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Original Article

Effect of Moderate Alcohol Intake on Nocturnal Sleep Respiratory Parameters in Healthy Middle-Aged Men

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Abstract

Purpose: It is known that a moderate to large volume of alcohol produces deterioration in obstructive sleep apnea (OSA), however, no consensus has been achieved with respect to the influence of a moderate volume of alcohol on mild to moderate OSA. In this study, we investigated the influence of alcohol on OSA-associated parameters in healthy middle-aged males drinking a moderate volume of alcohol (<1 g alcohol/kg bodyweight per day).

Methods: Subjects were 23 healthy males (mean age of 46.0) with a habitual ingestion of moderate amounts of alcohol. Respiratory sleep parameters were measured through the fitting of an Apnomonitor III (Chest Inc.) and portable sleep monitoring device (Actiwatch: AMI Inc.) to subjects on three nights; an alcohol-free night, a night on which they drank alcohol with dinner, and a night on which they drank alcohol within 30 minutes before retiring to bed. The measurements were categorized into the early and late halves of assumed sleep for analysis.

Results: The apnea-hypopnea index was significantly higher when drinking alcohol before retiring [mean (SD): 7.8 (8.2) events/hour] than the values on the alcohol-free day [2.9 (4.5) events/hour] and when drinking alcohol with dinner [3.8 (5.3) events/hour]. Furthermore, drinking alcohol before retiring resulted in lower arterial blood oxygen saturation (SpO_2) during the early half of sleep [94.8 (1.4) %] when compared to the values on the alcohol-free day [95.7 (1.3) %] and drinking alcohol with dinner [95.4 (1.6) %]. In addition, the percentage of time with SpO_2 <92% (hypoxic event) during the early half of sleep [4.9 (9.3) %] was significantly higher than the values on the alcohol-free day [1.2 (1.8) %] and when drinking alcohol with dinner [1.4 (1.8) %].

Conclusion: These results suggest that moderate ingestion of alcohol within 30 minutes before retiring aggravates OSA-associated parameters in healthy males.

Key words: obstructive sleep apnea, alcohol intake, oxygen saturation

Introduction

The treatment of obstructive sleep apnea (OSA), a condition commonly associated with cardiovascular disease and autonomic disturbance, usually includes lifestyle modification such as avoidance or minimization of alcohol intake (1). However health practitioners frequently tell patients that alcohol, taken in moderate quantities, has beneficial effects upon cardiovascular mortality (2, 3). In particular, published guidelines suggest a "safe upper level" of four standard (10 g alcohol) drinks of alcohol per day in males before the adverse effects of hypertension, heart and liver disease develop (4–7). For an 80 kg male, this would equate to 0.5 g alcohol/kg body weight (BW).

Alcohol, consumed in large quantities (>1.0 g alcohol/kg BW/day), sufficient to increase the blood alcohol concentrations (BAC) to >0.075 g/dl, increases apnea frequency, and duration and is associated with hypoxemia in patients with OSA (8–11). However, the effects of alcohol at lower doses (0.5–1.0 g alcohol/kg BW) on OSA are less clear. The consumption of 0.5 g alcohol/kg BW/day (with a corresponding mean BAC of 0.075 g/dl), was associated with a significant rise in the mean apnea-hypopnea index (AHI), from 10 to 20 events/h (12). In contrast, Block et al. (13) found no difference in the AHI (2.8 to 3.0 events/h) when subjects, with milder OSA, were given 1 g alcohol/kg BW (BAC 0.075 g/dl). Similarly, Teschler et al. (14)

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found no difference in the AHI (44–51 events/h) when males with severe OSA were given 0.5 g alcohol/kg BW (BAC 0.05 g/dl). To further understand the effects of alcohol on sleep-disordered breathing, we undertook this study to determine the effects of moderate alcohol consumption on apnea-hypopnea frequency in healthy middle-aged male subjects.

