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The Effect of Smoking Cessation on Sleep Patterns of Young Adults

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Abstract

Objective: The role of sleep quality in tobacco dependence of young adults, a population in which the prevalence of smoking is highest, is largely unknown. The current study aimed at examining whether the sleep quality of smokers, measured subjectively (the Mini Sleep Questionnaire; MSQ) and objectively (actigraphy) is worse than that of nonsmokers and further deteriorates during one week of abstinence from smoking (i.e., first stage of cessation).

Methods: Forty-six young (19–28 years old) volunteers, of them were 26 nonsmokers (73.1% women) and 20 were regular smokers (75% women) smoking at least 10 cigarettes a day. The participants completed the Brief Questionnaire on Smoking Urges, the Fagerström Test for Nicotine Dependence (FTND), and the Mini Sleep Questionnaire (MSQ). Their sleep was then monitored objectively for one week using an actigraph. Subsequently, the participants of the smokers group ceased smoking and their sleep was monitored via actigraphy during the first week of smoking abstinence. At the end of the week they again completed the FTND and the MSQ.

Results: Self-reported sleep quality did not differ between the groups. However, actigraphy data pointed to lower sleep continuity in smokers compared to nonsmokers as reflected by increased wake time after sleep onset (WASO) and nighttime awakenings. Total sleep time and sleep onset latency did not differ between the groups. During the week of abstinence sleep continuity further deteriorated as reflected by increases in WASO and in the number of awakenings, and a reduction in sleep efficiency. At the end of the week of abstinence the severity of self-reported symptoms of insomnia predicted urge to smoke.

Conclusion: Young adult smokers have lower sleep continuity compared to nonsmokers and their sleep difficulties worsen during smoking cessation. The findings suggest that interventions intended to promote sleep quality could serve as adjunct treatment for smoking cessation.

Keywords: Sleep quality; Nicotine; Smoking cessation; Actigraph; Sleep continuity; Dependence; MSQ

The Effect of Smoking Cessation on Sleep Patterns of Young Adults

Tobacco smoking is a major health problem, leading to considerable morbidity and mortality worldwide [1]. Accumulating data suggests that sleep difficulties are among the negative consequences of smoking [2-7]. Moreover, deterioration in sleep quality is considered among the symptoms of nicotine withdrawal and is often reported during smoking cessation [2,8]. Notably, sleep disturbances before and during smoking cessation were found to be associated with failure to quit and with eventual relapse [9,10].

As patterns of sleep and sleep disturbances vary by age [11], the patterns of association between smoking and smoking cessation and quality of sleep could also be expected to be age-dependent. In particular, young adults, commonly defined as being between their late teens and mid/late twenties [12], differ from older adults in several variables associated with sleep quality. For example, the amount of slow wave sleep decreases over the lifetime and especially at higher ages [13] and breathing-related sleep disorders such as obstructive sleep apnea are more common at older ages [14]. On the other hand, insufficient sleep is very common among young adults in general and college students in particular [15,16], particularly due to poor sleep habits such as irregular bedtime schedule and the use of electronic devices, such as tablet computers and smartphones, before going to bed [16-18]. As smokers tend to establish their smoking dependence during early adulthood [19,20], it is imperative to clarify the extent to which insufficient sleep is involved in the progression and persistence of smoking dependence among young adults. This has significant clinical implications, as evidence pointing to sleep-associated difficulties hindering smoking cessation may lead to the incorporation of sleep-promoting therapies in smoking cessation [9]. In this context, it is important to note that smoking cessation in early adulthood significantly reduces the odds for tobacco-related illnesses and premature death in later years [21]. Yet, the relationship between smoking cessation and sleep among young adults was the focus of only limited research.

The few studies reporting associations between smoking and sleep quality in samples of young adults [22,23] mostly relied on subjective self-reports of sleep quality. However, accumulating evidence suggests that only a moderate correlation exists between subjective sleep measures and objective recordings of sleep parameters [24-26]. Objective recording of parameters using polysomnography (PSG) revealed that active smokers who are older adults (mean ages ranging from 40 to 63.5) demonstrate longer sleep onset latencies [27], shorter sleep duration, and lower sleep efficiency [28] compared to nonsmokers. Smoking abstinence of such older adults led to impairments in sleep quality, reflected by increased number of sleep stage changes, awakenings, and arousal [29] or sleep fragmentation [30] following the first 48-72 hours of abstinence [31]. More recently, Jaehne and colleagues [32,33] reported similar results in a sample that included young adults alongside older adults (median age of group: 29; range: 18-52). Yet, the authors did not report analysis of sleep quality by age group.

