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ORIGINAL ARTICLE

Alcohol Hangover, Sleep Quality, and Daytime Sleepiness

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Abstract
Purpose Heavy drinking has been shown to disrupt sleep, increase sleepiness the next day, and produce symptoms collectively referred to as "hangover". A survey was conducted to determine the impact of heavy alcohol consumption on sleep, daytime sleepiness, and hangover severity.
Methods $N = 335$ adults, experienced with alcohol hangover, completed a survey of sleep quality, daytime sleepiness, and hangover symptoms comparing a heavy drinking occasion with a non-alcohol occasion. Data from those who reported >5-h sleep on the alcohol occasion were compared to those reporting <5-h sleep.
Results Participants consumed on average 22.4 (SD 16.8) alcoholic drinks per week. On their last heavy drinking session that produced a hangover, the number of alcoholic drinks they consumed equaled 14.3 (SD 8.2). Relative to a normal night of sleep, sleep quality was significantly worse after the last drinking session ($p < 0.006$), and the following day daytime sleepiness was significantly increased ($p < 0.0001$). When controlling for alcohol quantity, daytime sleepiness significantly correlated to overall hangover severity, whereas sleep quality and duration did not.
Conclusion Heavy alcohol consumption significantly reduces sleep quality, and significantly increases daytime sleepiness the following day.

Keywords Sleep · Sleepiness · Smoking · Alcohol · Hangover

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1 Introduction

The effects of low dosages of alcohol on sleep quality and next-day alertness have been studied previously. These studies consistently show that alcohol impairs sleep quality and increases next-day sleepiness. For example, Roehrs et al. examined sleep quality in five healthy subjects [1]. Before going to bed, they consumed alcohol (0.8 g/kg) to reach a peak blood alcohol concentration (BAC) of 0.06%. Although the dosage of alcohol was relatively low, there were profound effects of alcohol on sleep. Alcohol significantly reduced sleep latency and percent of REM sleep. In the first 4 h of the night, alcohol significantly increased the time spent in sleep stage 3 and 4 (deep sleep), whereas in the second half of the night time spent in stage 1 sleep (drowsy light sleep) was significantly increased. The observation of increased stage 1 sleep implies that sleep during the second half of the night, when blood alcohol levels are reaching zero, is relatively light and sleep maintenance may be easily compromised by external stimuli such as noise or light. The day following the experimental night, participants reported mild hangover effects that were primarily characterized by thirst. During the day, Roehrs et al. tested sleepiness using the Multiple Sleep Latency Test (MSLT). After alcohol compared to placebo the previous night, subjects fell asleep significantly faster throughout the day on the MSLT. Similar findings

with low dosages of alcohol were found in several other studies [2, 3].

Only few studies used higher alcohol dosages to provoke a next-day alcohol hangover, and also assessed sleep and sleepiness the next day. For example, Rohsenow et al. examined perceived sleep quality in 61 merchant marine cadets after an evening of alcohol consumption (peak BAC of 0.115%) or placebo [4]. All subjects were allowed a full 8-h sleeping period and completed the same sleep quality ratings as used by Roehrs et al. [1]. Subjects reported improved perceived sleep quality and a decreased latency to sleep onset after the alcohol session. No difference in perceived sleep duration was reported between the placebo and alcohol condition.

In a subsequent study, social drinkers consumed low and high congener alcoholic beverages to achieve a peak BAC of 0.11% [5]. Sleep quality and duration was assessed with polysomnography, and next-day hangover severity and subjective sleepiness were assessed. After both type of beverages, alcohol decreased sleep efficiency and rapid eye movement sleep and increased wake time. Also, next-day sleepiness was significantly increased during hangover, and sleepiness scores correlated significantly with hangover severity.

Unfortunately, due to ethical constraints, achieved BAC levels in controlled studies usually do not reach BAC levels seen in nightlife [6]. In this context, a recent study with a naturalistic design (i.e., participants alcohol consumption is not influenced by the researchers) revealed an estimated peak BAC of 0.18% [7]. Therefore, the aim of this study was to further examine the relationship between sleep quality and duration, and the presence or severity of hangover symptoms, experienced in real life.

