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Young adult waterpipe smokers: Smoking behaviors and associated subjective and physiological effects

Kawkab Shishani*, Donelle Howell, Sterling McPherson, and John Roll

Program of Excellence in the Addictions, College of Nursing, Washington State University, WA, USA

Abstract

Introduction: The purpose of this pilot study was to investigate smoking behaviors and subjective and physiological effects of nicotine on young adult occasional waterpipe smokers.

Methods: This study utilized a repeated-measures design that included one repeated factor for condition (nicotine and non-nicotine). For each participant, the sequencing of the repeated factor was assigned using random allocation. The two nicotine conditions were nicotine (0.75 g) and non-nicotine (0 g placebo) tobacco. Over the course of two weeks, twenty-two participants completed subjective (Acute Subjective Effects of Nicotine) and physiological (blood pressure, heart rate, and CO level) measures. Additional measures (QSU and MNWS-R) were used to assess for withdrawal symptoms.

Sample: The participants ($n = 22$) were young adults (23 ± 3.1 years); 71% smoked waterpipe once a month in the past year and 29% smoked waterpipe 1–2 times per week. In addition, 60% reported sharing their waterpipe with friends while smoking. None of the participants reported using any other forms of tobacco products.

Results: Under the nicotine condition, participants tended to smoke longer (i.e. smoking duration, $p = 0.004$), take more puffs ($p = 0.03$), take shorter puffs ($p = 0.03$), and inhale less volume with each puff ($p = 0.02$). The repeated measures analysis of the factor *headrush* revealed an effect of the nicotine condition ($F = 9.69$, $p = 0.001$, partial $\eta^2 = 0.31$) and time ($F = 8.17$, $p = 0.02$, partial $\eta^2 = 0.30$). Heart rate increased significantly across the nicotine condition ($F = 7.92$, $p = 0.01$, partial $\eta^2 = 0.31$) and over time ($F = 12.64$, $p = 0.01$, partial $\eta^2 = 0.41$).

Conclusions: This study demonstrates how differences between nicotine and non-nicotine waterpipe smoking are associated with changes in smoking behaviors, experiencing a *headrush* and an increase in heart rate.

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* Corresponding author at: P.O. Box 1495, Spokane, WA 99210, USA. Tel.: +1 509 324 7425. Kawkab.shishani@gmail.com (K. Shishani).

Contributors

Dr. Shishani reviewed the literature, interpreted the data, and prepared the manuscript. Dr. Howell designed the study.

Dr. Sterling conducted the statistical analysis.

Dr. Roll provided the consultation on all aspects of the project.

Conflict of interest

All authors declare no competing interests.

Keywords

Waterpipe; Young; Nicotine; Self-regulation; Headrush

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1. Introduction

Nearly all adults who smoke cigarettes started smoking before the age of 26 (U.S. Department of Health and Human Services, 2012). One in every four senior high school students uses tobacco (Arrazola, Dube, & Engstrom, 2012). As youth transition to adulthood, tobacco use becomes more prevalent (U.S. Department of Health and Human Services, 2012). In fact, young adults (18–25 years old) currently have the highest prevalence of cigarette smoking of all age groups (Substance Abuse and Mental Health Services Administration [SAMHSA], 2011).

In recent years, waterpipe smoking has become increasingly popular. Waterpipe smoking is becoming the most common type of tobacco smoking after cigarettes among U.S. young adults (Cobb, Khader, Nasim, & Eissenberg, 2012; Primack et al., 2008, 2013). Reports have shown a 40% increase from 2005 to 2008 (Smith et al., 2011). This rise is a major concern in the U.S. and globally (Maziak, 2011; The First International Conference on Waterpipe Tobacco Research Declaration, 2013; U.S. Department of Health and Human Services, 2012; World Health Organization, 2005).

Typically, waterpipe smoking in the young adult population is non-daily, with the majority smoking only on weekends (Ahmed, Jacob, Allen, & Benowitz, 2011). Additionally, substantial proportions (6–41%) of current waterpipe smokers do not report the use of other tobacco products (Cobb et al., 2012; Primack et al., 2013). As such, waterpipe smoking is affecting a population of otherwise nicotine-naïve individuals who might not have initiated tobacco use without waterpipes. This raises the concern that waterpipe smoking may serve as a portal to nicotine dependence (Maziak et al., 2009; Ward et al., 2007). Thus, understanding waterpipe smoking behaviors and the consequences of waterpipe smoking in young adult occasional smokers who do not smoke cigarettes or use other tobacco products is imperative.