Along the same lines as PSG studies, several studies using actigraphy, a non-invasive method of sleep monitoring that allows recording in the participant's home environment [34,35], demonstrated lower sleep quality among smokers compared to nonsmokers. Again, the samples in these studies were of either middle-aged/elderly participants [36-38] or pregnant women [39].

Thus, the current study aimed at examining whether the sleep quality of smokers, measured subjectively and objectively (actigraphy), is worse than that of nonsmokers and further deteriorates during one week of abstinence from smoking (i.e., first stage of smoking cessation).

Materials and Methods

Participants

The study sample included 46 young (19-28 years old) volunteers. Twenty participants (75.0% women) were regular smokers who expressed willingness to stop smoking, and twenty-six participants (73.1% women) were nonsmokers (Table 1). Inclusion criteria included consumption of at least 10 cigarettes a day for at least two years (in the smokers group) or lifetime consumption of less than 5 cigarettes, with no smoking at all for the past 12 months (in the nonsmokers group). Exclusion criteria included drug abuse, employment in night shifts, pregnancy, and regular use of any medications with a potential to affect sleep, such as psychostimulants for the treatment of Attention Deficit Hyperactivity Disorder (ADHD).

The participants were recruited from the student body of the Yezreel Valley College (Israel) by advertisements, with each volunteer meeting the inclusion criteria enrolled in the study. The Max Stern Yezreel Valley College Institutional Ethics Review Board approved the complete study protocol (ethical approval number: EMEK YVC 2018-51).

Procedure

As detailed below, the study included two stages: Stage 1. Smokers were compared to non-smokers on measures of sleep quality, and the data obtained from the smokers served as baseline for evaluating the effects of smoking cessation on their sleep. Stage 2. Smokers discontinued their smoking (i.e., smoking cessation) and their sleep during the first week of abstinence from smoking was measured. In detail, Stage 1 of the study begun with a session to which participant (smokers and nonsmokers alike) arrived to the laboratory between 8:00 AM and 9:00 AM, up to 60 minutes following awakening. Participants were allowed to smoke in the morning as usual, but to refrain from smoking at least 30 minutes prior to the session. During the session, the participants signed an informed consent form and the level of carbon monoxide (CO) they exhaled was measured in order to verify their smoking status. In addition, the participants completed a 17-item background questionnaire that included questions regarding their age, years of education, weight and height (for BMI calculation), smoking habits, and alcohol consumption (number of alcoholic beverages consumed on average per week during the past 12 months). Finally, the participants received actigraphs and sleep diaries, and their sleep was continuously monitored over a one-week period.

	Smokers			**Nonsmokers**			
N	20			26			
Number of women	15 (75.0%)			19 (73.1%)			χ" = .02
	Mean	**SD**	**Range**	**Mean**	**SD**	**Range**	
Age (years)	24.7	2.2	21-28	23.73	1.97	19-27	t=1.57
BMI	22.55	4.57	16.85-33.03	23.11	2.67	19.38-28.17	t=0.36
Education (years)	12.65	1.04	12-15	12.23	0.82	12-15	t=1.45
Alcoholic drinks consumed per week	1.82	1.67	0-5	0.93	1.15	0-5	U=272.5
Cigarettes smoked per day	13.7	4.96	10-30	N/A			
Previous smoking quitting attempts	1.89	1.37	0-5	N/A			
FTND	3.55	2.44	0-10	N/A			
QSU-brief	34.65	14.03	11-58	N/A			
Presented are basic demographic details of the study sample as well as measures of smoking and smoking behavior. BMI: Body Mass Index; FTND: Fagerström Test for Nicotine Dependence; QSU-brief: Brief Questionnaire on Smoking Urges							

Table 1: Characteristics of the study participants.