Little is known about the differences in sleep respiratory parameters with regard to timing of alcohol ingestion. In this study and as the second outcome measure, we examined the timing of moderate alcohol intake on sleep breathing abnormalities.

Methods

Subjects

After explaining the protocol of the study, informed consent was obtained from 23 apparently healthy males with a habitual moderate ingestion of alcohol and without respiratory/cardiovascular/metabolic diseases requiring treatment. The means and standard deviations of age, height, body weight, and BMI were 46.0 (3.0) years, 170.1 (4.7) cm, 69.8 (11.1) kg, and 24.1 (3.3) kg/m^2, respectively. Eight of the 23 subjects were smokers, and none of the subjects had a regular exercise habit.

Alcohol intake was calculated based on the daily recall of consumption. The alcohol concentration for beer, Japanese Sake, wine, and whisky were taken as 5%, 15.6%, 14%, and 43%, respectively. Alcohol intake [mean (standard deviation)] was 36.4 (25.6) g/day [0.5 (0.4) g alcohol/kg BW/day] when the subjects drank alcohol with dinner and 48.5 (30.5) g/day [0.7 (0.5) g alcohol/kg BW/day] when they drank alcohol before retiring, with no significant difference.

We asked subjects to adhere to the following schedule for three nights: no alcohol drinking during the day, drinking alcohol with dinner (around 7:00 pm) and drinking alcohol within 30 minutes before retiring to bed (11:00–12:00 pm). The order of measurements on the three nights was randomized.

Data acquisition

Sleep respiratory parameters were investigated using an Apnomonitor device (Apnomonitor III: Chest Inc. Tokyo, Japan). The Apnomonitor device consists of a monitoring recorder for lending to the subjects for home measurement. In the recorder, ventilation flow was monitored via a thermistor fixed in the nasal foramen, and tracheal sounds via a microphone applied to the thyroid cartilage.

Apnea-hypopnea was monitored by the flow sensor and tracheal sounds. Subjects also underwent monitoring of oxygen saturation using a digital SpO_2 (pulse oximetry) transducer. The recorded signals were processed in a computer with analytic software, and the development of apnea (more than a 10 second pause in ventilation) and hypopnea (defined as a ≥30% reduction in airflow) incidence with respect to duration, and heart rate were indicated in figures. Apnea-hypopnea index (the average number of apneas plus hypopneas per hour of sleep) was used as an outcome measure. Percentage of time with SpO_2 below 92% (hypoxic event) (15) was also calculated as a quantitative evaluation of the rate of decrease in arterial blood oxygen saturation. Takishima et al. (16) developed the Apnomonitor device in 1986 as a portable sleep apnea monitoring device for home measurement. Okada et al. (17) confirmed the reliability of the Apnomonitor device for the detection of apnea.

Measurements were performed on weekdays, and the subjects were provided with adequate explanation of the uses of the equipment (mouth/nose flow rate, tracheal sounds, arterial blood oxygen saturation, and heart rate). On the day of measurement, the subjects connected each sensor while watching the instructions for using the Apnomonitor on a videotape. To limit the influence of installation on sleep, the Apnomonitor III was used once during sleep, prior to the day of measurement.

In order to record sleep time, we used actigraphy (Actiwatch: Mini Mitter Company Inc. Bend, Oregon, USA), a method used to estimate sleep-wake rhythms by measurement of gross motor activity. Actigraphy has been established as a valid method in the assessment of sleep-wake patterns (18, 19).

The Actiwatch measures the three parameters of sleep duration, assumed sleep and actual sleep. The duration of assumed sleep was calculated by subtracting the duration of sleep latency and arousal from the duration of sleep calculated from the bedtime and wake-up time. The duration of actual sleep was calculated by subtracting the duration that was considered arousal time during sleep from the duration of assumed sleep. In this study, we used assumed sleep as the duration of sleep. Assumed sleep was also divided into early and late halves to examine to which extent alcohol may affect respiratory parameters during sleep.