Exposure to waterpipe tobacco smoke poses a serious health risk (Akl et al., 2010; Al Mutairi, Shihab-Eldeen, Mojiminiyi, & Anwar, 2006; Al-Kubati, Al-Kubati, al'Absi, & Fiser, 2006; Aydin et al., 2004; Boskabady, Farhang, Mahmodinia, Boskabady, & Heydari, 2012; El-Nachef & Hammond, 2008; El-Setouhy et al., 2008; Sajid, Chaouachi, & Mahmood, 2008; Sepetdjian, Shihadeh, & Saliba, 2008). Waterpipe smoke delivers the same or larger quantities of harmful gases and cancer-causing toxins as cigarettes (Al Rashidi, Shihadeh, & Saliba, 2008; Jacob et al., 2011, 2013; Saleh & Shihadeh, 2008; Sepetdjian et al., 2008; Shihadeh et al., 2012). The American Cancer Society warns that waterpipe tobacco smoking is linked to heart disease and cancers in a manner similar to cigarette smoking (American Cancer Society, 2012). However, current knowledge of waterpipe tobacco smoking is based largely on samples of dual users of both waterpipes and cigarettes (Blank et al., 2011; Eissenberg & Shihadeh, 2009; Rastam et al., 2011).

Using puff topography (puff numbers, volume, duration, and intermittent puff intervals [IPI]) measures, studies demonstrated that waterpipe smokers adjusted puffing during each smoking session by controlling the number of puffs and the volume of inhaled tobacco smoke in each puff (Eissenberg & Shihadeh, 2009; Maziak et al., 2009). Self-regulation is well demonstrated in cigarette smokers where the dose of nicotine obtained from tobacco products is regulated by the number of puffs, the duration of individual puffs, and the volume of inhaled tobacco smoke (Husten, 2009). This is further evidenced by waterpipe smoking studies. A study of dependent dual users found that plasma nicotine levels increased with an increase in total inhaled tobacco smoke volume, while puff number and total smoke volume decreased over the course of a waterpipe smoking session (Maziak et al., 2011). Similarly, a study of occasional dual users of waterpipe and cigarettes, ages 18–50, found that puff number and total smoke volume decreased over time (Blank et al., 2011). Smoking behaviors among younger naïve waterpipe smokers have not been studied. Therefore, a comparison of the nicotine and non-nicotine conditions will help in better understanding the effects of nicotine on waterpipe smoking behaviors in the young adult population.

Evidence suggests that non-daily cigarette smokers seek immediate positive reinforcement from cigarette smoking (Glautier, 2004), while daily smokers seek drug maintenance to avoid withdrawal symptoms when smoking—negative reinforcement (Shiffman, Dunbar, Scholl, & Tindle, 2012). A survey of occasional waterpipe smokers indicated that the most commonly reported subjective effect was lightheadedness (Ahmed et al., 2011). In a laboratory-based study examining the effectiveness of waterpipe and cigarette smoking in reducing tobacco abstinence symptoms experienced by dependent dual users of waterpipe and cigarettes, participants experienced lightheadedness, nausea, and dizziness (Maziak et al., 2009; Rastam et al., 2011). However, in a laboratory-based study comparing the subjective effects of waterpipe tobacco by occasional dual users of waterpipe and cigarettes compared to a placebo, subjective effects observed were not related to the nicotine condition (Blank et al., 2011). The subjective effects of nicotine on occasional waterpipe smokers who do not use other tobacco products need to be examined.

The purpose of this study was to inform our limited knowledge of the effects of waterpipe smoking on young adults in the U.S. who do not smoke cigarettes or use tobacco products other than occasional waterpipe smoking. The primary aim of this study was to examine smoking behaviors (puff topography) and the associated subjective and physiological effects of nicotine throughout waterpipe smoking session by comparing these parameters during a nicotine and a non-nicotine condition. The research hypotheses tested whether smoking behaviors differ by nicotine condition and can be associated with the direct effect of nicotine.

