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Effect of Night Smoking, Sleep Disturbance, and Their Co-Occurrence on Smoking Outcomes

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Abstract

Recent evidence suggests that smoking during the night is an indicator of nicotine dependence and predicts smoking cessation failure. Night smokers are likely to experience disturbance to their sleep cycle when they wake to smoke, but we are not aware of the prevalence of night smokers' self-reported sleep disturbance. Because sleep disturbance also predicts smoking cessation failure, we examined how the pre-cessation risk factors of night smoking and sleep disturbance, and their co-occurrence, predict smoking cessation failure in a 6-week double-blind randomized controlled trial examining whether naltrexone augments the efficacy of the nicotine patch (O'Malley et al., 2006). Smokers (N = 385) completed the Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) and a single item of waking at night to smoke pre-cessation. Smoking status was determined at weeks 1, 6, 24 and 48 weeks after quitting. The 2 main findings were: (1) night smokers reported significantly greater sleep disturbance than non-night smokers; and (2) smokers with co-occurring night smoking and sleep disturbance experienced significantly greater risk for smoking than smokers with neither risk factor. Results suggest that individuals who both wake during the night to smoke and report clinically-significant sleep disturbance represent a high-risk group of smokers. Future smoking cessation treatment might incorporate strategies related to managing these smokers' sleep habits and physiological dependence on nicotine in order to bolster their cessation outcomes.

Keywords

smoking cessation; night smoking; sleep disturbance; outcome predictors

Introduction

Smoking soon after waking is an indicator of nicotine dependence (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991), and recent evidence suggests that smoking during the night can also be an indicator of nicotine dependence (Bover, Foulds, Steinberg, Richardson, & Marcella, 2008; Scharf, Dunbar, & Shiffman, 2008). Night smokers report higher scores on

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the Fagerström Test for Nicotine Dependence (FTND; Heatherton et al., 1991) and an earlier time to first cigarette of the day than non-night smokers (Bover et al., 2008; Rieder, Unze, Groman, Kiefer, & Schoberger, 2001; Scharf et al., 2008); thus, some smokers may be motivated to smoke during the night due to the emergence of nicotine withdrawal symptoms within a few hours of going to sleep (i.e., within a few hours of abstinence). Night smoking appears to be common (19% of a convenience sample of heavy smokers - 51% of treatment-seekers) (Bover et al., 2008; Rieder et al., 2001), and importantly, those who smoke during the night are at increased risk for an unsuccessful quit attempt in comparison to non-night smokers (Bover et al., 2008; Foulds et al., 2006; Scharf et al., 2008).

Night smokers may wake at night due to dropping nicotine levels, but they may wake due to factors other than nicotine dependence, such as primary insomnia (APA, 2000), depression (APA, 2000; Armitage, 1995), or perceived stress (Morin, Rodrigue, & Ivers, 2003). In fact, the majority of night smokers in a convenience sample of heavy smokers attributed their sleep difficulties to causes other than nicotine (Rieder et al., 2001). Night smokers frequently reported post-cessation sleep disturbance during their last quit attempt (Scharf et al., 2008), but this sleep disturbance may be due to the effects of abstinence, not night smoking per se (APA, 2000).

Sleep disturbance has numerous negative physical and psychological sequelae, including disability, reduced quality of life, and psychological distress (Simon & Von Korff, 1997). Sleep disturbance is prevalent among smokers (Phillips & Danner, 1995; Soldatos, Kales, Scharf, Bixler, & Kales, 1980; Wetter & Young, 1994), and sleep disturbance due to abstinence predicts poor smoking treatment outcome (Boutou, Tsiata, Pataka, Kontou, Pitsiou & Argyrpoulou, 2008; Persico, 1992). Furthermore, pre-cessation sleep disturbance predicted failure to abstain from cigarettes over several years in Finnish male smokers (Augustson et al., 2008), suggesting that sleep disturbance prior to quitting also hinders smoking outcomes.