Statistical analysis

Since the variables we measured in the sample were not normally distributed we used nonparametric Friedman's test to compare differences among the three experimental states. When there was a significant difference, multiple comparison analysis was performed using Wilcoxon's test. The significance level was adjusted for multiple comparison analysis. For separate analysis, we classified measured assumed sleep into early and late halves and repeated the tests. By considering a standard deviation (SD) of 4.5 events/hour for AHI, with 23 subjects there is a power of 0.65 to detect differences of 3.4 events/hour (0.75 SD) between the three nights. The data was analyzed with SPSS.

Results

The comparison of the sleep parameters measured by the Actiwatch for the three experimental states is shown in Table 1. There were no significant differences in the duration of assumed sleep (min), actual sleep percent (%), sleep efficiency (%), or sleep latency (min) between the three experimental nights.

Table 2 shows the mean (SD) of the respiratory sleep parameters for the three nights. Heart rate was higher when drinking alcohol before retiring than that on the alcohol-free day and when drinking alcohol with dinner; however, there were no significant differences. When drinking alcohol before retiring, the frequency of AHI, was highest [7.8 (8.2) events/h], with significant differences in comparison to the values on the alcohol-free day [2.9 (4.5) events/h] and when drinking alcohol with dinner [3.8 (6.2) events/h]. Percentage of time with SpO_2

Table 1 Sleep parameters [Mean (SD)] measured by Actiwatch during whole sleep for three experimental states

	Whole sleep			
	Alcohol-free day	Drinking alcohol with dinner	Drinking alcohol before retiring	p value
ASSL (h)	6.2	6.3	5.7	0.154
	(1.4)	(1.1)	(1.3)	
ACTSLP (%)	93.2	92.7	92.8	0.741
	(4.4)	(5.1)	(6.4)	
SE (%)	89.6	89.4	89.0	0.878
	(7.0)	(6.9)	(7.4)	
SL (min)	8.7	5.9	6.6	0.471
	(17.6)	(10.7)	(9.3)	

ASSL: Assumed sleep; ACTSLP: Actual sleep %; SE: Sleep efficiency; SL: Sleep latency.

Table 2 Respiratory sleep parameters [Mean (SD)] during whole sleep for three experimental states

	Whole sleep			
	Alcohol-free day	Drinking alcohol with dinner	Drinking alcohol before retiring	p value
HR	64.8	66.5	70.0	0.054
(beats/min)	(8.4)	(7.2)	(7.7)	
AHI	2.9	3.8	7.8[#$]	0.002
(events/h)	(4.5)	(5.3)	(8.2)	
SpO_2	95.7	95.7	95.2	0.011
(%)	(1.3)	(1.2)	(1.3)	
SpO_2 <92%	1.3	1.4	3.8[#$]	0.018
(time %)	(2.6)	(2.0)	(6.2)	

[$] p<0.016, Drinking alcohol with dinner vs. drinking alcohol before retiring.
[#] p<0.025, Alcohol-free day vs. drinking alcohol before retiring.

<92% was highest [3.8 (6.2) %] and significantly different when drinking alcohol before retiring, in comparison to the values on the alcohol-free day [1.3 (2.6) %] and when drinking alcohol with dinner [1.4 (2.0) %].

Respiratory sleep parameters in the early and late halves of sleep were compared among the three conditions (Table 3). In the early half of sleep, the heart rate [73.3 (7.8) beats/min] was significantly higher when drinking alcohol before retiring than that on the alcohol-free day [66.8 (8.3) beats/min] and when drinking alcohol with dinner [68.6 (7.6) beats/min]. Furthermore, when the subjects drank alcohol before retiring to bed, the SpO_2 during the early half of sleep [94.8 (1.4) %] was significantly lower than the values on the alcohol-free day [95.7 (1.3) %] and when drinking alcohol with dinner [95.4 (1.6) %]. In addition, the percentage of time with SpO_2 <92% in the early half of sleep [4.9 (9.3) %] was significantly higher than the values on the alcohol-free day [1.2 (1.8) %] and when drinking alcohol with dinner [1.4 (1.8) %].

