observed that for females, on days where higher previous day alcohol consumption was reported, they reported consuming fewer servings of fruit and vegetables whereas this was not the case for males. This contradicts previous findings demonstrating that male drinkers are less likely to consume fruit than female drinkers in general [18], and further, indicates that even when controlling for typical food consumption, in the day following heavier alcohol consumption, females are more likely to reduce fruit and vegetable intake. The current findings are consistent with previous studies reporting an inverse relationship between alcohol use and nutrient intake [29] including healthy foods such as fruit and vegetables. It is possible that the lack of association demonstrated in males may be due to their overall low fruit and vegetable intake or due to females attaining a higher BAC at the same number of drinks compared to males [8]. Future studies should continue to investigate potential sex differences in functioning during alcohol hangover [8].

The pathophysiology of hangover includes the contributions of mechanisms such as accumulation of acetaldehyde and alcohol-induced endocrine changes, including a role for appetite-regulating hormones such as ghrelin [30]. Alcohol intoxication can also lead to electrolyte imbalance and dehydration [5] which could possibly contribute to eating behaviours targeted towards foods with higher sodium content and increased servings of soft drink such as 'Powerade' the following day. Hangovers have also been associated with poor impulse control [31], and impulsivity has been found to be associated with both increased food intake and snacking [32]. Indeed, Limbers and Young [33] have demonstrated that poor inhibitory control is associated with higher consumption of high fat foods specifically. Interestingly, previous literature has demonstrated that executive functions that predict avoidance of foods high in saturated fat are disparate from those that drive fruit and vegetable consumption [33]. Our current results indicating that hangover severity and alcohol consumption are linked with both higher fatty food and also lower vegetable and fruit intake are somewhat consistent with the idea that executive functions involved in healthy, goal-directed dietary behaviours and impulsive reward-inducing eating behaviours may be distinct [33]. Notwithstanding, an association between hangovers, alcohol consumption and high

caloric foods and low servings of healthy foods is of concern given the rising rates of multi-morbidities of non-communicable diseases [34]. High fat diet accelerates the development of including fatty liver disease [36] and alcohol-related liver diseases including liver cancer. Moreover, the specific combination of a high salt diet with alcohol consumption contributes to fatty liver disease development and progression in animal models [35].

Strengths and limitations

Strengths of the current manuscript include a large sample and prospective micro-longitudinal design which minimises recall bias. In addition, we explore the relationships between gender, previous alcohol consumption, and typical food consumption patterns. A major problem of past studies examining the effects of alcohol hangover has been the low sample size [8]. However, to optimise recruitment and retention of participants and complete data collection, we have necessarily simplified the measures utilised. One limitation may be the measurement of hangover severity [8]. For practical and feasibility reasons, we used a rating for overall hangover severity with one face-valid but not traditionally validated question that was rated numerically from ‘not at all’ to ‘very’. It is possible that this measure was not sufficiently sensitive or comprehensive to capture the wide array of hangover symptoms. Lastly, our study used single item dietary variables rather than a more extensive food frequency questionnaire or food diary.

Conclusions

In university students, hangover severity may lead to greater consumption of some unhealthy foods such as those high in salt and saturated fat and lower consumption of fruit and vegetables. The combination of high alcohol intake and poor eating behaviours is of concern given rising rates of multi-morbidities and associated non-communicable diseases. The relationship between alcohol use and food intake should be explored in other settings and longer term studies.

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Tables

Table 1. Sample demographics and descriptive statistics of the 605 participants who reported drinking alcohol at least twice during study.

Characteristic	
N	605
Male, N (%)	174 (28.8%)
Female, N (%)	431 (71.2%)
Age (years)	19.91 (1.86)
Year at university	2.01 (0.940)
1 st Year undergrad.	228
2 nd Year undergrad.	178
3 rd Year undergrad.	94
4 th or 5 th Year undergrad.	64
Postgraduate (Masters, PgDip, DipGrad)	34
Postgraduate PhD	7
Drinks per drinking day	6.56 (4.39)
Number of sessions	2 (range 1-10)
Ethnicity, n (%)	
European/Caucasian	514 (84.9%)
Asian	36 (6%)
Maori/Pacific Islander	32 (5.3%)
Indian	9 (1.5%)
Middle Eastern	3 (0.5%)
Mixed Ethnicity	3 (0.5%)
Other	8 (1.3%)

Notes: Data represent mean (standard deviation) unless otherwise stated. Drinks per drinking day and number of sessions were for the entire sample across the 13 day testing period.

433 **Table 2.** Models displaying the effect of reported hangover severity and gender on food consumption.