Waking during the night to smoke would seem to represent an intrusion to the sleep cycle, yet the prevalence of clinically-important sleep disturbance among this group of smokers is unknown. Night smokers may already be considered a high-risk group of smokers because of their difficulty quitting smoking relative to non-night smokers (Bover et al., 2008; Foulds et al., 2006; Scharf et al., 2008), and the presence of an additional risk factor of sleep disturbance (Augustson et al., 2008) might further worsen their smoking outcomes. Although night smoking and pre-cessation sleep disturbance have independently predicted cessation failure in separate studies (Augustson et al., 2008; Brower & Perron, 2010; Bover et al., 2008; Foulds et al., 2006; Scharf et al., 2008), we are not aware of a direct test of night smoking only vs. sleep disturbance only vs. their co-occurrence in predicting cessation failure. Such a direct test would show whether one unique risk factor confers more risk of a failed quit attempt than another or whether their co-occurrence confers more risk in comparison to either characteristic alone. If both night smoking and sleep disturbance have negative effects on smoking cessation outcomes, smoking cessation counselors might assess smokers for both night smoking status and clinically-important sleep disturbance and might then deliver quitting strategies tailored to both risk factors in order to improve their outcomes.

We sought to describe the prevalence of sleep disturbance irrespective of abstinence (i.e., pre-cessation) among night smokers and to examine whether pre-cessation sleep disturbance was greater among night smokers than non-night smokers. We also sought to describe the type of sleep disturbance that night smokers experience relative to non-night smokers with sleep disturbance, i.e., we investigated whether night smoking disrupts the quality vs. duration of sleep. To ascertain a clearer understanding of the unique contribution of each

risk factor of night smoking and sleep disturbance and of their combination to smoking outcomes, we endeavored to compare individuals who pre-cessation reported: 1) night smoking only, 2) sleep disturbance only, 3) co-occurring night smoking and sleep disturbance, and 4) neither night smoking nor sleep disturbance. To conduct these direct comparisons, we used data from a trial that examined whether naltrexone augmentation of nicotine patch therapy improves smoking abstinence in treatment-seeking smokers (O'Malley et al., 2006).

Method

Participants

We report data from a 6-week double-blind randomized controlled trial of smoking cessation examining whether naltrexone augments the efficacy of the nicotine patch (O'Malley et al., 2006). Individuals were eligible for the trial if they were 18 years or older, smoked 20 or more cigarettes daily for at least 1 year, and had a baseline expired carbon monoxide (CO) level of 10 ppm or greater. Smokers (N = 385) received open label 21 mg transdermal nicotine patch for 6 weeks, beginning on their quit date. They were also randomized to receive placebo (n = 93) or 1 of 3 dosages of naltrexone daily: 25 mg (n = 93), 50 mg (n = 96), or 100 mg (n = 103). Participants received weekly counseling based on protocols of the National Cancer Institute (Glynn & Manley, 1990). The study was approved by the institutional review boards of the Yale University School of Medicine, the University of Connecticut, and the Veterans Affairs Connecticut Healthcare System.

Procedure

At intake participants provided information on demographics and smoking history variables, including the FTND (Heatherton et al., 1991) and a single item of waking at night to smoke. They provided self-reports of daily tobacco and alcohol consumption for the prior 30 days via the Timeline Follow-back Interview (TLFB; Brown, Burgess, Sales, Whiteley, Evans, & Miller, 1998; Sobell and Sobell, 2003). At baseline (i.e., pre-cessation) and at each weekly appointment they provided body weight, CO levels, and self-reports of daily tobacco and alcohol consumption since the prior appointment via the TLFB (Sobell & Sobell, 2003). Participants also completed the Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman & Kupfer, 1989), the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), and the Perceived Stress Scale – 4 Item (PSS – 4; Cohen, Kamarck & Mermelstein, 1983) at baseline and each weekly appointment. Assessments to verify 7-day point prevalence smoking status (not even a puff) were conducted at 1, 6, 24 and 48 weeks after quitting. Self-reported abstinence was verified by an exhaled CO level of ≤10 ppm. Participants who dropped out or missed multiple appointments were classified as smoking. A single missed appointment was coded as abstinent only if abstinence was verified at the appointments before and after the missed session.

