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An Event-Level Investigation of Hangovers' Relationship to Age and Drinking

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Abstract

Animal and human data suggest that adolescents experience hangover effects that are distinct from adults. The present study used ecological momentary assessment (EMA) methods to examine the temporal relationships between drinking and hangovers and how this varied by age and sex. We hypothesized that alcohol's dose-dependent effects on hangover severity are more pronounced among adolescents and young adults than older drinkers. We also explored whether greater hangover severity would lead to a lower likelihood and volume of alcohol use later the same day. Data were pooled from four studies of drinkers (N = 274; ages 15 to 66 years) who completed a 4- to 14-day (M = 7.46, SD = 1.13) EMA monitoring period. Each morning, participants recorded how much alcohol they consumed the day before and rated their hangover severity. Participants who consumed a greater quantity of alcohol the prior day reported more severe hangover symptoms; however, there was an interaction between drinking volume and age such that hangover was more severe among younger drinkers, especially at higher drinking levels. More severe hangover symptoms did not predict the likelihood of drinking later that day; however, on

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drinking days more severe hangover symptoms predicted lower quantities of alcohol use later that day. This event-level effect did not vary as a function of age. Study outcomes did not vary by sex. Our findings suggest that younger drinkers experience more severe hangovers and that greater hangover results in lighter drinking later that same day regardless of age.

Keywords

hangover; age; drinking quantity; ecological momentary assessment

Hangovers are characterized by a constellation of aversive physiological and affective symptoms that occur following excessive alcohol consumption (Prat, Adan, & Sánchez-Turet, 2009; Rohsenow et al., 2007). These symptoms, which typically include headache, nausea, thirst, fatigue, dizziness, and stomach ache, begin several hours after the cessation of drinking when a person's blood alcohol concentration (BAC) falls to near zero (Rohsenow et al., 2007). Epidemiological data suggest that hangovers affect 75% of the general population after moderate alcohol consumption and hangovers result in substantial socioeconomic costs due to absenteeism, lower productivity, work-related accidents, and interpersonal conflicts (Frone 2006; Harburg, Gunn, Gleiberman, DiFranceisco, & Schork, 1993; Howland et al., 2008). Yet individuals exhibit considerable heterogeneity in terms of their susceptibility to hangovers, and this heterogeneity may be clinically important. Propensity toward hangovers appears to be a particularly powerful predictor of future drinking (Howland et al., 2008; Howland, Rohsenow, & Edwards, 2008; for a review, see Piasecki et al., 2010), especially during young adulthood (Piasecki, Sher, Slutske, & Jackson, 2005; Rohsenow et al., 2012). Improved understanding of individual differences in hangover susceptibility and how these differences influence the association between hangovers and future drinking would inform alcohol misuse prevention and intervention initiatives.

Research on hangover symptoms has primarily, but not exclusively, focused on younger adults. Although young adulthood is a period when people are especially prone to heavy episodic drinking, there may be developmental differences in the occurrence and severity of hangover symptoms across the lifespan even when controlling for the known age-related changes in the volume of alcohol consumed (Chen, Dufour, & Yi, 2004/2005). Research using animal models suggests that adolescent rodents, as compared to their adult counterparts, are insensitive to various acute alcohol withdrawal symptoms, such as anxiety, social suppression, and hyperthermia (Brasser & Spear, 2002; Doremus, Brunell, Varlinskaya, & Spear, 2003; Varlinskaya & Spear, 2004). It is not clear whether these findings would generalize to hangover, however, because acute withdrawal and hangover involve different hormonal, hemodynamic, and central nervous system changes (Prat et al., 2009).

Few studies have examined age-related differences in hangover symptoms in humans. Decreases in the frequency of hangover have been observed with increasing age (Piasecki et al., 2005; Piasecki et al., 2012; Tolstrup, Stephens, & Grønbæk, 2014), albeit not consistently (Howland, Rohsenow, & Edwards, 2008). One longitudinal survey showed that frequency of heavy-drinking occasions and hangovers decreased across the college years and at 11-year follow up (Piasecki et al., 2005). Similarly, a large epidemiological survey of men and women ages 18 to 94 years found that the occurrence of hangovers following binge drinking decreased with increasing age while controlling for the usual amount of alcohol consumed, frequency of binge drinking (more than five drinks per episode), and the proportion of alcohol consumed with meals (Tolstrup et al., 2014). In the only, to our knowledge, ecological study of age effects on hangover, Piasecki and colleagues (2012) showed a slight age-related decrease in hangover endorsement the morning after drinking among social drinkers ages 18 to 70. Additional prospective information is needed to complement evidence for general associations between drinking habits and occurrences of hangovers. In addition, studies may move beyond exploration of age-related differences in the likelihood of hangover occurrence and examine instead the potential relation of age and severity of hangover symptoms.

Research on the association between hangovers and subsequent drinking is also almost nonexistent. According to learning theory, the aversive nature of hangover symptoms should serve a protective function by deterring future drinking. Alternatively, alcohol consumption could also be used to alleviate hangover symptoms, leading to rapid onset of drinking in some individuals. Only one event-level prospective study has investigated whether hangover (dichotomized as yes/no) predicted subsequent drinking behavior, specifically the time to the onset of the next drinking episode. Using data collected in real time in participants' natural environment, Epler and colleagues (2014) found that having any hangover the morning after drinking was associated with increased time to next drink in a community-based sample of social drinkers. The median survival time was approximately 6 hours longer after drinking episodes with hangovers compared to those without. This association became non-significant, however, when person- and day-level predictors were included in the model, and results showed significant interactions such that hangover was associated with longer delays in time to next drink when craving levels recorded at the end of the prior night's drinking episode were higher and when financial stress occurred during the past day. Although this initial study provided the first prospective evidence that the occurrence of hangovers influences a particular facet of future drinking under specific conditions, the majority of participants were young adults, ages 18 to 25 years, thereby precluding inferences about age-related differences in these associations. Additionally, dichotomizing hangover as present versus absent may be insensitive to important variations in the underlying construct thereby lowering power to detect associations and inflating the type 2 error rate. Finally, other important drinking-related behaviors (e.g., the likelihood of drinking, quantity of alcohol use) were not examined.