	Hot chips			Soft drink			Fruit			Vegetables		
Predictors	β	CI	p	β	CI	p	β	CI	p	β	CI	p
(Intercept)	0.17	0.08 – 0.25	<0.001	0.11	0.03 – 0.20	0.009	0.28	0.15 – 0.40	<0.001	0.26	0.11 – 0.41	0.001
Gender (M= 0, F =1)	-0.01	-0.10 – 0.07	0.747	0.04	-0.05 – 0.13	0.393	-0.08	-0.21 – 0.04	0.189	0.07	-0.07 – 0.22	0.318
Hangover	0.09	0.05 – 0.13	<0.001	0.08	0.04 – 0.12	<0.001	-0.06	-0.12 – -0.00	0.050	0.00	-0.07 – 0.07	0.981
Gender x Hangover	-0.05	-0.10 – 0.01	0.082	-0.05	-0.11 – 0.00	0.051	-0.01	-0.09 – 0.06	0.758	-0.10	-0.19 – -0.01	0.037
Hot chips (control)	0.68	0.58 – 0.79	<0.001									
Soft drink (control)				0.72	0.64 – 0.81	<0.001						
Fruit (control)							0.74	0.68 – 0.80	<0.001			
Veg (control)										0.73	0.65 – 0.80	<0.001
Random effects												
σ^2	0.30			0.30			0.63			0.91		
τ_{00}	0.05 ID			0.06 ID			0.09 ID			0.10 ID		
ICC	0.15			0.17			0.13			0.10		
N	602 ID			601 ID			603 ID			603 ID		
Observations	1444			1438			1447			1445		
Marginal R ² / Conditional R ²	0.161 / 0.283			0.200 / 0.335			0.311 / 0.401			0.233 / 0.308		

434 Note. (control) = average servings on non-drinking days. σ^2 = random effects variance; τ_{00} = random intercept variance; ICC = intra-class correlation coefficient. M = male; F
 435 = female

436 **Table 3.** *Exploratory models displaying the effect of reported hangover severity, alcohol consumption and gender on food consumption.*

	Hot chips			Soft drink			Fruit			Vegetables		
Predictors	β	CI	p	β	CI	p	β	CI	p	β	CI	p
(Intercept)	0.15	0.05 – 0.24	0.003	0.07	-0.03 – 0.17	0.183	0.30	0.16 – 0.44	<0.001	0.28	0.10 – 0.45	0.002
Gender (M = 0, F = 1)	-0.04	-0.15 – 0.07	0.471	0.06	-0.05 – 0.18	0.284	0.04	-0.12 – 0.20	0.632	0.18	-0.00 – 0.37	0.054
Hangover	0.08	0.02 – 0.13	0.009	0.05	-0.01 – 0.10	0.108	-0.04	-0.12 – 0.04	0.307	0.01	-0.08 – 0.11	0.806
Previous day alcohol	0.00	-0.01 – 0.01	0.477	0.01	-0.00 – 0.02	0.094	-0.01	-0.02 – 0.01	0.471	-0.00	-0.02 – 0.01	0.736
Gender x Hangover	-0.06	-0.13 – 0.01	0.103	-0.03	-0.10 – 0.04	0.355	0.05	-0.05 – 0.15	0.334	-0.04	-0.16 – 0.08	0.500
Gender x Previous day alcohol	0.01	-0.01 – 0.02	0.314	-0.00	-0.02 – 0.01	0.689	-0.03	-0.06 – -0.01	0.003	-0.03	-0.06 – -0.00	0.030
Hot chips (control)	0.68	0.58 – 0.78	<0.001									
Soft drink (control)				0.72	0.64 – 0.81	<0.001						
Fruit (control)							0.74	0.68 – 0.80	<0.001			
Veg (control)										0.73	0.65 – 0.80	<0.001
Random Effects												
σ^2	0.30			0.30			0.63			0.91		
τ_{00}	0.05 ID			0.06 ID			0.09 ID			0.09 ID		
ICC	0.14			0.17			0.12			0.09		
N	602 ID			601 ID			603 ID			603 ID		
Observations	1444			1438			1447			1445		
Marginal R ² / Conditional R ²	0.164 / 0.282			0.202 / 0.336			0.322 / 0.404			0.238 / 0.309		

437 Note. (control) = average servings on non-drinking days. σ^2 = random effects variance; τ_{00} = random intercept variance ICC = intra-class correlation coefficient. M = male; F
438 = female; alcohol measured in standard drinks.
439

440

441

443 **Figure 1.** Violin plot and density figures for hangover severity rating and food type serving
444 (Hot chips, Soft drink, Fruit, Vegetables)
445