On the morning of day 8, the participants returned to the laboratory. All participants completed the Mini Sleep Questionnaire (MSQ), evaluating their subjective sleep quality. Smokers also completed the brief questionnaire on smoking urges (QSU-brief) to evaluate their craving for smoking. Note that again smokers were allowed to smoke in the morning as usual, but to refrain from smoking at least 30 minutes prior to the session. This cigarette was their last as they entered the smoking cessation stage (stage 2 of the study). These participants continued to wear their actigraphs for one week. To ensure that the participants remained abstinent from smoking during this week, they were required to arrive at the laboratory for testing of CO exhalation levels at four time points- 48 h, 72 h, five days, and 7 days following the initiation of smoking cessation. At the last time point, participants also completed the QSU and MSQ to evaluate their subjective quality of sleep and craving for smoking following the week of abstinence.

Sleep quality measures

The mini sleep questionnaire (MSQ): The MSQ [40], an established instrument for the assessment of sleep quality and risk for insomnia, consists of 10 statements, each describing a particular sleeping difficulty. Participants indicate the frequency of occurrence of each sleeping difficulty on a 7-point Likert scale. The MSQ can be administered more than one time and is thus useful for longitudinal studies. Two scores were calculated: A total of the 10 items for a final score of sleep quality (MSQ-general) and an insomnia score (MSQ-insomnia), calculated by summing items 1 (Difficulty falling asleep), 2 (Waking up too early), and 7 (Awakenings). On both scales, higher scores reflect more sleeping problems. On the general score: 10-24 points reflect good sleep-wake quality; 25-27 points reflect mild sleep–wake difficulties; 28-30 points reflect moderate sleep-wake difficulties; and >30 points reflect severe sleep-wake difficulties [41]. The MSQ was reported to have internal consistency (Cronbach's α) of α=0.73-0.77 in non-clinical populations [42,43].

Actigraphy: The actigraph (Mini-Motionlogger, Ambulatory Monitoring Inc., New York) is a wrist-worn ambulatory, small, non-invasive device designed for studies in naturalistic settings with minimal distortions. The actigraph measures wrist movements utilizing a piezoelectric element and translates them into 1-minute long epochs of sleep and wake. To that end, wrist activity levels were sampled at 10-second intervals, summed across 1-minute intervals. Actigraphic raw data were translated to sleep measures using the Actigraphic Scoring Analysis program for an IBM-compatible personal computer (W2 scoring algorithm) provided by the manufacturer. Actigraphy has been well-validated against polysomnographic measurements [34].

The participants were instructed to press a button on the actigraph when they started trying to fall asleep and when they woke the following morning. The first button press was used to determine bedtime and the second was used to determine wake time. In order to precisely analyze the actigraph data, over the course of actigraphic recording participants completed the Consensus Sleep Diary, which included the time they got into bed as well as their initial and final wake times, number of awakenings, and lengths of awakenings.

Five actigraphy measures of sleep quality were obtained: total sleep time (minutes of sleep from intended bedtime to final wake time), sleep onset latency (minutes to fall asleep from bedtime), and three measures of sleep continuity: Wake time after sleep onset (WASO; total number of wake minutes after sleep onset), the number of awakenings during the night, and sleep efficiency (percentage of total sleep time between falling asleep and final awakening). The daily actigraphy data of each participant were averaged over the one week of actigraph use in order to obtain aggregated measures that reliably characterize individuals [44]. Note that for smokers a week of actigraphy measurement was conducted once prior to smoking cessation (baseline) and once during the week of abstinence from smoking (smoking cessation).

Measures of smoking behavior

Carbon monoxide (CO) exhalation level: A piCO Smokerlyzer (Bedfont Scientific Ltd., Kent, UK) was used to objectively assess the smoking status of participants, particularly during the week of smoking abstinence. This device measures the CO level in the air exhaled into the monitor. CO in a concentration of 0-6 ppm is characteristic of nonsmokers and 12 ppm or higher is characteristic of chronic smokers.

Fagerström test for nicotine dependence (FTND): The FTND [45], a standard instrument for assessing the intensity of addiction to tobacco for both research and clinical purposes, includes six items, each relating to a specific characteristic of tobacco addiction. The internal consistency (Cronbach's α) of the FTND was reported to range from 0.56 to 0.67 [46] and was 0.55 in the current study.

Brief questionnaire on smoking urges (QSU-brief): The QSU-brief [47], used for the assessment of craving for smoking, consists of 10 statements, each referring to the amount of craving for a cigarette at a given point in time. Participants indicate the level of their agreement with each statement on a 7-point Likert scale. We translated the questionnaire into Hebrew using the accepted procedure [48] of translating from English into Hebrew by one researcher, translating back into English by another researcher, and comparing the two texts. The internal consistency (Cronbach's α) of the questionnaire in the current study was α=0.90.