The purpose of the present study was to advance our understanding of age-related differences in the association between drinking levels and next day hangover severity. We also examined the relationship between hangover severity and subsequent drinking and explored whether this association differed as a function of age. Data were pooled from four studies of non-treatment seeking drinkers who ranged in age from 15 to 66 years. This is the first prospective study, to our knowledge, to use ecological momentary assessment (EMA) methods to test the effects of age on hangover severity and its relationship with subsequent drinking. In addition to explicitly testing for age differences, this work extends prior studies by measuring hangover severity in real time in the natural environment and by testing the prospective relationship between hangover severity and subsequent drinking while controlling for average daily quantities of alcohol consumption. Based on recent findings from epidemiological survey research (Tolstrup et al., 2014), we hypothesized a negative association between age and hangover severity when controlling for average drinking levels, such that adolescents and younger adults would experience greater hangover severity than older adults. Given the dearth of research on how hangover symptoms influence subsequent drinking levels, we also explored whether hangover severity reported in real time each morning would be associated with the likelihood and quantity of alcohol use later that day and examined whether this association differed as a function of age. Finally, we explored sex differences for all age-hangover relations. Although recent ecological and biometric analyses do not suggest sex differences in the likelihood of experiencing hangover (Piasecki, Alley, Slutske et al., 2012; Slutske, Piasecki, Nathanson, Statham, & Martin, 2014), no studies to date have evaluated whether sex influences age-related discrepancies in hangover severity.

Methods

Participants

The study sample consisted of participants from four separate clinical trials conducted by the same research group between 1998 and 2014. All studies were randomized, placebo-controlled trials initially designed to test the effects of a medication on alcohol- or cannabis-related outcomes among nontreatment-seeking individuals recruited from the community. In all four trials, participants completed a baseline assessment of alcohol habits followed by a premedication EMA monitoring period, which constitutes the focus of this study. Together, the four samples contain participants who range in age from 15 to 66 years, allowing a robust test of age-related influences on hangover.

The first trial (Sample 1) consisted of adolescent drinkers, ages 15 to 19 years, recruited from the community for a pharmacotherapy study on drinking and reactions to alcohol. Youths were excluded for the following reasons: prepubescent; history of alcohol treatment or treatment-seeking; opiate use in the past 30 days or opiate use disorder; positive toxicology screen for narcotics, amphetamines, sedative hypnotics, or opiates; clinically significant alcohol withdrawal; actively suicidal or psychotic, and medical conditions or medications that contraindicated taking the medication studied in the larger trial (Miranda et al., 2014). The second trial (Sample 2), which is currently ongoing, has identical participant selection criteria as Sample 1, except that ages 20–24 are also included.

The third trial (Sample 3) consisted of alcohol users aged 15–24, 28% of whom met criteria for alcohol abuse or dependence, recruited from the community for a pharmacotherapy study on smoking and reactions to cannabis. Eligible youths consumed cannabis ≥ 2 days per week in the past 30 days and were able to read simple English for EMA purposes. Youths were excluded for the following reasons: history of cannabis treatment or treatment seeking; positive toxicology screen for narcotics, amphetamines, sedative hypnotics, or opiates; clinically significant alcohol withdrawal; actively suicidal or psychotic, and medical conditions or medications that contraindicated taking the medication studied in the larger trial.

The fourth trial (Sample 4) included participants 21 or older who drank 4 or more days per week and reported an average of 8 heavy drinking days per month. Exclusion criteria were current substance abuse or dependence other than nicotine and alcohol, prior treatment or seeking treatment for alcohol or drug use, positive urine opiate screen, or medical conditions or medications that contraindicated taking the medication studied in the larger trial (Tidey et al., 2008). Across all four samples, females were ineligible if they were pregnant, nursing, or unwilling to use birth control. A description of the participants from each sample is provided in Table 1. The Brown University Institution Review Board approved these studies.

Procedures

Volunteers completed a telephone screen and those who appeared eligible underwent additional in-person screening. Consent was obtained from participants who were ≥18 years of age and from parents of minors; minors provided assent. Following a baseline assessment session, participants completed a 4- to 14-day (M = 7.46, SD = 1.13) premedication EMA monitoring period. This report focuses on the data participants recorded each morning upon waking regarding the number of standard alcoholic drinks they consumed the prior day and their hangover symptoms in the moment. Participants were not instructed to reduce or otherwise alter their drinking.

Measures

Alcohol use—Baseline drinking was assessed using the 90-day Timeline Follow-back interview (TLFB; Sobell & Sobell, 1992). Alcohol use during the monitoring period was assessed by EMA and TLFB. Each morning, participants recorded the number of standard alcoholic drinks they consumed the prior day on the electronic device. The EMA data obtained from the morning reports were our primary measure of drinking, with missing data culled from the TLFB.

Hangover symptoms—Each morning, participants rated a subset of four hangover symptoms (*hangover*, *nauseous*, *headache*, and *dizzy*) from the Acute Hangover Scale (Rohsenow et al., 2007) in real time in the natural environment. Items were rated on a 0 (*Not At All*) to 10 (*Extremely*) scale (changed from the original to be consistent with other EMA ratings being made) and were combined into a mean score (Cronbach's alpha = 0.88).[1]

Demographic and clinical characteristics—Participants completed baseline assessments of demographic and clinical characteristics and were weighed in our laboratory. AUD diagnoses were derived using the Kiddie Schedule for Affective Disorders for School-Age Children for Samples 1, 2, and 3 (Kaufman et al., 1997). Diagnoses were derived using the Structured Clinical Interview for DSM-IV Axis I Disorders, Fourth Edition (DSM-IV) - Patient Version (First, Spitzer, & Gibbon, 1995) for Sample 4.

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[1]We repeated all models using the single item hangover rating. These analyses produced the same pattern of significant results as those reported here.