2. Materials and methods

2.1. Participants

Twenty-two participants were recruited. Inclusion criteria were: (a) 18–30 years of age, (b) smoked a waterpipe at least 10 times in the past year, and (c) had not smoked a waterpipe more than two times per week in the past 3 months. Exclusion criteria were: (a) smoked

cigarettes or used any other tobacco product, (b) the use of illicit drugs, including marijuana and prescribed opioids, in the past 14 days, and (c) pregnancy. Participants were recruited from the community through postings on craigslist and flyers. Participants were compensated financially for their time. This study was approved by the Institutional Review Board at Washington State University.

2.2. Study procedures

This study as reported here utilized a repeated-measures design that included one repeated factor for condition (nicotine and non-nicotine). For each participant, the sequencing of the repeated factor was assigned using random allocation. The two nicotine conditions were nicotine (0.75 g) and non-nicotine (0 g placebo) tobacco. Initially, the study was designed to include a second repeated factor focusing on two target smoke volumes: low volume (40 liters) and high volume (80 liters) such that there were four conditions (high-volume nicotine, high-volume non-nicotine, low-volume nicotine, and low-volume non-nicotine). However, initial analyses showed that the low-volume conditions did not produce a meaningful amount of variance in the primary outcomes. Participants smoking low volumes of nicotine and non-nicotine tobacco reached the total volume of smoke inhaled in approximately 24 min and 14 min respectively. This was a truncated timeframe, and thus produced a period of outcome observation that was qualitatively different from the high-volume visits, which made a comparison between high and low conditions difficult to interpret. Based on the puff topography data, the low-volume conditions were met early due to the number of puffs and tobacco smoke volume inhaled early in the visit. Consequently, the study design and analyses reported here only include the two conditions of nicotine and non-nicotine tobacco at the high volume (80 liters).

Each participant attended three visits during a week, one smoking visit and two follow-up visits, on consecutive days, for a total of 2 weeks (one week for each smoking condition). Follow-up visits were conducted at 24 and 48 h after completion of the smoking visit to assess for withdrawal symptoms. Upon completion of all visits, participants were given monetary compensation of \$25 for each smoking visit and \$20 for each follow-up visit. A bonus of \$40 was given for completion of all study visits.

Once consent was obtained, the Lebanon Waterpipe Dependence Scale (LWDS) was administered to assess for nicotine dependence (Salameh, Waked, & Aoun, 2008). Participants were asked to abstain from nicotine for at least 24 h before the smoking visit and through both follow-up visits each week; abstinence from nicotine was verified by saliva cotinine using the NicAlert test (<10 ng/ml) and a CO measurement (< 7 ppm). Participants were blinded to study condition assignments.

All smoking visits took place in a private, fenced, outdoor location. Measures were taken to provide a natural smoking environment (e.g., participants were provided with magazines to read). The quantity of tobacco and type of charcoal were controlled for all the smoking conditions. Tobacco was heated with charcoal (30 mm diameter; 5.6 g; Golden Coal, UAE). The participants were free to move the charcoal around on the aluminum foil with tongs. Smoking visits lasted 45–60 min. The topography system was programmed to cue the individual to stop smoking once the target volume was reached. Participants were instructed

to stop smoking immediately when the cue alarm sounded. As an extra precaution, participants were advised to report adverse effects, such as headaches, and were given the option to discontinue the smoking visit at any time.

2.3. Study measures

2.3.1. Puff topography—The waterpipe topography system was developed to measure puff topography (Shihadeh, Antonios, & Azar, 2005). The system consists of a flow sensor connected to the waterpipe, which in turn is connected to an analog differential pressure transducer. The signal output of the pressure transducer feeds to a 22-bit analog-to-digital data logger, and the logged data can be periodically downloaded through a serial port to a laptop, which allows for the measurement of puff topography parameters over time. For each participant, these serial measurements are summarized as average puff volume (liters), average puff duration (seconds), average intermittent puff intervals (seconds), total number of puffs, and smoking session duration (minutes). The interface can be programmed to standardized smoking behaviors by cueing the participant once the smoking volume is reached. The topography apparatus was validated in previous studies measuring topography and exposure in waterpipe smokers (Blank et al., 2011; Eissenberg & Shihadeh, 2009; Maziak et al., 2009). The waterpipe connected to the topography system consisted of a chrome body that screwed into a glass base. Commercial tobacco preparations were used in both smoking conditions. The nicotine tobacco brand used was Al Fakher (Vansickel, Shihadeh, & Eissenberg, 2012). The non-nicotine tobacco brand used was Evolution Tea Shisha (natural herbs with added flavoring to mimic tobacco). The standard tobacco package was 15 g, and the flavors used were double apple and watermelon.