Measures

The FTND (Heatherton et al., 1991) is a 6-item self-report questionnaire that assesses nicotine dependence. It has a scoring range of 0 to 10, with greater scores indicating more severe nicotine dependence. A single item of waking at night to smoke (“Do you wake up at night and smoke?”) had response options of 0 = no and 1 = yes.

The PSQI (Buysse et al., 1989) is a 9-item self-report questionnaire that measures sleep disturbance retrospectively over a 1-month period. We modified the PSQI to measure sleep disturbance retrospectively over a 1-week period. The 7 components of the PSQI (subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction) each have a scoring range of 0 (“no

difficulty") to 3 ("severe difficulty"), and the component scores are summed to determine the global score (range = 0 - 21). Greater global scores indicate more sleep disturbance. As described in Buysse et al. (1989), a global score of > 5 suggests that an individual has severe difficulties in at least two components of sleep or moderate difficulties in more than three components and, thus, it distinguishes "poor sleepers" from "good sleepers."

The CES-D (Radloff, 1977) is a 20-item self-report scale that measures depressive symptomatology. The range of possible scores on the CES-D is 0 – 60, with higher scores indicating greater depressive symptomatology. The PSS – 4 (Cohen et al., 1983) measures the degree to which individuals appraise situations in their lives as stressful. The range of possible scores on the PSS - 4 is 0 – 16, with higher scores indicating greater perceived stress.

Data Analysis

Independent-samples *t*-tests compared night smokers and non-night smokers on pre-cessation PSQI global and component scores. A chi-square test compared night smokers and non-night smokers on the prevalence of poor sleepers (i.e., PSQI global score > 5). To investigate how night smoking relates to sleep disturbance, independent samples *t*-tests compared PSQI global and component scores between night smokers who were also poor sleepers and non-night smokers who were poor sleepers.

A mutually-exclusive categorization of all participants was created based on both their answers to the pre-cessation item of waking at night to smoke and whether their pre-cessation PSQI global score was above or below the established cut-off for being a poor sleeper (i.e., > 5). In this categorization, 0 = answered "no" to the item of waking at night to smoke and reported pre-cessation PSQI global score ≤5 ($n = 179$); 1 = answered "yes" to the item of waking at night to smoke and reported pre-cessation PSQI global score ≤ 5 ($n = 69$); 2 = answered "no" to the item of waking at night to smoke and reported pre-cessation PSQI global score > 5 ($n = 63$); and 3 = answered "yes" to the item of waking at night to smoke and reported pre-cessation PSQI global score > 5 ($n = 62$).

Chi-square tests and analyses of variance with Tukey post-hoc tests compared the 4 groups of smokers on demographic, smoking, and psychological characteristics (i.e., CES-D and PSS-4 scores). Logistic regression models examined the unique contribution of being: 1) a night smoker only vs. 2) a poor sleeper only vs. 3) both a night smoker and poor sleeper to the prediction of smoking outcomes (0 = abstinent and 1 = smoking) at weeks 1, 6, 24, and 48. Regression models were adjusted for treatment group and gender and specified the referent group of being neither a night smoker nor a poor sleeper.

Results

Forty-eight percent of participants were female; 87% were Caucasian; and their mean age was 45.9 (standard deviation [*SD*] = 11.2) years. Participants smoked a mean of 26.4 (*SD* = 9.3) cigarettes per day (CPD), and their mean FTND score was 6.33 (*SD* = 2.01) (O'Malley et al., 2006).

Prevalence of Night Smoking and Sleep Disturbance

Among the 385 participants, 135 (35%) reported waking at night to smoke. Of these 135 night smokers, 62 (47%) were poor sleepers and 69 (53%) were good sleepers pre-cessation. The prevalence of night smokers did not differ by treatment group ($\chi^2_4 = 3.42$, $p = .33$), nor did the prevalence of poor sleepers ($\chi^2_3 = 1.55$, $p = .67$).

Differences in Sleep Disturbance

Table 1 presents sleep disturbance differences between night smokers and non-night smokers. Night smokers reported significantly greater pre-cessation PSQI global scores than non-night smokers ($p < .01$), indicating more sleep disturbance for night smokers than non-night smokers. Night smokers also reported significantly greater pre-cessation PSQI component scores related to subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, and daytime dysfunction than non-night smokers (all ps $\leq .03$). The 2 groups did not significantly differ on the PSQI component score related to use of sleep medication. The prevalence of poor sleepers was significantly greater in the night smokers group than the non-night smokers group ($p < .01$).