Analytic Approach

Descriptive statistics were calculated for each sample, including means and standard deviations for continuous variables and percentages for categorical variables. Given that participants provided multiple reports of hangover severity and drinking behavior across the monitoring period, we tested our hypotheses using two-level (observations within participants) generalized estimating equation (GEE) models (Zegar, Liang, & Albert, 1988). This approach accommodates varying numbers of observations across individuals while controlling for autocorrelation and without biasing results. Days were sorted according to each participant's sleep-wake schedule (e.g., 8 am to 3 am) rather than calendar day. An independent structure provided the best fit for the data and the models assumed a normal link function when the dependent measure was continuous (i.e., hangover severity, daily drinking volumes) and a logit link function when the outcome was binary (i.e., likelihood of drinking). Analyses were performed using SPSS, version 22.0 (IBM, Armonk, NY).

Our hypothesis concerned age-related influences on the association between volumes of alcohol consumption and next-day hangover severity. Specifically, we estimated a model to predict hangover severity reported in real time in the natural environment from age and the number of standard drinks consumed the prior day. Given our primary interest in within-person effects, our daily drinking volume variable was calculated as a deviation from each participant's average drinking volume (i.e., each person's mean drinking volume was subtracted from their daily drinking volume). Thus, our daily drinking volume variables reflect fluctuations from each person's average drinking volume. In addition, we included average (i.e., person-mean) drinking-volume variables in all models to remove between-person variance from our within-person predictors, thereby isolating within-person associations between changes in daily drinking volumes and hangover severity independent of any between-person relations (Enders & Tofighi, 2007; Palta, 2003). The resultant within-person effect examines the association between an individual's drinking level the prior day on his or her hangover severity while the between-person effect reflects their typical (average) volume of alcohol consumed during the monitoring period. We used z scores to detect outlier values (≥ 3.25) for the alcohol volume predictor variable. These cases (n = 9) were reassigned a raw score one unit larger than the next most extreme score (Tabachnick & Fidell, 2007). Hangover severity required transformation (logarithmic) to correct for positive skewness. The potential for sex differences in age-related differences in next-day hangover severity was explored in final models through the addition of full factorial interactive effects for sex (coded −1 for females and 1 for males), age, and within-person prior day drinking volume.

Our exploratory analyses concerned whether severity of hangovers predicted the likelihood and volume of alcohol consumed later that day and whether these effects were influenced by age and sex. Similar to the tests of our primary hypotheses, we created a daily hangover severity variable by centering hangover ratings at the person mean and included between-person hangover severity in the models. The resultant within-person effect examines the association between an individual's hangover severity on his or her drinking later that day while the between-person effect reflects their typical (average) hangover severity across the monitoring period. We first tested whether severity of hangover symptoms predicted the likelihood of drinking later that day by categorizing drinking as a binary dependent variable (no drinking = 0, any drinking = 1). We then conducted a separate model to predict the volume of alcohol consumed on drinking days. The dependent variable was the quantity of alcohol consumed (in number of standard drinks) on drinking days, which required transformation (logarithmic) to correct for positive skewness. All models examined the main and interactive effects of age, sex, and severity of hangover symptoms on subsequent drinking each day.

For all analyses, we limited our models to occasions that followed drinking days. In all models, continuous variables were standardized ($M = 0$, $SD = 1$) to ease interpretation of results; the model coefficients represent differences in standard deviation units associated with the predictors. We also reran all models to examine whether initial findings were upheld when person-level covariates (i.e., alcohol dependence, baseline drinking levels, and weight) and the data source (i.e., sample) were included. Data source was dummy coded with the first sample (Sample 1) used as the reference category.[2]

Results

Sample Characteristics

Pooling data from the four samples generated a total 313 participants with EMA data. Of these participants, nine failed to record any EMA data regarding drinking or hangover and 30 were abstinent throughout the monitoring period. These 39 individuals were excluded from analyses. Characteristics of the final sample ($N = 294$) are presented in Table 1. Participants were 15 to 66 years old, with 63 participants aged 15–19 years (23.0% of the sample); 164 aged 20–29 years (59.9%); 17 aged 30 to 39 years (6.2%); 14 aged 40 to 49 years (5.1%); 13 aged 50 to 59 years (4.7%), and 3 aged 60 to 66 years (1.1%). The majority met criteria for either alcohol abuse or dependence.

As shown in Table 1, across samples participants completed an average of 7.46 monitoring days ($SD = 1.13$) and consumed alcohol on an average of 4.03 days ($SD = 2.18$). On average, males consumed 6.64 standard drinks ($SD = 3.48$) on drinking days while females consumed 5.45 standard drinks ($SD = 4.45$). These averages exceeded established thresholds for binge drinking (National Institute on Alcohol Abuse and Alcoholism, 2004).

Associations of Drinking Levels and Age on Hangover Severity

Examination of unconditional main effects showed that when participants consumed higher volumes of alcohol their hangover symptoms were more severe, $\beta = 0.25$, 95% CI [0.19, 0.31], $p < .001$. Similarly, an unconditional model of the between-person effect indicated that participants who consumed higher average volumes of alcohol across the monitoring period reported more severe hangover symptoms, $\beta = 0.25$, 95% CI [0.14, 0.35], $p < .001$. Follow-up analyses tested whether hangover severity was dependent upon the number of drinks consumed. Effects remained significant regardless of the number of drinks consumed,

[2]We also repeated all models while excluding participants recruited for the cannabis study (Sample 3). In addition, we repeated all models while excluding participants younger than 18 years or 60 and older because few participants were in these age ranges. These analyses produced the same pattern of significant results as those reported here.

*p*s for ≤ 2 and ≤ 3 drinks < 0.02, *p*s for ≤ 4 to ≤ 10 drinks < .001. The unconditional main effect of age on hangover severity was also significant, such that younger participants reported more severe hangover symptoms, β = −0.12, 95% CI [−0.22, −0.02], $p = .023$. Results of the multivariate model showed the Age × Sex × Within-person Drinking Volume interaction was not significant, β = 0.00, 95% CI [−0.07, 0.07], $p = .979$. As shown in Table 2, results of the multivariate model without the three-way interaction indicated a significant Age × Within-person Drinking Volume interaction, such that age effects on hangover severity were more pronounced when higher quantities of alcohol consumption were consumed the prior day. This interaction remained significant even when person-level covariates (i.e., weight, alcohol dependence, and baseline drinking levels) and the data source (i.e., sample) were included in the model.