In the late half of sleep, AHI [5.5 (5.5) events/h] was significantly higher when drinking alcohol before retiring than the values on the alcohol-free day [1.3 (1.6) events/h] and when drinking alcohol with dinner [2.8 (3.4) events/h].

Discussion

In this study the effects of moderate alcohol intake on nocturnal sleep parameters were studied. The arterial blood oxygen saturation in the early half of sleep was significantly lower when drinking alcohol before retiring than the values on the alcohol-free day and when drinking alcohol with dinner, although the values were within the normal range. Briefly, apnea during sleep was observed to some degree, but apnea-related hypoxemia was not observed.

In the pathophysiology of OSA, repeated warning responses such as hypoxemia, hypercapnia, and respiratory acidosis are important signs. Among the blood gas parameters, arterial blood hemoglobin oxygen saturation can be measured as the most stable parameter without invasiveness. The rate of decrease in SpO_2 is a representative parameter of blood gas, and may be important in indicating the grade of disorder.

During sleep, vital functions are reduced. In the respiratory system, ventilation volume per minute is decreased; however, this finding is mainly related to a decrease in tidal volume exchange. Tidal volume exchange decreases without changes in the respiratory rate, therefore, partial carbon dioxide pressure in the blood slightly increases, and partial oxygen pressure decreases. Usually, the system for sensitively detecting these abnormalities in blood gas acts, but becomes dulled during sleep.

The major finding of this study was that bedtime alcohol intake (<1 g alcohol/kg BW/day), resulted in a small but statistically significant rise in the frequency of AHI and percent of

Table 3 Respiratory sleep parameters [Mean (SD)] during early and late halves of sleep for three experimental states

	Early half of sleep				Late half of sleep			
	Alcohol-free day	Drinking alcohol with dinner	Drinking alcohol before retiring	p value	Alcohol-free day	Drinking alcohol with dinner	Drinking alcohol before retiring	p value
HR	66.8	68.6	73.3[#$]	0.018	62.9	64.3	66.7	0.026
(beats/min)	(8.3)	(7.6)	(7.8)		(9.2)	(7.1)	(8.1)	
AHI	4.5	4.8	10.0	0.032	1.3	2.8	5.5*[#$]	<0.001
(events/h)	(8.1)	(8.8)	(13.3)		(1.6)	(3.4)	(5.5)	
SpO_2	95.7	95.4	94.8[#$]	<0.001	95.7	96.0	95.6	0.200
(%)	(1.3)	(1.6)	(1.4)		(1.5)	(0.9)	(1.3)	
SpO_2 <92%	1.2	1.4	4.9[#$]	0.022	1.4	1.5	2.7	0.064
(time %)	(1.8)	(1.8)	(9.3)		(4.7)	(2.5)	(6.0)	

[#] p<0.016, Alcohol-free day vs. drinking alcohol before retiring.
[$] p<0.025, Drinking alcohol with dinner vs. drinking alcohol before retiring.
* p<0.05, Alcohol-free day vs. drinking alcohol with dinner.

time with SpO_2 <92% compared with alcohol-free and alcohol dinner nights. Moreover, mean heart rate during sleep increased significantly with bedtime alcohol. These results would suggest that the severity of obstructive sleep apnea in middle-aged men might increase with moderate alcohol consumption prior to sleep time.

Alcohol minimization or abstinence is frequently recommended in the management of patients with obstructive sleep apnea (1). Proposed mechanisms for the adverse effects of alcohol upon OSA include a selective reduction in genioglossus and hypoglossal motor nerve transmission, thereby increasing upper airway resistance (20), a reduction in arousal response (8–10) and a reduced hemoglobin affinity for oxygen (21). In addition, considerable evidence exists that alcohol fragments sleep, independent of apnea status (22), which may further aggravate OSA (23).

Sleep efficiency was not changed significantly during the three experimental nights. One possible reason for this might be that the values of SpO_2 were within the normal range during both early and late halves of sleep, even when drinking before retiring.