PSQI global scores and the majority of component scores did not differ between poor sleepers who were also night smokers and poor sleepers who were not night smokers. However, those who were both night smokers and poor sleepers reported significantly greater scores on the PSQI component of sleep duration ($M = 1.57$, $SD = 0.83$) than non-night smokers who were poor sleepers ($M = 1.24$, $SD = 0.68$, $t(116) = -2.32$, $p = .02$), indicating that poor sleepers who smoked during the night slept significantly less than poor sleepers who did not smoke during the night.

Differences in Demographic, Smoking, and Psychological Characteristics between Groups of Smokers Based on Night Smoking and Sleep Disturbance

Table 2 presents the demographic, smoking, and psychological differences between the 4 groups of smokers based on their self-report of pre-cessation night smoking and sleep disturbance. The prevalence of Caucasian and married or cohabiting individuals differed among the 4 groups ($p < .01$). Both poor sleepers and night smokers were less likely to be married or cohabiting (42%) than those who were neither poor sleepers nor night smokers (61%, $\chi^2_1 = 7.16$, $p < .01$) and those who were poor sleepers only (65%, $\chi^2_1 = 6.76$, $p < .01$). Individuals who were neither poor sleepers nor night smokers were more likely to be Caucasian (94%) than night smokers only (77%, $\chi^2_1 = 9.18$, $p < .01$) and those who were both poor sleepers and night smokers (81%, $\chi^2_1 = 13.38$, $p < .01$). The 2 groups with night smokers reported greater mean CPD over the 30 days prior to baseline and greater FTND scores, and were more likely to smoke their first cigarette of the day within 5 minutes of waking, than the 2 groups without night smokers. The 2 groups of poor sleepers reported significantly greater depression and perceived stress than the 2 groups without poor sleepers. The 4 groups did not significantly differ on age, gender, education, employment status, body weight, carbon monoxide levels at baseline, and mean alcohol drinks per drinking occasion in the 30 days prior to baseline.

Smoking Outcomes

Table 3 presents the prevalence of smoking, adjusted odds ratios and 95% confidence intervals for the unique ability of those who were night smokers only, those who were poor sleepers only, and those who were both night smokers and poor sleepers to predict cessation failure at each follow-up week. All logistic regression models presented in Table 3 included the group of those who were neither night smokers nor poor sleepers as the referent group. After adjusting for treatment group and gender, night smokers only and poor sleepers only were significantly more likely to be cessation failures at week 1 than those who were neither night smokers nor poor sleepers. However, those who were both night smokers and poor sleepers were significantly more likely to be smoking at weeks 6, 24, and 48 than those who were neither night smokers nor poor sleepers. Results remained significant when also adjusting for marital status and race.

Given the relations between night smoking and nicotine dependence (Scharf et al., 2008) and between sleep disturbance and depression (Armitage, 1995) and perceived stress (Morin et al., 2003), we conducted an alternative test of the effects of nicotine dependence, depression, and perceived stress, and their interactions to predict smoking outcomes. Logistic regression analyses that controlled for treatment group and gender examined the ability of: 1) FTND scores, CES-D scores, and their interaction, and 2) FTND scores, PSS-4 scores, and their interaction to predict smoking outcomes at each follow-up. There was a unique effect of greater nicotine dependence to predict worse smoking outcomes at week 1 (adjusted OR = 1.22, 95% confidence interval = 1.01, 1.48, $p < .04$), but not at any other week. There were no unique effects of depression or perceived stress, nor any interaction effects of nicotine dependence with depression or perceived stress, in predicting smoking outcomes. Thus, night smoking does not seem to serve merely as a proxy for nicotine dependence, and sleep disturbance does not seem to serve as a proxy for depression or perceived stress in this study.