Supplemental analyses in conjunction with Figures 1 and 2 explored the Age × Within-person Drinking Volume interactive effect. The left panel of Figure 1 shows the relation of age to hangover severity as a function of within-person fluctuations in prior day drinking levels. The inverse relation of hangover severity to age was stronger on above average drinking days, relative to below average days β = −0.14, 95% CI [−0.26, −0.03], $p = .016$, reflecting a stronger association of hangover severity and drinking levels at younger ages. Neither above nor below average drinking days were significantly different from average drinking days. The right panel of Figure 1 shows this relation again with within-person fluctuations in prior day drinking levels as the outcome, predicted by age and hangover severity tertiles (i.e., low, medium, high). The inverse association of within-person prior day drinking and age was significantly stronger for high hangover days, relative to low hangover days, β = −0.13, 95% CI [−0.24, −0.01], $p = .030$, also reflecting a stronger association of drinking levels and hangover severity at younger ages. Neither high nor low hangover severity days were significantly different from medium hangover severity days. Finally, Table 3 and Figure 2 illustrate this relation when age is grouped into three categories (i.e., 15–24, 25–34, and 35 + years). Significant interactive effects shown in Table 3 illustrate the diminishing relation of drinking levels and hangover severity for upper age groups, relative to 15 to 24 year olds. The standardized regression weights suggest that the effect size of this difference increases with increasing age (25–34 relative to 15–24: β = −0.17, 95% CI [−0.31, −0.03], $p = .015$; 35+ relative to 15–24: β = −0.24, 95% CI [−0.36, −0.12], $p < .001$).

Associations of Binge-Drinking Levels and Age on Hangover Severity

We conducted additional analyses to determine whether our findings varied based on whether individuals consumed 1 to 4 drinks versus 5+ drinks the prior day. The three-way interactive effect of Age × Binge × Within-person Drinking Volume was not significant, indicating that age differences were not dependent upon whether the prior day’s drinking was at a level approximating a “binge”. As shown in Table 4, the inclusion of binge episode did not change our pattern of significant results and related interactive effects did not change our pattern of significant results. The Age × Within-person Drinking Volume effect on hangover severity remained a significant (see Table 4). In addition, including sex in the model did not change the pattern of significant results.

Associations of Hangover Severity and Age on Subsequent Drinking

Drinking likelihood—Unconditional main effects showed that age was positively associated with the likelihood of drinking, Exp(B) = 2.50, 95% CI [1.83, 3.43], $p < .001$. The unconditional main effects of the between- and within-person hangover severity variables were not significant, Exp(B) = 0.95, 95% CI [0.82, 1.11], $p = .511$ and Exp(B) = .98, 95% CI [0.85, 1.12], $p = .746$, respectively. Results of the multivariate model showed the Age × Sex × Within-person Drinking Volume interaction was not significant, Exp(B) = 0.89, 95% CI [0.64, 1.24], $p = .497$. As shown in Table 5, results of the multivariate model without the three-way interaction showed no significant two-way interactions between age, sex, and hangover severity.

Drinking volume—Tests of univariate effects indicated that a significant unconditional main effect of within-person hangover severity, such that increases in hangover severity in the morning was associated with decreased levels of alcohol consumption later that day, $\beta = -0.06$, 95% CI [−0.12, 0.00], $p = .047$. Unconditional between-person individual differences in hangover severity were also significantly related to drinking levels, such that individuals with higher average levels of hangover across the monitoring period also consumed higher volumes of alcohol on average on drinking days, $\beta = 0.18$, 95% CI [0.09, 0.27], $p < .001$. The unconditional main effect of age on drinking volume was not significant, $\beta = -0.04$, 95% CI [−0.15, 0.07], $p = .494$. Results of the multivariate model showed the Age × Sex × Within-person Drinking Volume interaction was not significant, $\beta = 0.01$, 95% CI [−0.07, 0.09], $p = .886$. As shown in Table 5, results of the multivariate model without the three-way interaction showed no significant two-way interactions between age, sex, and the hangover severity variables on the volume of alcohol consumed on drinking days. Taken together, unconditional tests show general associations of between-person hangover and volume of alcohol consumption. However, on mornings when an individual experienced more severe hangovers, he or she consumed lower volumes of alcohol later that same day, and this association did not vary as a function of age.

Discussion

In this study, we used EMA methods to prospectively examine event-level associations between drinking and hangover symptoms in the natural environment, and we tested whether these associations differed as a function of age and sex. Our findings provide the first event-level evidence that age influences the effects of alcohol on the severity of next-day hangover symptoms in a sample of adolescent and adult heavy drinkers. Specifically, we found that younger participants experienced more severe hangover symptoms than older participants, especially after consuming greater quantities of alcohol, and the size of this effect increased with increasing age. These age differences remained significant after controlling for weight, alcohol dependence, and baseline drinking levels. In addition, findings did not vary by sex and were reflected over the full range of drinking quantities, not just at levels approximating a binge episode. These findings are consistent with a recent, large-scale epidemiological survey with a more broad age range (i.e., 18 to 94 years) that showed that the association between average drinking levels and the occurrence of hangovers decreased with increasing age (Tolstrup et al., 2014). This study builds on prior work by testing temporally-sequenced hypotheses about the event-level association of alcohol consumption during specific drinking episodes and next-day hangover symptoms in the natural environment.