Data analysis

Statistical analyses were performed using SPSS version 21 software (IBM Corporation). Prior to conducting any parametric tests, the normality assumption of each dependent measure was verified using the Shapiro-Wilk test. The variables alcohol consumption (average number of alcoholic drinks per week), WASO, sleep onset latency, and number of awakenings per night did not meet this assumption and were thus subject to square root transformation that normalized the distribution of WASO, sleep onset latency, and number of awakenings but not of alcohol consumption. Thus, differences between smokers and nonsmokers in alcohol consumption were examined using the Mann-Whitney U test. We used the Chi-square test to compare categorical variables between the groups.

Differences between smokers and nonsmokers in the measures of sleep and demographic characteristics were examined using independent t-tests. The effects of smoking cessation on sleep variables were examined via paired t-tests. Pearson correlations were conducted in order to examine the associations between urge to smoke (QSU) and subjective sleep measures (scores on the MSQ scales) following a week of abstinence from smoking. The significance threshold was set at 0.05. Data in the text are presented as mean ± standard deviation (SD).

Sample size: We calculated that a sample size of 46 would be required in order to be 95% sure that there was a 5 point or more difference in total MSQ between the smokers and non-smokers with 80% power assuming a standard deviation of 6 in each group. Similarly, we calculated that a sample size of 42 would be needed in order to detect a 7-minute difference in WASO between the groups.

This sample size would allow detection of a medium effect size for the worsening of MSQ and WASO after smoking withdrawal.

Results

Smokers and nonsmokers did not significantly differ in their proportion of women and men, age, alcohol consumption, BMI, or years of education (Table 1). Among smokers, the average score on the FTND (Mean=3.55, SD=2.44) was within the range of low to moderate tobacco dependence and all but two of them experienced in their past at least one failed attempt to quit smoking (Mean number of quitting attempts=1.89, SD=1.37).

Smokers' baseline (i.e., prior to smoking cessation) quality of sleep was compared to that of nonsmokers (Table 2).The groups were compared via independent t-tests in actigraphy measures of sleep (WASO, sleep efficiency, number of nighttime awakenings, total sleep time, and sleep onset latency) and in their scores on the MSQ scales. As depicted in Table 2, smokers demonstrated significantly higher WASO and number of nighttime awakenings compared to nonsmokers. In contrast, there were no differences between smokers and nonsmokers in sleep onset latency, in sleep efficiency, or in total sleep time. The groups also did not differ in their time of going to bed or time of waking up.

Sleep Measure	Smokers			Nonsmokers				
	Mean	SD	Range	Mean	SD	Range	t	Cohen's d
Objective measures (Actigraphy)								
Time of going to bed (hh:mm)	00:17	00:55	22:32-01:49	00:08	00:57	22:23-02:08	0.55	0.169
Wake up time (hh:mm)	07:22	00:20	22:32-01:49	07:20	00:23	05:43-08:34	0.14	0.04
Total sleep time (min.)	434.10	47.75	345.57-514.17	432.16	64.62	328.33-521.17	0.11	0.033
Sleep onset latency (min.)	11.31	8.75	3.71-37.43	9.9	5.97	2.50-20.20	0.53	0.158
WASO (min.)	13.44	9.11	0.00-34.33	8.02	8.58	0.00-28.33	2.10*	0.625
Sleep efficiency (%)	96.46	3.04	87.32-99.61	97.73	2.6	91.44-100.00	1.5	0.446
Number of awakenings	2.53	1.06	1.17-5.38	2.00	0.94	1-4.29	1.91*	0.568
Subjective measures (MSQ)								
MSQ-general	27.5	6.8	19-42	26.12	5.52	17-37	0.36	0.107
MSQ-insomnia	8.5	2.54	4-13	9.23	3.33	4-15	0.82	0.244

Sleep onset latency, WASO (wake after sleep onset), and number of nighttime awakenings were analyzed following square root transformation. MSQ: Mini sleep questioner *p<0.05 (one tailed t-test).

Table 2: Differences between smokers and nonsmokers in different parameters of sleep quality.