To examine whether the co-occurrence of night smoking and sleep disturbance conferred greater risk for smoking than the risk conferred by either risk factor alone, logistic regression models were conducted using those who were both night smokers and poor sleepers as the referent group. Those who were poor sleepers only were significantly less likely to be smoking at week 6 than those who were both night smokers and poor sleepers (adjusted odds ratio = 0.44, 95% confidence interval = 0.22, 0.91, $p = .03$), i.e., the co-occurrence of night smoking and sleep disturbance conferred greater risk for smoking than the occurrence of sleep disturbance alone. There were no other differences in risk for smoking for those with co-occurring night smoking and sleep disturbance vs. those with 1 risk factor only at any other week.

We examined an alternative test of whether the co-occurrence of night smoking and sleep disturbance conferred greater risk for smoking than the risk conferred by either risk factor alone by creating an interaction term of the categorical variable of night smoking (yes/no) and the continuous variable of pre-cessation PSQI global scores. We then included the night smoking variable, pre-cessation PSQI global scores, and their interaction term in logistic regression models with smoking outcomes at each follow-up as the dependent variable. The interaction of night smoking and pre-cessation PSQI global scores did not significantly increase the risk of smoking at any follow-up in comparison to either risk factor alone (all ps $> .05$).

Discussion

Two main findings emerged from this examination of treatment-seeking night smokers and poor sleepers: 1) night smokers reported significantly greater pre-cessation sleep disturbance than non-night smokers; and 2) smokers with co-occurring night smoking and sleep disturbance experienced greater risk for smoking at 6 weeks post-quit date and at subsequent follow-ups than those with neither risk factor.

Treatment-seeking night smokers in this study reported significantly worse overall sleep and greater disturbance in the majority of components of sleep (e.g., sleep latency, sleep efficiency) than non-night smokers. Night smokers have retrospectively reported sleep disturbance when quitting smoking (Scharf et al., 2008), but because sleep disturbance is a common withdrawal symptom for all smokers (APA, 2000; Hughes & Hatsukami, 1986), it had not been clear whether night smokers experience sleep disturbance prior to abstinence. Waking up at night to smoke does appear to represent an important intrusion to the sleep cycle, as night smokers reported significantly worse pre-cessation sleep quality in comparison to non-night smokers. This disturbance involves multiple components of sleep

and is associated with clinically-significant problems, e.g., night smokers reported significantly greater daytime dysfunction and were more likely to be classified as “poor sleepers” in comparison to non-night smokers. Moreover, in comparison to poor sleepers who do not smoke during the night, night smokers with significant sleep disturbance reported that they slept for a shorter duration, indicating that night smoking itself may further worsen at least one component of sleep.

Consistent with findings from prior studies, night smokers in this treatment study smoked more cigarettes and reported greater dependence on nicotine than non-night smokers, suggesting that some night smokers may wake during the night due to a physiological need for nicotine. However, a subgroup of night smokers in this study (i.e., those with co-occurring sleep disturbance) reported greater depression and perceived stress than night smokers without sleep disturbance. Given the association of sleep disturbance with depression (Armitage, 1995) and perceived stress (Morin et al., 2003), those night smokers who experience depression or perceived stress may wake during the night due to these non-nicotine factors. Because the present study was not designed to determine whether nicotine vs. non-nicotine factors promote night smoking, future studies might utilize a daily, prospective design (e.g., ecological momentary assessment) to determine the causality of night smoking among those smokers with sleep disturbance, depression, and perceived stress. If future studies demonstrate that psychological factors (e.g., depression) cause sleep disturbance which then causes night smoking, treatment strategies can focus on treating those factors and assisting smokers in using coping strategies other than smoking when experiencing sleep disturbance.