Although this ecological study provided a more fine-grained picture of drinking and hangover in daily life, age effects were still cross sectional and subject to all related biases and limitations. Given the cross-sectional nature of the age variable in the present study, it is possible that people who experience severe hangovers as a result of heavy drinking have discontinued heavy drinking as they get older. Thus, older cohorts may contain self-selected individuals with lower risk of hangover causing spurious age-related differences to emerge as a result of comparing developmentally-limited heavy drinkers to chronic drinkers. This concern is further underscored by the large percentage of youth/adults in our pooled samples that met criteria for abuse or dependence. Without longitudinal research of within-person changes across a broad age range, the mechanisms of age-related differences in hangover severity remain speculative.

The increased susceptibility of youths to experience more severe hangovers after drinking, especially at higher drinking levels, has several possible explanations. First, increased drinking experience may accompany increasing age, and greater drinking experience is associated with higher acute alcohol tolerance (Hiltunen, 1997). Older people with more drinking experiences than youth may be more tolerant to the effects of alcohol, including hangovers. Similarly, older and more experienced drinkers may be more practiced at altering their drinking habits to avoid hangovers. For example, the use of other drugs or smoking in conjunction with alcohol has been shown to increase hangover severity (Jackson, Rohsenow, Piasecki, Howland, & Richardson, 2013), providing controllable sources of effects on hangover. Second, a few controlled studies report less severe hangovers after consumption of beverages with more pure ethanol, such as gin or vodka, versus beverages with more congeners (toxic chemicals inherent in the brewing or ageing process or added for flavorings) such as beer, whiskey, brandy, or red wine (see review by Rohsenow & Howland, 2010), and youth may preferentially drink beer over the pricier liquors. Third, developmental differences in neurological development or alcohol metabolism may mediate the risk for hangover severity, such that different stages of development or incomplete development may increase risk for feeling greater hangover after drinking.

We also found that on mornings when individuals experienced more severe hangover symptoms they consumed less alcohol later that same day if they drank, regardless of age. Yet, hangover severity did not affect the likelihood of drinking. Several aspects of these findings are noteworthy. First, our finding that hangover severity impacted subsequent drinking levels later that same day indicates that our window of assessment, albeit short, was sufficient to capture hangovers' effects on subsequent behavior. The time course of our findings generally converged with those from Epler and colleagues (2014) who found the occurrence of hangover extended the time to the next drinking occasion by an average of 6 hours. Together these studies show that hangover symptoms serve as a deterrent for subsequent drinking levels and that this effect occurs quickly despite the delayed nature of the onset of hangover symptoms relative to the offset of drinking. That said, although we found that more severe hangover symptoms were associated with lower levels of subsequent drinking later that same day, the magnitude of this effect was quit small. It is possible hangover symptoms exert more potent effects on drinking levels over the longer term and that our relatively short assessment window hampered our ability to detect larger effects. Second, our finding that hangover reduced how much alcohol individuals consumed on subsequent drinking days but it did not affect the likelihood of drinking suggests that hangover symptoms may serve as indicators to curb drinking levels rather than to abstain from alcohol altogether. It is possible that drinkers learn to curtail their volume of alcohol consumption when they experience more severe hangover symptoms whereas external factors (e.g., social context) and alcohol expectancies rather than internal states play a more salient role in determining the likelihood of drinking. It is also plausible that less drinking on days when participants had more severe hangovers is attributable to a delayed onset of drinking, which would be consistent with findings from Epler et al. (2014). Our EMA protocol, however, did not capture the time of the last drink of the day. Therefore, we cannot examine whether hangover severity influenced the latency to next drink. Understanding how contextual factors and alcohol expectancies influence within-person variations in hangover severity and drinking would be important to examine in future work.

Unsurprisingly, we also found that individuals with higher average hangover severity across the monitoring period were also consuming greater volumes of alcohol each day, an association that did not differ as a function of age. Those who drank more heavily in this sample probably had greater opportunity to experience hangover symptoms since some evidence suggests that alcohol only produces hangover symptoms when breath alcohol concentrations reach or exceed about .10 g% (Rohsenow et al., 2007; Verster et al., 2010). Alternatively, heightened susceptibility to hangovers may reflect a broader predisposition for heavy drinking.

Limitations

Several limitations qualify our findings. First, in an effort to conduct an initial event-level examination of age-related differences in hangover severity, we pooled data from four distinct studies to comprise the sample included in this investigation. To fulfill the broader research projects, Samples 1, 2, and 4 recruited a disproportionate amount of heavy drinkers, and Sample 3 recruited cannabis users. Inasmuch as age and other potentially relevant person-level characteristics (e.g., cannabis use, substance dependence) were disproportionately represented across the four samples, pooling data from four sources may have influenced our findings. This concern is mitigated, however, by the fact that the pattern of significant findings remained the same when the data source (i.e., sample) was entered as a covariate in the models and when Sample 3, which recruited cannabis users, was removed from analyses. In addition, all of the studies used the same mode (i.e., EMA) and schedule (i.e., data recorded upon waking each morning) of assessments, and the survey questions to assess drinking volumes and hangover symptoms were identical across the projects. In addition, all four studies recruited participants for a larger randomized trial designed to test the efficacy of pharmacotherapy for alcohol or cannabis misuse. Although this may limit the generalizability of our findings, this commonality further minimizes potential concerns regarding pooling data from multiple sources.

Next, drinking outcomes are inherently limited by the short duration of our EMA monitoring period, which may have hindered our ability to detect associations between hangover symptoms and subsequent drinking. It is possible that the time course of hangovers' effects on subsequent drinking extends beyond the immediate day. For instance, individuals may learn to drink less over time if they experience repeated hangover symptoms. In addition, alcohol use among youth is often characterized by heavy episodic drinking. Therefore, youths may not drink on subsequent days and so the immediate day may be less sensitive than a longer window in this age group. In addition, while this study allowed for a prospective test of temporally sequenced relations of alcohol consumption with next-day hangover and hangover with subsequent drinking, our study was cross-sectional with regard to evaluation of age effects; longitudinal data are needed to explore within-person effects of increasing age on hangover severity. Further, recent studies suggest that using other substances while drinking, such as nicotine, may influence hangover symptoms (Jackson et al., 2013). It is possible that concurrent use of other substances was associated with age in the present study and influenced our findings. However, we did not assess other substance use across the studies from which the data were pooled. Understanding the influence of other substance use and other event-specific contextual factors will be an important endeavor for future research. In addition, although this study provides important new information about the associations between drinking, hangover severity, and age, our sample size is too small for finer grained analyses regarding the specific age at which the association between drinking and hangover severity meaningfully changes.