2.3.2. Subjective measures—Effects of nicotine were assessed five times during the smoking visit, immediately before the first puff, while smoking (at 5 min, 15 min, and 30 min), and immediately post-smoking using the Acute Subjective Effects of Nicotine. This 17-item measure is rated on a visual analog scale (100-mm lines) (0-mm = not at all, 100-mm = extremely) that is anchored at both ends by opposing adjectives. Participants rate how they feel by making a mark along the line. The 17 items are summarized into five factors that are constructed by averaging the responses across items within each of the factors (Perkins, Jetton, & Keenan, 2003). These five factors include: factor 1 — *headrush* (items: buzzed, headrush, lightheaded, jittery); factor 2 — *positive affect* (items: comfortable, satisfied, relaxed, pleasant, nauseated); factor 3 — *negative affect* (items: angry, depressed, tense); factor 4 — *fatigued* (items: tired, sedated, fatigued); and factor 5 — *energized* (items: stimulated, vigorous).

Withdrawal effects of nicotine were assessed four times: pre-smoking (to obtain a baseline), post-smoking, and then again at each of the follow-up visits (24 h post-smoking, and 48 h post-smoking). Withdrawal effects were measured using both the Tiffany–Drobes Questionnaire on Smoking Urges (QSU) and the Minnesota Withdrawal Scale (MNWS-R). The QSU is a 10-item instrument rated on a visual analog scale from 0- mm (strongly disagree) to 100-mm (strongly agree) to evaluate the craving to smoke (Cox, Tiffany, & Christen, 2001). The 10 items on the QSU are reported as a mean score for the two factors constructed by averaging the responses for all items within each of the factors: factor 1 —

intention to smoke; and factor 2 — *anticipation of relief from withdrawal*. The MNWS-R is a 15-item instrument also rated on a visual analog scale from 0-mm (none) to 100-mm (severe). This instrument measures nicotine withdrawal in chronic smokers (Hughes & Hatsukami, 1998) and has demonstrated adequate psychometric properties (Blank et al., 2011; Maziak et al., 2009). Responses for each of the 15 items on the MNWS-R are reported.

The Lebanon Waterpipe Dependence Scale (LWDS-11) is an 11-item instrument developed to assess dependency in waterpipe smokers. Each item score ranges from 0 to 3 with a total score of 33 points. A total score above 10 demonstrates nicotine dependency (Salameh et al., 2008).

2.3.3. Physiological measures—Systolic and diastolic blood pressure (SBP and DBP) and heart rate (HR) were measured with a Welch-Allyn monitor. Physiological measures were taken five times during the smoking visit: presmoking, 10 min, 20 min, 30 min and post-smoking. The NicAlert test was used to verify abstinence from the use of nicotine within 24 h prior to a smoking visit. This is a valid and reliable test (Cooke et al., 2008). The test yields six semi-quantitative results ranging from 0 to 6. CO was measured with a Bedford Micro + Smokerlyzer (www.covita.net). For this study, abstinence was defined as a saliva cotinine reading of 0 (< 10 ng/ml) and a CO reading of less than 7.

3. Statistical analysis

All analyses were conducted in SPSS version.20.0, and our alpha threshold for determining statistical significance was set at 0.05. Descriptive analyses of sample characteristics included the calculation of percentages for categorical variables and a mean (M)/standard deviation (SD) for continuous variables. To compare puff topography outcomes for participants during the nicotine condition to the same participants during the non-nicotine condition, paired t-tests were performed. To examine the differences in measures of the subjective effects of nicotine (measured at five time points) and measures of withdrawal (measured at four time points) during the two nicotine conditions, repeated measures analysis of variance (ANOVA) including the main effects for nicotine condition, time, and the nicotine condition by time interaction (i.e., moderation) was performed. During our analyses of repeated measures, the Greenhouse-Geisser corrected *F* values were used when non-sphericity was detected.