In addition to overlapping with depression and perceived stress, the co-occurrence of night smoking and sleep disturbance predicts failure to quit smoking. Beginning at 6 weeks post-quit date and lasting until 1 year post-cessation, smokers who were both night smokers and poor sleepers were significantly less likely to have quit smoking than those who had neither risk factor. While previous reports have shown that night smoking is associated with cessation failure (Bover et al., 2008; Foulds et al., 2006; Scharf et al., 2008) and that sleep disturbance is associated with cessation failure (Augustson et al., 2008), the present study only showed an association between each risk factor and cessation failure at 1 week post-cessation. Rather, the *co-occurrence* of night smoking and sleep disturbance predicted cessation failure at all later post-cessation assessments. In addition, overlapping factors with night smoking and sleep disturbance (i.e., nicotine dependence, depression, perceived stress) did not significantly predict smoking outcomes, with the exception of nicotine dependence predicting greater odds of continued smoking one week post-quit. Thus, although there do appear to be significant relations between night smoking and nicotine dependence and between sleep disturbance and depression and perceived stress, the findings of this study support night smoking and sleep disturbance as unique predictors of failure to quit smoking. Because of their likelihood of failing to quit smoking and because they report other characteristics that might complicate smoking treatment (e.g., depression), individuals who report both night smoking and sleep disturbance represent a high-risk group of smokers who might need additional interventions to support them in their cessation efforts. As Scharf and colleagues (2008) suggested, those who wake at night to smoke might need overnight nicotine replacement therapy, and those who both wake at night to smoke and have significant sleep disturbance might also benefit from psychological interventions to improve sleep, such as cognitive-behavioral therapy (CBT) for insomnia. CBT for insomnia focuses on improving sleep hygiene and restructuring negative, unrealistic thoughts about sleep (Morin, Bootzin, Buysse, Edinger, Espie, & Lichstein, 2006), and it has improved sleep quality and daytime functioning in individuals with primary insomnia (Edinger, Wohlgemuth, Radtke, Marsh, & Quillian, 2001; Morin, Colecchi, Stone, Sood, & Brink, 1999) and in recovering alcoholic patients with sleep disturbance (Arnedt, Conroy, Rutt,

Aloia, Brower & Armitage, 2007; Currie, Clark, Hodgins & el-Guebaly, 2004). To our knowledge, the efficacy of CBT for insomnia has not been examined in treatment-seeking smokers with sleep disturbance. Future research might consider whether the addition of CBT for insomnia to existing smoking cessation treatments for those with sleep disturbance would improve smoking outcomes.

Smokers with the co-occurrence of night smoking and sleep disturbance were significantly less likely to quit smoking at 6 weeks post-quit date than smokers with only 1 risk factor (i.e., sleep disturbance), although this difference did not persist beyond 6 weeks. Our alternative analysis substituting continuous pre-cessation PSQI global scores for the dichotomous categories of poor and good sleepers did not reveal that the interaction of night smoking and sleep disturbance produced greater risk for smoking than either risk factor alone. Taken together, these findings suggest that the co-occurrence of night smoking and sleep disturbance predicted cessation failure after 6 weeks of treatment but did not significantly worsen the risk of smoking in comparison to either risk factor alone.

Although the findings from this study relate to sleep disturbance, we did not administer the Diagnostic and Statistical Manual of Mental Disorders – Fourth edition (DSM-IV; APA, 2000) criteria for insomnia, so we do not know whether participants' self-report of sleep disturbance matches the DSM-IV criteria of insomnia. This study is also limited by its lack of objective assessment of sleep disturbance (e.g., polysomnography; wrist actigraphy). Despite utilizing a self-report instrument with sound psychometric properties to assess sleep disturbance (Buysse et al., 1989), some participants may have underestimated the time they slept or overestimated the severity of their sleep disturbance (Currie, Malhotra, & Clark, 2004; Means, Edinger, Glenn, & Fins, 2003). The assessment of sleep disturbance retrospectively over a 1-week period may have introduced recall bias; i.e., participants may have reported sleep disturbance for the most salient night of the week, rather than the average disturbance across the entire week. The assessment of night smoking with a single item of undetermined validity is another limitation of this study. Consistent with the standard in the field of smoking cessation research (e.g., Gonzales et al., 2006), no adjustments have been made for multiple comparisons of multiple outcomes. Further, we did not adjust for multiple comparisons because this was a secondary analysis into the co-occurrence of night smoking and sleep disturbance; adjusting for multiple comparisons may have obscured these initial findings (Perneger, 1998).