Last, several aspects of our assessment approach warrant consideration. Although our EMA protocol captured hangover symptoms in real time in the natural environment, each morning participants still retrospectively reported on the prior day's alcohol consumption. It is possible that participants' momentary level of hangover severity influenced their report of last night's drinking. Further, although our 4-item measure of hangover severity provided a more diverse measure of hangover symptoms and avoided relying on a participant's own understanding of the term "*hangover*" (Rohsenow et al., 2007; Slutske, Piasecki, & Hunt-Carter, 2003), this measure still may not have captured all relevant symptoms of hangover, some of which may be differently related to age or drinking.

Conclusion

On balance, this is the first study to test the associations between the real-time effects of drinking on hangover severity and hangover severity on subsequent same-day drinking, especially as moderated by age. Our findings add important, new information about the relationships between age, hangover severity, and subsequent alcohol use across a broad age span. An important goal for future research is to replicate our findings using a longer monitoring period in order to assess more hangover episodes per person and to capture the characteristics of hangovers and subsequent drinking that are independent of within-week variations, such as significant life events. In addition, although the ecological setting and ability to test temporal relations of hangover and drinking are strengths of this study, longitudinal research is an important next step in understanding changes in hangover with increasing age.

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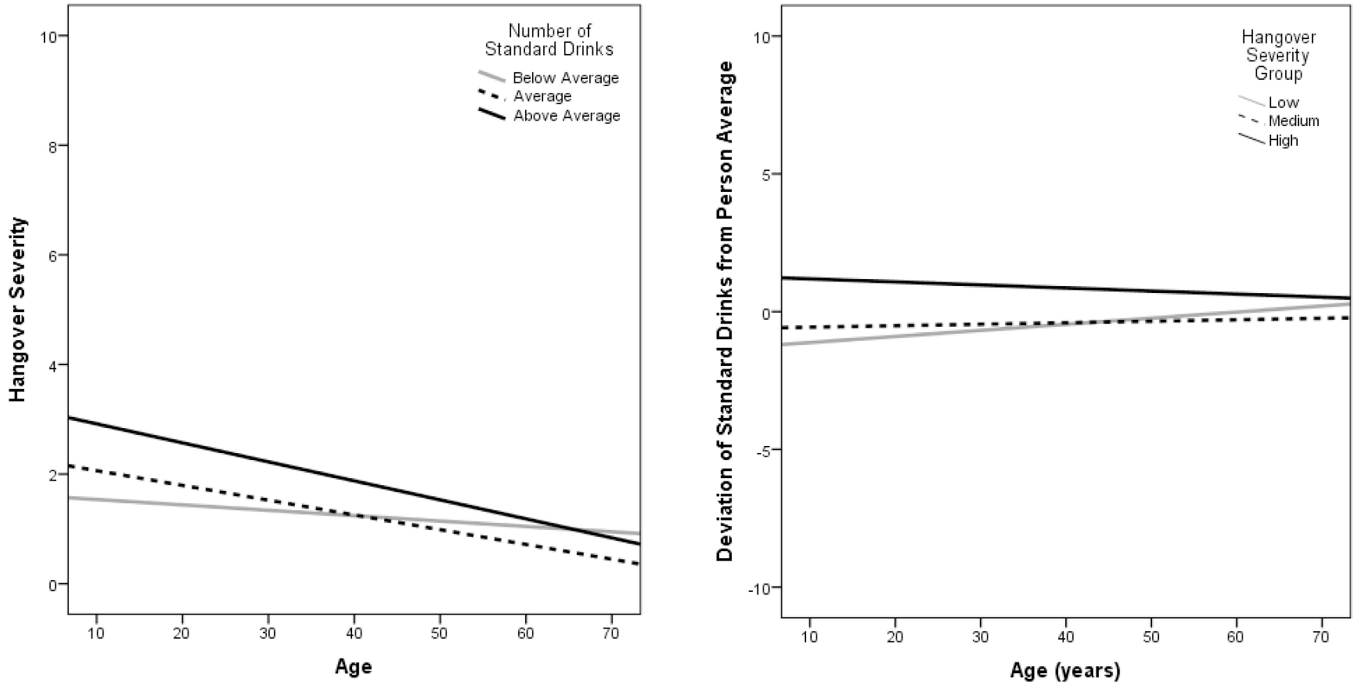

Figure 1.

Observed hangover severity (0–10 scale) as a function of age. The left panel shows the association between hangover severity and age as a function of within-person fluctuations in prior day drinking levels. Best fitting lines for the number of standard drinks consumed the prior day relative to each participant's average number of standard drinks are illustrated. The right panel shows the association between within-person fluctuations in prior day drinking levels, defined as deviations in the number of standard drinks individuals consumed from their average, and age as a function of hangover severity (split into tertiles for illustrative purposes). Best fitting lines for each level of hangover severity are illustrated.

