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Smoking Topography in Korean American and White Men: Preliminary Findings

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Abstract

Introduction—This is the first study of Korean Americans' smoking behavior using a topography device. Korean American men smoke at higher rates than the general U.S. population.

Methods—Korean American and White men were compared based on standard tobacco assessment and smoking topography measures. They smoked their preferred brand of cigarettes *ad libitum* with a portable smoking topography device for 24 hours.

Results—Compared to White men (N = 26), Korean American men (N = 27) were more likely to smoke low nicotine-yield cigarettes ($p < 0.001$) and have lower Fagerstrom nicotine dependence scores ($p = 0.04$). Koreans smoked fewer cigarettes with the device ($p = 0.01$) than Whites. Controlling for the number of cigarettes smoked, Koreans smoked with higher average puff flows ($p = 0.05$), greater peak puff flows ($p = 0.02$), and shorter interpuff intervals ($p < 0.001$) than Whites. Puff counts, puff volumes, and puff durations did not differ between the two groups.

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Declaration of Interests
None declared.

Conclusions—This study offers preliminary insight into unique smoking patterns among Korean American men who are likely to smoke low nicotine-yield cigarettes. We found that Korean American men compensated their lower number and low nicotine-yield cigarettes by smoking more frequently with greater puff flows than White men, which may suggest exposures to similar amounts of nicotine and harmful tobacco toxins by both groups. Clinicians will need to consider in identifying and treating smokers in a mutually aggressive manner, irrespective of cigarette type and number of cigarette smoked per day.

INTRODUCTION

Although Asian Americans are generally known for low smoking prevalence rates, Korean American men reportedly smoke at rates about 50% higher than the general U.S. male population [1, 2]. In support of this, a compiled data set from 1995 to 2002 indicated that 71% of the Korean American men's cancer deaths were linked to smoking [3] as opposed to 30% of the general U.S. population [4]. The high rates of smoking and smoking-related mortality among Korean American men compared to the general U.S. population are largely related to the social norm of male smoking in their native country. Men in Korea typically become regular smokers during mandatory military service and continue smoking throughout adulthood [5]. The majority of Korean men in the United States are immigrants who are employed in labor-intensive small businesses such as cleaners and retail stores [6].

Korean male smokers differ in cigarette consumption and nicotine metabolism from other Asian male smokers (e.g., Chinese and Vietnamese). Korean men are more likely to be daily and moderate to heavy smokers, whereas Chinese and Vietnamese men are more likely to be nondaily and light smokers [7, 8]. Unlike Chinese [9], Japanese [10, 11], and Southeast Asians [12] who manifested slower nicotine metabolism rates than Whites, Koreans showed no difference from Whites [11]. Despite these differences within the Asian American population, tobacco studies on Asian Americans have been conducted with aggregated data.

This study was conducted to compare smoking behavior between Korean American and White men, using a topography device. To our knowledge, this is the first smoking topography study of Koreans and the first to compare smoking topography between Asian and White smokers. We also examined whether ethnicity would explain differences in any topography measures beyond smoking variables such as cigarette type, number of cigarettes smoked, negative moods (depression and anxiety), and workplace smoking restriction.

Smokers vary in the nicotine blood levels that they maintain due to considerable variability in the number of cigarettes consumed per day and the effectiveness of smoking each cigarette [13]. How each individual smokes a cigarette can be measured by using a smoking topography device that records automatically puff count per cigarette, puff volume, puff duration, puff flow (also called puff velocity), time to peak puff flow, and interpuff interval [14]. These measures provide an understanding of how effective and efficient is the smoking method of an individual. For example, an effective smoker would have more puffs per cigarette and be able to inhale more of the smoke. Thus, topography is an indirect measure of nicotine intake and exposure to tobacco toxins [15–17]. There is ample evidence indicating the relationship between topography measures and blood nicotine and

carboxyhemoglobin levels [e.g., 14, 18–20]. Furthermore, the advent of a portable, hand-held topography device made it possible to assess individuals' puffing behavior in their natural environment.

Smoking topography varies in relation to nicotine and tar yields [14, 21]. For example, Japanese smokers who smoked ultra-low/low nicotine-yield cigarettes smoked more intensely than those who smoked medium/high nicotine-yield cigarettes [22]. Individuals especially smoke more intensely after they switched from high- to low-yield cigarettes as a function of compensatory mechanism [14, 22–25]. The majority of smokers in Korea switched their cigarettes to low-yield cigarettes in the past decade as they noticed a dose-response fashion in harms associated with smoking. In 2002, the Korean government enacted a law that mandates nicotine and tar levels on every cigarette pack sold in Korea [26, 27]. As a result, the retail volume sales of low-yield cigarettes in Korea soared from 1.8% share in 2002 [28] to 90.4% share in 2009 [29]. Especially, ultra-low-yield cigarettes shared 46% of the total sale in 2009. Nearly 50% of smokers in the 2005 Tobacco Control Policy Evaluation Survey-Korea responded that they chose their current brand of cigarettes because of its low tar and nicotine yields [30]. Similar to the trend observed in Korea, in 2006, 61% of Korean American men in a community-based survey [Kim, unpublished data] reported smoking ultra-low or low-yield cigarettes.