This investigation provides preliminary information on the cross-sectional co-occurrence of night smoking and sleep disturbance and how their co-occurrence predicts smoking outcomes. Future studies might examine temporal relations among sleep disturbance and other factors (e.g., depression) to understand how these characteristics interact over time to promote night smoking. Future studies might also address alternative explanations for the results observed in this investigation. For example, we do not know how naltrexone and transdermal nicotine patch interacted with night smoking and sleep disturbance to affect outcome. Although treatment group was statistically controlled for in analyses pertaining to smoking outcomes, it is possible that the pharmacological treatments provided to participants in this study may have improved or disrupted sleep (Aubin, Luthringer, Demazieres, Dupont & Lagrue, 2006; Staedt et al., 1996; Staner, Luthringer, Dupont, Aubin, & Lagrue, 2006; Wetter, Fiore, Baker & Young, 1995) and, thus, may have altered smoking outcomes. Another potential explanation for our findings is that night smokers may have experienced worse smoking outcomes because the nicotine patch did not sufficiently relieve craving or withdrawal symptoms because of their greater tolerance to nicotine. Future work can investigate how the nicotine patch may reduce night smoking over time and whether this reduction improves smoking outcomes.

In conclusion, night smokers report significantly greater sleep disturbance than non-night smokers, and the co-occurrence of night smoking and sleep disturbance durably predicts cessation failure. Individuals who both wake during the night to smoke and experience clinically-significant sleep disturbance represent a high-risk group of smokers, and future smoking cessation treatment might incorporate strategies related to managing their sleep habits and physiological dependence on nicotine in order to bolster their cessation outcomes.

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Table 1

Pre-Cessation PSQI Differences between Night Smokers and Non-Night Smokers.

	Night Smokers (*n* = 135)	Non-Night Smokers (*n* = 245)	Statistic	*p*
Global Score	5.8 (3.3)	4.4 (2.6)	$t(218) = -4.15$	< .01 *
Component 1 – Subjective Sleep Quality	0.99 (0.82)	0.78 (0.72)	$t(368) = -2.58$	.01 *
Component 2 – Sleep Latency	1.09 (1.01)	0.83 (0.85)	$t(366) = -2.63$	< .01 *
Component 3 – Sleep Duration	1.18 (0.82)	0.90 (0.63)	$t(197) = -3.20$	< .01 *
Component 4 – Sleep Efficiency	0.53 (0.96)	0.21 (0.60)	$t(175) = -3.28$	< .01 *
Component 5 – Sleep Disturbances	1.21 (0.58)	1.05 (0.48)	$t(228) = -2.65$	< .01 *
Component 6 – Use of Sleeping Medication	0.29 (0.74)	0.24 (0.72)	$t(370) = -0.66$	.51
Component 7 – Daytime Dysfunction	0.65 (0.61)	0.51 (0.56)	$t(370) = -2.12$	.03 *
Poor Sleepers (%)	46	26	$\chi^2_1 = 17.30$	< .01 *

Note. Means of PSQI scores presented, with standard deviations in parentheses, except where noted. PSQI = Pittsburgh Sleep Quality Index. Range of global score = 0 – 21, and range of component scores = 0 – 3, with higher scores indicating more sleep disturbance.

* $p < .05$.

Table 2

Demographic, Smoking, and Psychological Differences between Groups of Smokers Based on Night Smoking and Sleep Disturbance.