Smoker's baseline actigraphy measures of sleep quality were compared to their actigraphy data obtained during the week of abstinence from smoking (i.e., smoking cessation). During the week of abstinence, there was a significant increase in WASO [t(19)=3.31; p<0.01; d=0.505; Figure 1A], as well as in the number of awakenings [t(19)=3.23; p<0.01; d=0.499; Figure 1B]. Sleep efficiency was also significantly reduced [t(19)=2.49; p<0.05; d=0.421], though the difference between baseline (Mean=94.94, SD=3.76) and abstinence (Mean=96.46, SD=3.04) was quite modest. In contrast, there was no significant change in sleep onset latency [t(19)=0.75; p>0.05; d=0.163; Figure 1C] or in total sleep time [t(19)=0.81; p>0.05; d=0.160; Figure 1D]. Interestingly, during abstinence the participants went to bed slightly sooner (Mean=23:57:18, SD=1.04) than during baseline (Mean=00:17:31, SD=0.91) [t(19)=2.28; p<0.05; d=0.271]. In contrast, there was no difference in the time of awakening.

As for the subjective quality of sleep following one week of abstinence from smoking, scores on the MSQ-general did not change following the week of abstinence [t(19)=0.29; p> 0.05; d=0.039]. However, one-tailed paired t-test demonstrated that the scores on the MSQ-insomnia scale increased from baseline (Mean=8.50, SD=2.54) to the end of the week of abstinence (Mean=10.15, SD=4.69) [t(19)=1.88; p<0.05; d=0.358]. Interestingly, at the end of the week of abstinence from smoking there was a significant positive correlation (r=0.42; p<0.05) between the participants' urge to smoke and subjective insomnia, as measured at that time point using the QSU and MSQ-insomnia, respectively.

Discussion

The current study is among the first to systematically examine the effects of smoking and smoking cessation on objective and subjective measures of sleep quality among young adults. While the subjective sleep measures did not differ between active smokers and nonsmokers, the actigraphy data pointed to lower sleep continuity (higher WASO and a higher number of awakenings) in smokers compared to nonsmokers. WASO and the number of awakenings further increased during the first week of smoking cessation (i.e., a week of smoking abstinence). In contrast, total sleep time and sleep onset latency did not differ between smokers and nonsmokers and were not affected by smoking cessation. Finally, the participants tended to go to sleep sooner during the week of smoking abstinence compared to baseline (approximately 20 min difference).

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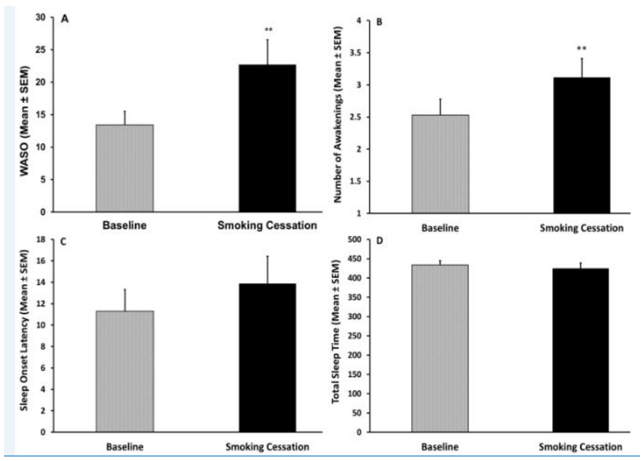

Figure 1: Effects of smoking abstinence on actigraphy-measured sleep quality. During one week of smoking abstinence there were significant increases in wake time after sleep onset (WASO; panel A) and in the number of awakenings during the night (panel B). In contrast there was no significant change in the sleep onset latency (panel C) or total sleep time (panel D) $^{**}p<0.01$.

The fact that smokers in the current study differed from nonsmokers on actigraphy measures of sleep but not in their MSQ scores is consistent with previous reports of only a moderate correlation between objective and subjective measurement of sleep [24,25]. These dissimilarities could be partially explained by an inclination of subjective measures of sleep to underestimate difficulties in sleep continuity [26,49]. In addition, evidence suggests that subjective experience of sleep quality is influenced by the general emotional state in addition to the actual sleep patterns [50]. The latter proposition is consistent with the observation that while the MSQ-insomnia scores of smokers in the current study did not differ from those of nonsmokers, it tended to increase following a week of abstinence from smoking, possibly reflecting not only the objective deterioration in sleep continuity but also the overall distressing impact of nicotine withdrawal.