4. Results

4.1. Descriptive characteristics

The study included 22 participants. The participants were young adults (23 years of age $\pm$ 3.1 years) of several ethnicities: Caucasian (82%), African American (4.5%), Asian (4.5%), Hispanic (4.5%), and Middle Eastern (4.5%). The sample was predominantly male (59%), and less than half of the participants were employed part-time (45.5%), while more than one fourth (27%) were unemployed or students (18%). Less than one third (29%) smoked a waterpipe 1–2 times per week, and the majority (71%) did not smoke on a weekly basis. Also, 60% reported that they always shared waterpipe smoking with friends, and 40%

reported sharing occasionally. None of the participants reported using other forms of tobacco products. Participants' average score on the LWDS was 6.7 ± 3.2 (a score below 10 indicates no dependency on nicotine).

4.2. Smoking behaviors

Table 1 presents key puff topography parameters collected on participants during each of the two nicotine conditions. Analyses of the nicotine and non-nicotine conditions showed that participants in the nicotine condition tended to take more puffs (M (SD): 187 (128) vs. 109 (54), $p = 0.03$), and take shorter puffs (M (SD): 2.97 (1.85) vs. 4.04 (1.90) seconds, $p = 0.03$). The average puff volume inhaled in the nicotine condition was less compared to that in the non-nicotine condition (M (SD): 0.55 (0.50) vs. 0.87 (0.62), $p = 0.02$). The total volume (80 liters) was reached on average in 30 min in the non-nicotine condition and in 46 min in the nicotine condition ($p = 0.004$).

4.3. Subjective effects

Acute Subjective Effects of Nicotine results by nicotine condition and across time are presented in Table 2. For factor 1 *headrush* — differences by nicotine condition ($F = 9.69$, $p = 0.001$, partial $\eta^2 = 0.33$), time ($F = 8.17$, $p = 0.02$, partial $\eta^2 = 0.30$), and the time by nicotine interaction ($F = 5.35$, $p = 0.001$, partial $\eta^2 = 0.22$) were found. As shown in Fig. 1, the factor *headrush* increased sharply during the smoking session for the nicotine condition, but increased only slightly over time when the participants were in the non-nicotine condition. The relative effect size of the time by nicotine condition interaction for the *headrush* analysis (18% variance accounted for) indicates that exposure to nicotine during the smoking session resulted in the subjective effects referred to as *headrush*. No significant differences by condition, across time or for the time by nicotine condition interaction were found for the other four factors (positive affect, negative affect, fatigued, and energized).

Using the MNWS-R to measure withdrawal effects (Table 3) significant differences for the main effects of condition, time or condition by time were found for the items *dizziness* ($p = 0.02$, $p < 0.001$, and $p < 0.001$ respectively) and *nausea* ($p = 0.03$, $p = 0.01$, and $p = 0.03$ respectively). The mean score for dizziness was highest in the nicotine condition post-smoking (22.04 ± 30.54) as compared to pre-smoking and at 24 h and 48 h post-smoking (2.57 ± 2.60 , 2.50 ± 2.44 , and 2.71 ± 3.16 respectively). Similarly, the mean score for nausea was highest in the nicotine condition post-smoking (20.82 ± 30.03) as compared to pre-smoking and at 24 h and 48 h post-smoking (2.55 ± 2.84 , 3.14 ± 6.15 , and 2.43 ± 2.65 respectively). No significant differences were found for any of the other 13 items on the MNWS-R. Using the QSU to measure withdrawal effects, a significant main effect for time was found for the factor *intention to smoke* ($F = 4.43$, $p = 0.02$, partial $\eta^2 = 0.18$); however, these changes across time were not different between the nicotine and the non-nicotine conditions ($F = 0.37$, $p = 0.66$, partial $\eta^2 = 0.02$). Of note, the mean score for *intention to smoke* was highest after 48 h for the nicotine condition (17.32 ± 16.18) as compared to pre-smoking, post-smoking, and 24 h post-smoking (14.72 ± 12.30 , 7.99 ± 9.99 , and 11.47 ± 11.50 respectively).