Alcohol given in large quantities significantly worsens OSA (8, 9). At doses of 0.9–3.0 g alcohol/kg BW/day, AHI and apnea duration increased significantly resulting in greater hypoxemia in seven males with severe OSA (8). Similarly, Taasan et al. (9) described an increase in OSA severity in subjects, asymptomatic of OSA, given 1 g alcohol/kg BW. However, when alcohol is given in moderate doses (0.5–1.0 g/kg BW), the effects upon apnea severity are less clear. Some researchers have reported an increase (9, 12, 15) and others no effect (13, 14) upon the severity of OSA. Berry et al. (10) reported that 0.5 g alcohol/kg BW/day did not alter the pressure requirement to maintain ventilation during sleep in patients with severe OSA.

In contrast, Collop (12) has shown that doses of 0.5 g alcohol/kg BW/day increased the AHI from 10 to 20 events/h. The findings of the present study support the findings of Collop (12), although our investigation was conducted on normal middle-aged men free of OSA symptoms. Scrima et al. (15) reported no breathing abnormalities or hypoxic event in healthy (OSA-free) subjects. However, their study was conducted on 6 subjects which lacks the power for finding a significant difference.

In our study five subjects consumed more than 1 g/kg BW/day of alcohol when drinking before retiring, and although the mean percent of time with SpO_2 less than 92% was slightly higher there was no significant difference from other 18 subjects who consumed less than 1 g/kg BW of alcohol per day (results not shown). Results were almost same after five subjects who consumed more than 1 g/kg BW of alcohol before retiring were excluded from the analysis (results not shown).

Another finding of interest in this study was that moderate alcohol consumption before retiring had no significant effect on the percentage of actual sleep as detected by actigraphy. This observation could be explained by a greater depressant effect of alcohol upon upper airway muscle activity than on arousability and limb movement. This would be consistent with previous data presented by Berry et al. (10) who reported an increase in upper airway resistance without a significant change in apnea length in subjects given alcohol.

We found a substantial rise in mean heart rate during sleep with bedtime alcohol. Firstly, it is possible that the rise was due to the elevation in AHI. However, OSA is usually associated with bradycardia during the apnea and tachycardia at the terminating arousal. The net gain is usually no significant change in mean heart rate. Therefore, the authors believe that the rise in heart rate cannot simply be explained by an increase in OSA severity. Alternatively, the relative tachycardia may have been a response to peripheral systemic vasodilation, an acute effect that occurs with alcohol in subjects with intact baroreceptor function (24, 25). This may also have contributed to a rise in the overnight urinary excretion of noradrenalin, as observed by Scanlan (26).

Increased skeletal muscle sympathetic nerve activity, blood pressure and cardiac frequency were observed in awake normal subjects given 1 g alcohol/kg BW/day suggesting that alcohol has a direct sympathetic stimulatory function (24). The arterial oxygen saturation measurements that were observed reflected an alcohol-induced trend towards both metabolic acidosis, which may reflect a manifestation of sympathetic stimulation and an increase in the frequency of AHI during sleep.

Several limitations in this study should be considered while interpreting the results. Firstly, the amount of alcohol intake was assessed using a self-report of alcohol intake. However, there is evidence for the validity of daily self-reported alcohol consumption comparing to blood alcohol concentration (27). Secondly, our study investigated the timing effect of alcohol intake in only one day in healthy moderate alcohol drinkers, therefore checking for long time effects of alcohol drinking with dinner or before retiring to bed requires longitudinal investigations. Furthermore, since our subjects were OSA-free middle-aged men, extrapolating of the results to OSA patients needs further investigation in this field.

In conclusion, a small but significant rise in sleep apnea severity, percentage of time with SpO_2 <92% and cardiac frequency were observed in subjects consuming moderate alcohol within 30 minutes before retiring to bed, when compared to an alcohol-free day, and drinking alcohol with dinner.

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