Overall, the differences in sleep quality between smokers and nonsmokers, and the effects of smoking cessation in the current study were moderate compared to previous studies that were conducted on samples of older adults (usually mean age ≥40 compared to 24.7 in the current study). Specifically, these studies usually reported lower subjective sleep quality among active smokers compared to nonsmokers and following abstinence from smoking [5,7,10]. In addition, in studies using PSG or actigraphy, the poorer sleep of smokers was reflected not only by reduced sleep continuity but also by increased sleep onset latency and/or decreased total sleep time [28,33,36].

While other methodological differences could account for the described discrepancies, age and level of smoking dependence likely play an important factor. Specifically, longitudinal studies suggest that there may be long-term and cumulative effects for tobacco smoking on the development of sleep disturbances [51]. Older regular smokers have longer history of smoking and may also have higher daily rates of cigarette smoking. Indeed, the average daily smoking of older adults in the aforementioned studies was usually higher (≤ 20) than in the current study (13.7). These differences in level of exposure to tobacco smoke could explain differences in severity of sleep difficulties in various ways. For example, while older adults who are heavy smokers may develop smoking-related pulmonary and respiratory diseases that are known to disturb sleep, such conditions are rare among young adults [52]. Moreover, such heavy smokers are likely to be have a more severe nicotine dependence. Indeed, the FTND score of the smokers in the current study (3.55) reflected only a low to moderate dependence. Thus, the sleep quality of young adults who are highly tobacco dependent remains to be examined. However, the current results suggest that at least some aspects of sleep quality of smokers are disturbed before and after smoking cessation, even if they are only moderate smokers.

The positive correlation found in the current study between scores on the MSQ-insomnia and levels of urge to smoke (QSU scores) following one week of abstinence from smoking is consistent with several studies in older adults. In these studies, the severity of sleep disturbances before and during smoking cessation predicted difficulties to remain abstinent and eventual relapse [9,20,33]. For example, higher frequency of awakenings during the first nights of abstinence from smoking was inversely related to successful smoking cessation [53,54]. Importantly, while most of these studies relied on subjective measures of sleep, Jaehne and colleagues [33] also demonstrated that relapse along a three-month period following a cessation attempt was associated with longer REM latency and reduced total REM during the night of the acute withdrawal state (i.e., following 24-36 h of abstinence). Possibly, insufficient sleep increases the motivation to smoke due to the expectation that smoking will decrease the resulting fatigue and cognitive deficits [55,56]. However, other mechanisms may be involved. For example, fatigue may induce self-control failure [57], which in turn could increase the risk for relapse [58]. Finally, it is important to note that several of the current pharmacological treatments for smoking cessation, including transdermal nicotine, bupropion, and varenicline, can also cause sleep difficulties [4,59,60], further complicating the challenge faced by smokers who wish to quit.

Taken together, the findings of the current study and previous research suggest that the incorporation of sleep therapy in smoking session treatment programs could potentially increase their odds for success. However, further research is needed in order to explore this possibility.

The findings of this study should be viewed in light of several limitations. First, the sample size of the groups was relatively small, undermining statistical power. Second, the participants in the current study were sampled from a population of healthy students. Thus, generalization to young adults of different backgrounds should be taken with caution. Third, alcohol consumption was evaluated in the current study based on on a single question regarding the average number of drinks consumed per week rather than on a standard instrument that could examine this variable more accurately and fully. However, from the participants' responses it was clear that their alcohol consumption was very low (an average of fewer than two drinks per week) and thus likely did not have much impact on the results. Finally, this study examined only the first week of smoking cessation. The relationship between sleep quality and long-term odds for relapse among young adults should be addressed in future studies.

In sum, the current study demonstrates that, among young adults, tobacco smoking and smoking cessation are associated with lower levels of objectively measured sleep continuity. Specifically, smokers demonstrate higher WASO and more nighttime awakenings compared to nonsmokers. During the first week of smoking cessation, the sleep quality of smokers further deteriorated as reflected by increased WASO and increased number of awakenings during the night. Moreover, the level of subjective sleep difficulties after this week of abstinence was positively correlated with the urge to smoke again. These results suggest that smokers who wish to quit could substantially benefit from treatments intended to promote their quality of sleep.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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