Smoking topography also can vary in relation to mood states [31–34], workplace smoking restriction [35, 36], and nicotine metabolism [37–40]. In a laboratory setting, topography measures such as puff volumes and puff counts increased following negative affect induction [31–33]. In support of this finding, individuals diagnosed with posttraumatic stress disorder smoked higher puff volumes than those without the diagnosis [34]. Findings pertaining to the relationship between workplace smoking restriction and topography measures are mixed. Some [35] reported that smokers who worked in work settings where indoor smoking was restricted puffed more frequently with shorter interpuff intervals on outdoor work breaks compared to when they smoked in off-work settings such as social gathering, whereas others [36] found no difference before and after the introduction of workplace smoking restriction.

Nicotine metabolism influences how individuals smoke cigarettes [37–40]. Nicotine is primarily metabolized into cotinine by the liver enzyme called cytochrome protein (CYP) 2A6 [41, 42]. Cotinine is then metabolized by the CYP 2A6 to trans-3′-hydroxycotinine (3-HC) [43]. The CYP 2A6 enzyme has genetically polymorphic variants that mediate the rate of nicotine metabolism, that is, when nicotine is metabolized more rapidly, smokers tend to smoke more intensely (e.g., smoke with more puffs per cigarette, inhale more smoke per puff, and wait less time between puffs). It was reported that nicotine metabolism rate did not differ between Koreans and Whites [11].

METHOD

Subjects

Smokers were recruited via advertisements in newspapers, magazines, and flyers along with a snowball sampling technique between May 2011 and January 2012. Volunteers were first

screened to determine eligibility for participation based on the following inclusion criteria: adult male smokers who (1) were between the ages of 18 and 65; (2) had no history of cardiovascular, respiratory, and neurological diseases; (3) had not received any treatments for psychiatric disorders within the past 12 months; (4) had smoked at least five cigarettes per day for the past six months; (5) yielded a breath carbon monoxide level > 6 parts per million (ppm) at screening; and (6) were able to speak and read English or Korean. Those who were actively trying to quit smoking and/or taking medications that might affect smoking behavior such as nicotine replacement medications, bupropion, clonidine, and varenicline were excluded. The study was approved by the Institutional Review Board of University of Massachusetts Medical School.

Procedure

At Visit 1, instruction for the proper use of a Clinical Research Support System (CReSS) Pocket device (Borgwaldt KC, Inc., Richmond, VA, USA) was provided. The device is a portable version of the CReSS Laboratory system. It is a battery-operated hand-held device and has a software application function for the Windows platform that allows researchers to download stored measures. It records following characteristics: puff volume (0–150 ml), puff duration (0–28 sec), interpuff interval (0–1200 sec), puff flow (0–150 ml/sec), puff count per cigarette (0–40 puffs), and time to peak puff flow. Participants were instructed to smoke their usual brand of cigarettes *ad libitum* through the mouthpiece of the pocket device. Each participant had to demonstrate the use by properly inserting a cigarette into the device and hearing the beep sound before taking out the device. To assess compliance with the device, participants were asked to monitor the number of cigarettes that they smoked during the 24-hour record period and then this number was later compared with that recorded in the device. To examine the influence of workplace smoking policy on topography measures, we made the device taken out only during workdays if participants were employed. The device was returned in 24 hours at Visit 2 and data from the device was downloaded. Participants were paid US$10 for administration of a research questionnaire at the first visit and US$50 at the second visit when they returned the device.

Measures

All measures were administered in English and Korean men with limited English proficiency were assisted by the first and second authors.

Demographics—Information was gathered on the following areas: age, marital status, education, employment status, annual family income, medical insurance coverage, and the year of immigration if they were not U.S.-born.

Acculturation—It was assessed using a brief form of the Suinn-Lew Asian Self-Identify Acculturation Scale [44] that was made of five question items: language spoken, language preferred, language read, childhood friends and cultural identity. These items had the highest item-to-total correlations among 21 items in its full version [45]. Scores for each item range from “1 = *very Korean-culture oriented*” to “5 = *very American-culture oriented*,” and the scale score is the mean of the scores of the five-items.