2 Methods

Dutch adults were asked whether or not they had experienced an alcohol hangover during the past year. Approximately half answered affirmatively, and these subjects we asked to complete a survey to examine alcohol consumption, hangovers and sleep. A total of $N = 335$ surveys were completed at various locations in cities of the province of Utrecht, The Netherlands. Informed consent was obtained from all participants.

Sleep quality and daytime sleepiness were assessed for an average regular night and for the night after an evening of heavy drinking and the corresponding subsequent day. In addition to reporting their regular drinking habits and those on their last occasion of heavy drinking that caused a hangover, the presence of 24 hangover symptoms and their severity were rated on 11-point scales ranging from 0 (absent) to 10 (extreme).

Sleep Quality was assessed using the 14-item Groningen Sleep Quality Scale (GSQS) [8]. GSQS scores range from 0 to 14. A higher sleep quality score indicates poorer sleep. The Stanford Sleepiness Scale (SSS), a subjective measure of sleepiness/alertness, was used to assess subject's perception of their state of sleepiness/alertness [9, 10]. The SSS is a seven-point Likert scale with 7 being the most sleepy and 1 being the most alert.

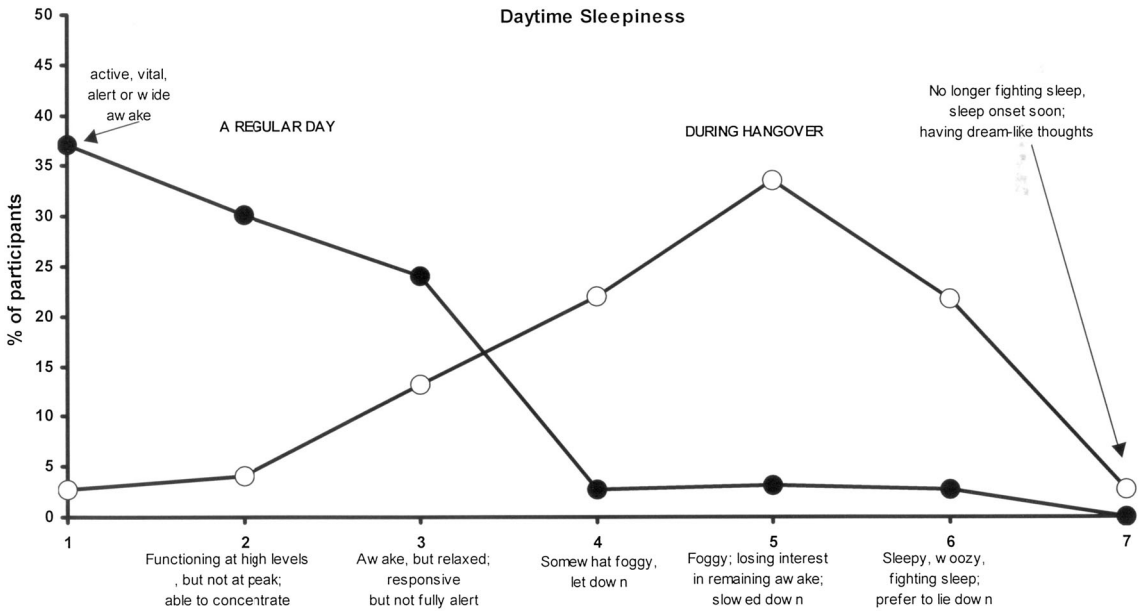

Fig. 1 Stanford Sleepiness Scale scores for a regular day and during hangover

Table 1 Presence and severity of hangover symptoms and their relationship to the number of alcoholic drinks consumed the evening before