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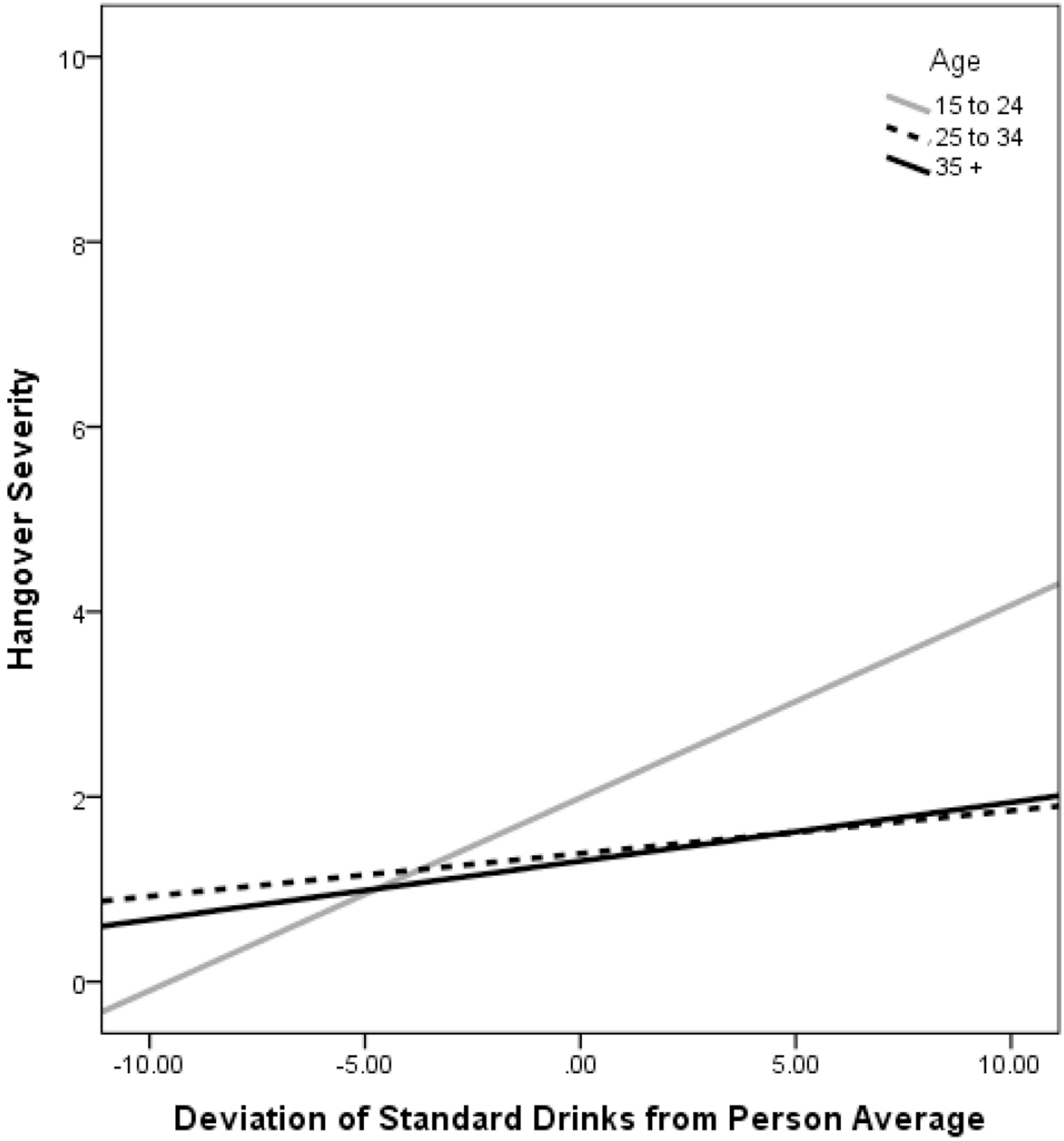

Figure 2.

Observed hangover severity (0–10 scale) as a function of within-person fluctuations in prior day drinking levels, as indicated by the deviation in the number of standard drinks consumed from their average. Best fitting lines for age groups are illustrated.

Table 1

Summary of Descriptive Statistics

Variable	Sample 1 (*n* = 28)	2 (*n* = 14)	3 (*n* = 60)	4 (*n* = 172)	Overall (*N* = 274)
Age					
Observed Range	15 – 19	15 – 24	15 – 24	21 – 66	15 – 66
M (*SD*)	18.1 (1.1)	19.0 (0.9)	20.1 (1.8)	29.3 (11.7)	25.6 (10.4)
Sex, # (%) female	16 (57)	6 (43)	30 (50)	73 (42)	125 (46)
Race, # (%)					
Caucasian	20 (71.4)	10 (71.4)	35 (58.3)	159 (92.4)	224 (81.8)
African-American	3 (10.7)	2 (14.3)	15 (25.0)	7 (4.0)	27 (10.0)
American Indian	1 (3.5)	0	0	1 (0.5)	2 (0.01)
Asian/Pacific Islander	3 (10.7)	1 (7.1)	4 (6.7)	1 (0.5)	9 (0.03)
Hispanic, # (%)	5 (17.9)	3 (24.1)	11 (18.3)	3 (0.2)	22 (8.0)
Alcohol Use Disorder, # (%)					
Abuse	8 (28.6)	1 (7.1)	7 (11.7)	35 (20.3)	51 (18.6)
Dependence	13 (46.4)	9 (64.2)	10 (16.7)	102 (59.3)	134 (48.9)
Baseline drinking levels [a]					
% drinking days, *M* (*SD*)	28.4 (16.9)	29.2 (14.1)	18.7 (14.0)	65.6 (16.7)	49.6 (26.4)
% heavy drinking days, *M* (*SD*)	15.6 (18.6)	12.8 (10.1)	10.8 (10.4)	45.2 (19.3)	32.9 (23.5)
Drinks per drinking day, *M* (*SD*)	4.8 (3.4)	6.0 (4.1)	5.1 (2.8)	7.3 (3.3)	6.5 (3.4)
Included monitoring days					
Observed range	5 – 13	4 – 10	6 – 8	5 – 14	4 – 14
M (*SD*)	6.61 (1.55)	6.86 (1.61)	7.83 (0.44)	6.95 (1.60)	7.46 (1.13)
Drinking days in monitoring period					
Observed range	1 – 7	1 – 5	1 – 7	1 – 8	1 – 8
M (*SD*)	2.46 (1.43)	2.21 (1.31)	2.12 (1.35)	5.10 (1.85)	4.03 (2.18)
Drinks per drinking day, *M* (*SD*)[b]	4.80 (4.54)	3.50 (1.80)	4.22 (3.01)	7.18 (3.94)	6.10 (3.99)

Note

[a]Derived from the 90-day Timeline Follow-Back interview administered at baseline.