4.4. Physiological effects

Heart rate increased significantly over time ($F = 12.64, p < 0.01$, partial $\eta^2 = 0.41$), and by the nicotine condition ($F = 7.92, p = 0.01$, partial $\eta^2 = 0.31$). The time by nicotine condition interaction for heart rate was not significant ($F = 1.91, p = 0.16$, partial $\eta^2 = 0.09$). The mean heart rate increased from 78 ± 12 (baseline) to 86 ± 13 (post-smoking) in the nicotine condition, and from 72 ± 11 (baseline) to 77 ± 9 (post-smoking) in the non-nicotine condition, as illustrated in Fig. 2. No differences in the mean systolic blood pressure by condition ($F = 2.12, p = 0.17$, partial $\eta^2 = 0.12$), across time ($F = 1.23, p = 0.31$, partial $\eta^2 = 0.07$) or for the group by time interaction ($F = 1.4, p = 0.20$, partial $\eta^2 = 0.31$) were found. Similarly, no differences in the mean diastolic blood pressure between the nicotine and non-nicotine conditions ($F = 6.32, p = 0.27$, partial $\eta^2 = 0.02$) or across time ($F = 3.41, p = 0.78$, partial $\eta^2 = 0.17$) were found. The mean CO levels increased from pre-smoking to post-smoking during both the nicotine and the non-nicotine condition with the largest change in the mean CO levels occurring during the non-nicotine condition. The mean CO levels during the nicotine condition were: pre-smoking (1.18 ± 1.05), post-smoking (16.83 ± 12.45), $t = 6.18, p < 0.001$. The mean CO levels during the non-nicotine condition were: pre-smoking ($1.27 \pm .93$), post-smoking (19.62 ± 12.64), $t = 6.89, p < 0.001$.

5. Discussion

This study demonstrates that changes in smoking behaviors (i.e. puff topography measures) occur as a result of the nicotine condition. In the current study, the target total tobacco smoke volume was pre-determined. The nicotine condition, compared to the non-nicotine condition, was associated with longer smoking visits, shorter puffs, less volume inhaled per puff, and more overall puffs during waterpipe smoking. Participants in the nicotine condition took a longer time (45 min) to reach the target volume compared to those in the non-nicotine condition (30 min). These findings suggest that occasional waterpipe smokers who are not dependent on nicotine and who do not use any other tobacco product may compensate for nicotine behaviorally through puffing. This result is consistent with the work of Maziak et al. (2009, 2011) who demonstrated similar findings but in a sample of dependent smokers. One conclusion from this finding may be that behavioral compensation for nicotine precedes dependency.

Increased *headrush* was the main subjective effect experienced by participants during the nicotine condition. The subjective effects of nicotine vary in “nicotine-naïve” individuals as compared to dependent smokers (Perkins, Gerlach, Broge, Grobe, & Wilson, 2000; Perkins et al., 2003). A meta-analysis of placebo-controlled laboratory studies of the subjective effects of nicotine, administered with nasal spray or intravenously, demonstrated increased *headrush* for non-smokers (Kalman & Smith, 2005). Young adult smokers describe their initial cigarette smoking experiences as “pleasurable” and characterized by a “headrush” (Eissenberg & Balster, 2000; Pomerleau, Pomerleau, Namenek, & Marks, 1999). In the current study, occasional waterpipe smokers experienced the pleasurable effects of nicotine (i.e., *headrush*) throughout the smoking session. One study, which examined movement across smoking behaviors over 2 years, demonstrated that significant numbers of light and intermittent smokers moved into heavy smoking (White, Bray, Fleming, & Catalano, 2009).

Indeed, DiFranza, Sweet, Savageau, and Ursprung (2012) concluded that pleasure derived from tobacco use increases over time in proportion to the growing strength of the addiction. Of concern, seeking increased pleasure derived from tobacco use, occasional waterpipe smokers may find cigarettes a more convenient source for nicotine and over time become dependent. Examination of the relationship between these initial nicotine-related positive or liking experiences and the transition to dependency in occasional waterpipe smokers is warranted.