	Presence (%)	Mean (SD) severity	Correlation with the number of alcoholic drinks (r)	Correlation with sleep quality (r)	Correlation with daytime sleepiness (r)
Overall hangover severity	100	4.5 (2.0)	0.24*	0.13	0.28*
Dry mouth	94.1	5.6 (2.6)	0.37*	0.01	0.04
Thirst	92.8	6.0 (2.6)	0.33*	−0.04	0.10
Sleepiness	92.1	5.3 (2.3)	0.06	0.15*	0.29*
Weakness	89.8	5.2 (2.6)	0.05	0.12	0.21*
Drowsiness	87.9	5.0 (2.4)	0.10	0.15*	0.26*
Headache	86.9	4.6 (2.2)	0.14*	0.07	0.25*
Reduced reaction speed	75.7	4.1 (2.3)	0.22*	0.16*	0.12
Nausea	71.1	4.1 (2.3)	−0.01	0.15*	0.16*
Concentration problems	70.2	4.2 (2.2)	0.09	0.18*	0.15*
Reduced appetite	65.9	4.4 (2.8)	0.08	0.19*	0.18*
Agitation	63.9	4.1 (2.4)	−0.03	0.16*	0.07
Apathy	63.6	4.4 (2.4)	0.20*	0.12	0.21*
Memory problems	63.6	4.0 (2.4)	0.10	−0.02	0.10
Sweating	63.0	3.8 (2.3)	0.24*	0.16	0.09
Coordination problems	62.6	3.4 (2.2)	0.17*	0.13*	0.10
Sensitivity to light	60.3	3.6 (2.4)	0.10	0.06	0.09
Dizziness	58.7	3.4 (2.3)	0.13	0.24*	0.21*
Shaking	50.5	3.7 (2.6)	0.18*	0.22*	0.07
Stomach pain	49.5	3.4 (2.2)	0.02	0.19*	0.14*
Hot/cold flushes	44.9	3.2 (2.3)	0.12	0.22*	0.12
Vomiting	45.2	3.6 (2.2)	−0.04	0.09	0.08
Guilt, regret	31.8	3.4 (2.4)	0.06	0.11	0.02
Depression	30.5	3.3 (2.4)	0.01	0.12	0.01
Anxiety	26.9	3.4 (2.5)	0.05	0.06	−0.03

The relationship with sleep quality and daytime sleepiness was corrected for the number of alcoholic drinks. Severity scores range from 0 = absent, 10 = extreme. Spearman's rho correlations were computed. Significant correlations ($p < 0.05$) are indicated by *

2.1 Statistical Analyses

Data from subjects who used drugs other than alcohol and nicotine during the drinking session were excluded from the analyses. Scores on sleep quality and daytime sleepiness for a regular night and after the heavy drinking session were statistically compared using ANOVA. Differences were statistically significant if $p < 0.05$. Presence and severity of hangover symptoms were correlated with the number of alcoholic drinks, sleep quality and daytime sleepiness scores, controlling the latter two for the analysis on number of alcoholic drinks. In addition, presence and severity of hangover symptoms were compared between groups of habitual sleep (>5 h) and short sleep subjects (<5 h) on the night of heavy alcohol consumption. Univariate ANOVA was used with "short/habitual sleeper" as a between group factor and "number of alcoholic drinks" on the heavy drinking night as a covariate.

3 Results

Of the $N = 335$ surveys, $N = 305$ surveys (91%) were eligible for statistical analysis. Of the eligible surveys, 42 surveys were excluded because the subjects had used drugs during the drinking session. Data from the remaining 263 subjects were analyzed.

On average, participants reported consuming a mean (SD) of 22.4 (16.8) alcoholic drinks per week and smoking 8.8 (10.7) cigarettes per day. On their last heavy drinking session that produced a hangover, they consumed 14.3 (8.2) alcoholic drinks and smoked 13.2 (14.6) cigarettes during the night.

Relative to their habitual night of sleep, Sleep Quality was significantly worse after the drinking session that produced the hangover ($F_{1,250} = 7.6$, $p < 0.006$). On the hangover day, daytime sleepiness was significantly elevated ($F_{1,249} = 682.3$, $p < 0.0001$). This is illustrated in Fig. 1.

When controlling for the number of consumed alcoholic drinks, the difference in daytime sleepiness after a normal night or after a night of heavy drinking remained significant ($F_{1,235} = 170.8$, $p < 0.0001$). However, when controlling for the number of alcoholic drinks, sleep quality did not differ from their habitual night.