	Night Smokers Only (*n* = 69)	Poor Sleepers Only (*n* = 63)	Both Night Smokers and Poor Sleepers (*n* = 62)	Neither Night Smokers nor Poor Sleepers (*n* = 179)	Statistic	*p*
Age (*M* [*SD*])	45.5 (11.5)	46.3 (12.0)	48.0 (9.4)	44.8 (11.2)	$F(3, 369) = 1.36$	.26
Female (%)	41	56	60	45	$\chi^2_3 = 7.12$	.07
Caucasian (%)	81_{ab}	89_{bc}	77_{a}	94_{c}	$\chi^2_3 = 15.42$	< .01 *
Married or Cohabiting (%)	51_{ab}	65_{b}	42_{ac}	61_{b}	$\chi^2_3 = 9.98$	.01 *
Employed Full- or Part-Time	76	71	81	85	$\chi^2_3 = 6.52$	.09
High School Education (%)	97	97	95	98	$\chi^2_3 = 1.29$	.73
Body Weight (pounds) (*M* [*SD*])	178.9 (31.8)	175.6 (36.9)	176.4 (41.0)	173.8 (36.6)	$F(3, 364) = 0.33$	.80
Cigarettes per Day (*M* [*SD*])	$28.6\ (10.0)_{b}$	$24.3\ (8.2)_{a}$	$29.3\ (10.6)_{b}$	$25.0\ (7.8)_{a}$	$F(3, 369) = 6.23$	< .01 *
FTND Total Score (*M* [*SD*])	$7.5\ (1.7)_{b}$	$5.8\ (1.9)_{a}$	$7.2\ (1.7)_{b}$	$5.7\ (2.0)_{a}$	$F(3, 361) = 20.43$	< .01 *
TTFC within 5 minutes (%)	68_{a}	27_{b}	73_{a}	30_{b}	$\chi^2_3 = 59.41$	< .01 *
Carbon Monoxide (ppm) (*M* [*SD*])	25.7 (10.5)	23.1 (10.4)	26.6 (11.0)	24.9 (9.8)	$F(3, 368) = 1.34$	.26
Alcohol Drinks per Drinking Occasion (*M* [*SD*])	2.1 (2.3)	1.6 (1.8)	2.0 (2.1)	2.0 (2.1)	$F(3, 369) = 0.73$	.54
CES-D Total Score (*M* [*SD*])	$7.2\ (6.0)_{a}$	$11.0\ (8.0)_{b}$	$9.9\ (6.3)_{b}$	$5.4\ (4.9)_{a}$	$F(3, 365) = 17.51$	< .01 *
PSS – 4 Total Score (*M* [*SD*])	$4.0\ (2.2)_{a}$	$5.4\ (2.6)_{b}$	$4.9\ (2.5)_{b}$	$3.8\ (2.5)_{a}$	$F(3, 366) = 8.20$	< .01 *

Note. Means in the same row that do not share subscripts differ at $p < .05$ in Tukey comparisons. Percentages in the same row that do not share subscripts differ at $p < .05$ in chi-square between-group comparisons. FTND = Fagerström Test for Nicotine Dependence. TTFC = time to first cigarette. CES-D = Center for Epidemiological Studies Depression Scale. PSS - 4 = Perceived Stress Scale – 4 Item.

* $p < .05$.

Table 3

Night Smoking, Sleep Disturbance, and Their Co-Occurrence as Predictors of Smoking Outcomes.

Week	Predictor	% Smoking	Adjusted Odds Ratio (aOR)	95% Confidence Interval of aOR	
				Lower	Upper
1	Night Smoker Only	41	1.99*	1.10	3.58
	Poor Sleeper Only	41	1.91*	1.04	3.50
	Both Night Smoker & Poor Sleeper	37	1.65	0.87	3.07
	Neither Night Smoker nor Poor Sleeper	26	Ref	--	--
6	Night Smoker Only	43	1.18	0.67	2.08
	Poor Sleeper Only	38	0.91	0.50	1.67
	Both Night Smoker & Poor Sleeper	56	2.06*	1.14	3.72
	Neither Night Smoker nor Poor Sleeper	40	Ref	--	--
24	Night Smoker Only	86	2.08	0.98	4.43
	Poor Sleeper Only	83	1.59	0.76	3.33
	Both Night Smoker & Poor Sleeper	89	2.77*	1.17	6.54
	Neither Night Smoker nor Poor Sleeper	74	Ref	--	--
48	Night Smoker Only	87	1.73	0.78	3.82
	Poor Sleeper Only	86	1.47	0.66	3.29
	Both Night Smoker & Poor Sleeper	92	2.97*	1.10	8.02
	Neither Night Smoker nor Poor Sleeper	80	Ref	--	--

Note. Smoking outcomes were coded as 0 = abstinent and 1 = smoking. Models adjusted for treatment group and gender. *N*s for each group were: night smokers = 69; poor sleepers = 63; both night smoker and poor sleepers = 62. Referent group for all models was neither night smoker nor poor sleeper ($n = 179$). Ref = reference category for logistic regression analyses.

*$p < .05$.

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