Several studies have reported on the physiological effects of waterpipe smoking (Al Mutairi et al., 2006; Al-Kubati et al., 2006; Blank et al., 2011; Eissenberg & Shihadeh, 2009). A significant increase in heart rate by nicotine condition and across time was observed in the current study. The mean post-smoking heart rate for participants during the nicotine condition remained significantly elevated from pre-smoking (78 bpm increasing to 89 bpm) as compared to the same participants during the non-nicotine condition (74 bpm increasing to 79 bpm). A significant increase in CO levels was observed after smoking in both conditions. However, the increase was higher in the non-nicotine condition. This finding is consistent with the literature and adds to the evidence dispelling the myth that “herbal” or flavored non-nicotine waterpipe smoking is not harmful. Studies that examine health effects of “herbal” waterpipe smoking are needed to increase our understanding of the potential dangers of this behavior.

This study has limitations. The study participants smoked a waterpipe in a laboratory setting. Waterpipes in the U.S. are smoked in hookah lounges and with friends. The social context of this environment may play a role in smoking behaviors. To this end, smoking behaviors in laboratory settings may not be similar to smoking behaviors in natural settings (e.g., hookah lounges, homes). The majority of the participants in this study reported sharing a waterpipe with multiple users whenever they smoked in the past. In the current study, participants did not share a waterpipe while smoking under the study conditions. This may further contribute to the variation in smoking behaviors between a natural setting and a research setting.

This study demonstrates that, in young adult, occasional waterpipe smokers who are otherwise non-dependent, smoking behaviors associated with the nicotine condition include a longer duration of smoking, taking more puffs, taking shorter puffs, and inhaling less tobacco smoke per puff when compared to the non-nicotine condition. Nicotine naïve waterpipe smokers adjust their nicotine dose through puffing to experience *headrush*. More research is needed on transition from seeking positive reinforcement to avoiding withdrawal symptoms when smoking waterpipe.

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HIGHLIGHTS

- Waterpipe smokers compensate behaviorally through puffing.
- Occasional waterpipe smoking is associated with headrush.
- Waterpipe smoking is associated with an increased heart rate.
- Non-nicotine waterpipe smoking is associated with high levels of carbon monoxide.

Fig. 1. Mean Differences in headrush by nicotine and non-nicotine conditions across time ($n = 22$) compared using repeated measures analysis of variance including the main effects for nicotine condition ($p = <0.001$), time ($p = 0.02$) and time by nicotine condition interaction ($p = <0.001$).

Fig. 2.

Mean differences in heart rate by nicotine and non-nicotine conditions across time ($n = 22$) compared using repeated measures analysis of variance including the main effects for nicotine condition ($p = 0.01$), time ($p < 0.001$) and time by nicotine condition interaction ($p = 0.16$).

Table 1

Mean puff topography measures by nicotine and non-nicotine conditions (n = 22).

Puff topography parameters	Nicotine M (SD)	Non-nicotine M (SD)	<i>p</i> -Value ^a
Average puff volume (liters)	0.55 (0.50)	0.87 (0.62)	0.02
Average puff duration (seconds)	2.97 (1.85)	4.04 (1.90)	0.03
Average intermittent puff intervals (IPI) (seconds)	16.97 (11.17)	13.92 (6.42)	0.13
Total number of puffs	187 (128)	109 (54)	0.03
Smoking visit duration (minutes)	46.11 (15.07)	29.55 (12.92)	0.004

^a *p*-Value from paired t-tests comparing the mean puff topography measures for participants during both the nicotine and non-nicotine conditions.

Table 2

Comparison of the Acute Subjective Effects of Nicotine (five factors) by nicotine condition across time (n = 22).^a

Subjective effects of nicotine Factors	Condition			Time			Time * condition		
	F	p-Value	η^2	F	p-Value	η^2	F	p-Value	η^2
Factor 1 — headrush	9.69	<0.001	0.30	8.17	0.02	0.30	5.35	<0.001	0.22
Factor 2 — positive affect	0.21	0.64	0.01	0.36	0.75	0.01	1.64	0.20	0.08
Factor 3 — negative affect	0.003	0.95	0.00	1.43	0.24	0.06	0.27	0.74	0.01
Factor 4 — fatigued	0.09	0.57	0.00	1.60	0.21	0.08	2.61	0.07	0.13
Factor 5 — energized	0.06	0.79	0.00	0.83	0.46	0.04	1.10	0.34	0.06

^a *F*-statistic, *p*-value and η^2 from repeated measures analysis of variance including the main effects for nicotine condition, time and the time by nicotine condition interaction.