[b] Average drinks per drinking day during the monitoring period.

Table 2

Summary of GEE Model Predicting Hangover Severity as a Function of Age and Drinking

Predictor	β	*SE*	95% CI *LL*	95% CI *UL*	*p*
Age	−0.122	0.049	−0.217	−0.026	.012
Sex	−0.087	0.053	−0.191	0.018	.105
Between-person drinking volume	0.262	0.062	0.141	0.383	< .001
Within-person prior day drinking volume	0.250	0.034	0.182	0.317	< .001
Age × Sex	0.014	0.049	−0.081	0.109	.770
Age × Within-person prior day drinking volume	−0.088	0.031	−0.149	0.027	.005
Sex × Within-person prior day drinking volume	0.003	0.034	−0.064	0.071	.923

Note: Continuous measures are standardized. Sex was coded −1 for females and 1 for males. The reported coefficients represent standardized effects (effect size d). GEE = generalized estimating equation; *SE* = standard error; *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit; Between-person drinking volume = grand-mean centered average number of standard alcoholic drinks consumed on drinking days during the monitoring period and reflects the between-person effect; Within-person prior day drinking volume = person-centered number of standard alcoholic drinks consumed the day before each hangover assessment and reflects the within-person effect; The pattern of significant results remained unchanged when the data source (i.e., sample) and person-level covariates (i.e., alcohol dependence, baseline drinking levels, and weight) were included in the model. Thus, we report the results of the final model without these additional covariates to preserve statistical power. The three-way interactive effect of age, sex, and within-person prior day drinking volume was not significant, and exclusion of all main and interactive effects of sex also did not alter our pattern of significant results.

Table 3

Summary of GEE Model Predicting Hangover Severity as a Function of the Within-person Prior Day's Drinking Volume by Age Group

Model	β	*SE*	95% CI *LL*	95% CI *UL*	*p*
Within-person prior day drinking volume	0.33	0.04	0.25	0.41	< .001
15 to 24 (*reference*)	—	—	—	—	—
25 to 34	−0.21	0.16	−0.53	−0.11	.192
35 to 66	−0.35	0.14	−0.64	−0.07	.015
15 to 24 × Within-person prior day drinking volume (*reference*)	—	—	—	—	—
25 to 34 × Within-person prior day drinking volume	−0.17	0.07	−0.31	−0.03	.015
35 to 66 × Within-person prior day drinking volume	−0.24	0.06	−0.36	−0.12	< .001

Note: GEE = generalized estimating equation; *SE* = standard error; *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit

Table 4

Summary of GEE Model Predicting Hangover Severity as a Function of Age, Drinking Volume, and Binge Drinking

			95% CI		
Predictor	**β**	***SE***	***LL***	***UL***	***p***
Age	−0.11	0.05	−0.20	−0.01	.026
Binge	0.15	0.06	0.03	0.27	.016
Between-person drinking volume	0.17	0.07	0.04	0.31	.011
Within-person prior day drinking volume	0.20	0.05	0.11	0.30	< .001
Age × Binge	−0.05	0.04	−0.13	0.03	.191
Binge × Within-person prior day drinking volume	−0.03	0.04	−0.11	0.05	.446
Age × Within-person prior day drinking volume	−0.07	0.03	−0.13	0.00	.046

Note: Continuous measures are standardized. Day were coded −1 for when participants consumed 1 to 4 standard drinks the prior day and 1 when participants consumed ≥ 5 standard drinks the prior day. The reported coefficients represent standardized effects (effect size d). GEE = generalized estimating equation; *SE* = standard error; *CI* = confidence interval; *LL* = lower limit; *UL* = upper limit; Between-person drinking volume = grand-mean centered average number of standard alcoholic drinks consumed on drinking days during the monitoring period and reflects the between-person effect; Within-person prior day drinking volume = person-centered number of standard alcoholic drinks consumed the day before each hangover assessment and reflects the within-person effect. The three-way interactive effect of age, binge episode, and within-person prior day drinking volume was not significant.

Table 5

Summary of GEE Model Predicting Drinking from Age and Hangover Severity

	Dependent Measures					
	Likelihood of Drinking [a]			Volume of Alcohol Use [b]		
Predictor	**Exp(B)**	**95% CI**	***p***	**β**	**95% CI**	***p***
Age	2.569	[1.804, 3.658]	< .001	0.001	[−0.110, 0.111]	.993
Sex	1.041	[0.849,1.278]	.698	0.188	[0.083, 0.294]	< .001
Between-person hangover severity	1.050	[0.906, 1.217]	.519	0.180	[0.088, 0.272]	< .001
Within-person hangover severity	0.894	[0.724, 1.103]	.294	−0.055	[−0.122, 0.013]	.111
Age × Sex	1.023	[0.741, 1.411]	.891	−0.002	[−0.110, 0.106]	.975
Age × Within-person hangover severity	0.817	[0.576, 1.160]	.258	0.028	[−0.051, 0.106]	.490
Sex × Within-person hangover severity	1.082	[0.946, 1.236]	.250	0.037	[−0.025, 0.099]	.246

Note. Continuous measures are standardized. Sex was coded −1 for females and 1 for males. The reported coefficients represent standardized effects (effect size d). Between-subject hangover severity = grand-mean centered average hangover severity during the monitoring period and reflects the between-person effect; Within-person hangover severity = person-centered hangover severity during the monitoring period and reflects the within-person effect. The pattern of significant results remained unchanged when the data source (i.e., sample) and person-level covariates (i.e., alcohol dependence, baseline drinking levels, and weight) were included in the model. Thus, we report the results of the model without these additional covariates to preserve statistical power. GEE = generalized estimating equation; CI = confidence interval;

[a] Binary outcome (0 when participants abstained versus 1 when participants reported any alcohol use).

[b] Continuous outcome (# of standard drinks consumed each drinking day). The three-way interactive effect of age, sex, and within-person prior day drinking volume was not significant, and exclusion of all main and interactive effects of sex also did not alter our pattern of significant results.