Women reported consuming significantly less alcohol ($p < 0.0001$) when compared to men; however, daytime sleepiness and sleep quality did not differ between men and women.

Table 1 presents the frequency and severity of hangover symptoms and their relationship to the number of alcoholic drinks that were consumed, sleep quality and daytime sleepiness.

Hangover severity correlated significantly with the amount of consumed alcohol ($p = 0.0001$), as did a number of individual hangover symptoms. Hangover severity correlated with daytime sleepiness ($p = 0.0001$), but not with sleep quality ($p = 0.069$). However, sleep quality and daytime sleepiness were significantly associated with the presence and severity of various individual hangover symptoms (see Table 1).

To further examine the relationship between sleep quality and hangover symptom severity, subjects were divided into two groups comprising those who reported sleeping less than 5 h and those who slept more than 5 h on the night of the heavy drinking.

When controlling the number of alcoholic drinks that were consumed, no significant differences were observed in overall hangover severity ($F_{1,243} = 0.46, p < 0.50$) between those who slept less than 5 h and those who had a habitual night of sleep. This is consistent with the result that when correcting for the number of alcoholic drinks consumed, most individual hangover symptoms did not differ significantly between normal subjects and those who reported sleeping less than 5 h. Although anxiety ($F_{1,238} = 4.80$, $p < 0.029$) and impulsivity ($F_{1,236} = 5.53, p < 0.020$) were significantly different between the groups, severity scores for these symptoms were low (0–2 out of 10), confirming that they are not core symptoms of the alcohol hangover state, nor profound effects of sleep duration.

Daytime sleepiness ($F_{1,238} = 0.03$, $p < 0.86$) did not significantly differ between the groups. As expected, sleep quality ($F_{1,241} = 13.9$, $p < 0.0001$) differed significantly between short and habitual sleepers, indicating that sleep duration has a direct effect on perceived sleep quality.

4 Conclusions

This study confirms the previous reports that heavy alcohol consumption significantly and negatively affects sleep quality and increases next-day sleepiness [4, 5]. In those who have a daytime job, time spent drinking often goes at the expense of the time spent in bed. Indeed, those who report sleeping less hours also report a higher weekly alcohol consumption and an earlier age of drinking onset [11, 12]. Given this, more research, including polysomnographic recordings, is needed to examine the impact of alcohol consumption on sleep and the relationship between sleep quality and the presence and severity of next-day hangover symptoms.

Compliance with Ethical Standards

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Conflict of interest Joris Verster has received grants/research support from the Dutch Ministry of Infrastructure and the Environment, Janssen Research and Development, Nutricia, Red Bull and Takeda, and has acted as a consultant for the Canadian Beverage Association, Centraal Bureau Drogisterijbedrijven, Coleman Frost, Danone, Deenox, Eisai, Janssen, Jazz, Purdue, Red Bull, Sanofi-Aventis, Sen-Jam Pharmaceutical, Sepracor, Takeda, Transcept, Trimbos Institute, and Vital Beverages. Thomas Roth has received grants/research support from Aventis, Cephalon, GlaxoSmithKline, Neurocrine, Pfizer, Sanofi, Schering-Plough, Sepracor, Somaxon, Syrex, Takeda, TransOral, Wyeth and Xenoport; has acted as a consultant for Abbott, Acadia, Acoglix, Actelion, Alchemers, Alza, Ancil, Arena, AstraZeneca, Aventis, AVER, BMS, BTG, Cephalon, Cypress, Dove, Elan, Eli Lilly, Evotec, Forest, GlaxoSmithKline, Hypnion, Impax, Intec, Intra-Cellular, Jazz, Johnson & Johnson, King, Lundbeck, McNeil, MediciNova, Merck, Neurim, Neurocrine, Neurogen, Novartis, Orexo, Organon, Prestwick, ProctereGamble, Pfizer, Purdue, Resteva, Roche, Sanofi, Schering-Plough, Sepracor, Servier, Shire, Somaxon, Syrex, Takeda, TransOral, Vanda, Vivometrics, Wyeth, Yamanuchi, and Xenoport. Timothy Roehrs has received grants/research support from Pfizer.

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