Table 3

Comparisons of withdrawal effects measured using the Minnesota Withdrawal Scale and the Tiffany–Drobes Questionnaire on Smoking Urges by nicotine conditions across time (n = 22).^a

Withdrawal effects	Condition			Time			Time * condition		
	F	Sig	eta	F	Sig	eta	F	Sig	eta
<i>Minnesota Withdrawal Scale (MNWS-R)</i>									
15 items:									
Angry, irritable, frustrated	0.71	0.41	0.03	0.96	0.56	0.03	0.92	0.41	0.04
Anxious, nervous	0.06	0.79	0.01	2.17	0.10	0.10	1.21	0.29	0.06
Depressed mood, sad	0.90	1.00	0.90	0.70	0.60	0.03	0.78	0.5	0.04
Desire or craving to smoke	0.96	0.33	0.05	0.77	0.43	0.04	0.57	0.61	0.03
Difficulty concentrating	0.65	0.42	0.03	3.10	0.07	0.14	1.22	0.30	0.06
Increased appetite, hungry, weight gain	0.45	0.51	0.02	1.22	0.31	0.06	0.28	0.79	0.01
Insomnia, sleep problems, awakening at night	7.69	0.07	0.28	0.96	0.39	0.04	0.59	0.54	0.03
Restless	1.00	0.75	0.01	2.54	0.08	0.11	0.41	0.69	0.02
Impatient	2.71	0.11	0.12	0.64	0.52	0.03	1.13	0.32	0.06
Constipation	0.68	0.41	0.03	1.79	0.19	0.08	1.32	0.27	0.06
Dizziness ^b	6.15	0.02	0.24	7.88	<0.001	0.29	4.93	<.001	0.20
Coughing	0.45	0.51	0.02	1.22	0.31	0.06	0.28	0.79	0.01
Dreaming or nightmares	0.74	0.40	0.03	0.49	0.05	0.02	0.49	0.61	0.02
Nausea ^c	5.76	0.03	0.27	6.94	0.01	0.31	5.20	0.03	0.25
Sore throat	0.16	0.69	0.01	2.35	0.08	0.12	0.87	0.40	0.05
<i>Tiffany–Drobes Questionnaire on Smoking Urges (QSU)</i>									
Factor 1 — intention to smoke ^d	0.45	0.51	0.21	4.43	0.02	0.18	0.37	0.66	0.02
Factor 2 — anticipation of relief from withdrawal	0.88	0.35	0.04	1.00	0.33	0.05	1.42	0.25	0.07

^aF-statistic, p-value and η^2 from repeated measures analysis of variance including the main effects for nicotine condition, time and time by nicotine condition interaction.

^bNicotine condition: pre 2.57 ± 2.60 ; post 22.04 ± 30.54 ; 24 h. 2.50 ± 2.44 ; 48 h. 2.71 ± 3.16 . Non-nicotine: pre 2.27 ± 2.47 ; post 4.50 ± 7.00 ; 24 h. 2.05 ± 2.43 ; 48 h. 2.57 ± 3.17 .

^cNicotine condition: pre — 2.55 ± 2.84 ; post — 20.82 ± 30.03 ; 24 h. 3.14 ± 6.15 ; 48 h. 2.43 ± 2.65 . Non-nicotine: pre — 4.10 ± 6.34 ; post — 2.45 ± 2.90 ; 24 h. 1.86 ± 2.35 ; 48 h. 2.57 ± 4.31 .

^dNicotine condition: pre — 14.72 ± 12.30 ; post — 7.99 ± 9.99 ; 24 h. 11.47 ± 11.50 ; 48 h. 17.32 ± 16.18 . Non-nicotine: pre — 18.64 ± 16.27 ; post — 10.34 ± 11.25 ; 24 h. 15.21 ± 15.15 ; 48 h. 15.91 ± 17.50 .