Smoking behavior—Information was gathered regarding age at which participants began smoking regularly, their preferred brand of cigarettes and its nicotine and tar concentrations (in milligrams), number of cigarettes smoked per day on average, use of other tobacco products, history of any serious quit attempts in the past year, and workplace smoking restriction.

Nicotine dependence—The Fagerström Test for Nicotine Dependence (FTND) [46] was used. The total score is the sum of the scores of six items and ranges from 0 to 10. More scores indicate higher dependence.

Depression—The Patient Health Questionnaire 9-items (PHQ-9) scale was used. It is the depression module, which scores each of the *Diagnostic Statistical Manual of Mental Disorders, Fourth Edition* (DSM-IV) symptom criteria as "0" (not at all) to "3" (nearly every day) [47]. Using a mental health professional interview as the criterion standard, PHQ-9 scores of 10 and higher had a sensitivity of 88% and a specificity of 88% for major depressive disorder [47]. PHQ-9 scores were dichotomized as < 10 or ≥ 10, using the recommended cutoff score.

Anxiety—Generalized Anxiety Disorder 7-items (GAD-7) scale was used and its initial item pool consisted of 9 items reflecting all of the DSM-IV symptom criteria for GAD [48]. Two items were later dropped from the scale by the developers. Responses to the items range from "0" (not at all) to "3" (nearly every day) and scores of 10 or higher had a sensitivity of 89% and a specificity of 82% for GAD [48]. GAD-7 scores were dichotomized as < 10 or ≥ 10, using the recommended cutoff score.

Smoking topography—Puffing behaviors were measured using the CReSS pocket device. A data cleaning procedure (Plowshare Technologies) was used to identify and delete erroneous puffs/cigarettes beyond the normal physiologic measures, which could result from movement artifacts such as dropping or mishandling the device while smoking. Topography measures included puff count, total puff volume (ml), average puff volume (ml), average puff duration (sec), average puff flow (ml/sec), average peak puff flow (ml/sec), average interpuff interval (sec) per cigarette as well as the number of cigarettes smoked during the record period (about 24 hours). Peak puff flow captures the greatest velocity at any one instant during the puff. The peak puff flow was calculated in two steps: first the sum of the peak puff flow for each puff divided by the total number of puffs and second the sum of the average peak puff flow for each cigarette was divided by the total number of cigarettes smoked during the 24-hour period. In contrast, average puff flow was calculated by dividing each puff volume by the corresponding puff duration, summing these values for all puffs, and dividing by the total number of puffs. The average puff flow for each cigarette was summed and then divided by the total number of cigarettes. The validity and reliability of these measures through the CReSS system have been validated by Lee and colleagues [49].

Data Analysis

Korean American and White men were compared for differences in demographics, smoking behavior, negative emotions and topography measures, using Chi-square and independent *t*-

tests. Linear regression analyses were performed with backward stepwise elimination to retain variables that showed a significant association with topography measures such as puff count, puff volume, average flow, peak flow, puff duration, interpuff interval, and time to peak puff flow. In addition, hierarchical linear models were applied using the mixed procedure in SAS 9.3 to analyze differences by ethnicity in those topography measures. This method takes into account the nesting of each puff within a cigarette and each cigarette within an individual.

RESULTS

A total of 56 men (27 Korean and 29 White Americans) initially participated in this study; however, data from three smokers (all Whites) were not used because they smoked cigars or roll-your-own cigarettes in addition to regular cigarettes. Whites were all American born, whereas Koreans were all foreign born with 6 years of U.S. residency on average. Of the Korean men, 14 (51.9%) completed the instruments with assistance for limited English proficiency.

Table 1 compares participants on demographics, smoking behavior, and psychosocial variables. Koreans and Whites were similar with regard to age, annual income, and employment status. Koreans had more years of education ($t_{30} = 4.56$, $p < 0.001$). More Koreans tended to be married (χ^2 [1, 53] = 3.87, $p = 0.08$) and to have high family income (χ^2 [5, 53] = 9.49, $p = 0.09$) than Whites. Compared to Whites, Koreans were more likely to smoke ultra-low/low-yield cigarettes than high-yield cigarettes (χ^2 [2, 53] = 18.01, $p < 0.001$). Nicotine dependence scores were higher in Whites than in Koreans ($t_{51} = 2.15$, $p < 0.05$).

Koreans were more likely to work mainly in indoor areas (χ^2 [4, 53] = 14.95, $p < 0.01$) and work at a place where indoor smoking was completely banned (χ^2 [3, 37] = 19.19, $p < 0.001$). Whites were more likely to have anxiety than Koreans (χ^2 [1, 53] = 8.38, $p < 0.01$); yet, depression did not differ between the two. Korean men reported having smoked 13 cigarettes on average during the study period but the device recorded 11.8 cigarettes on average (*difference* = 1.19, *standard deviation [SD]* = 1.82). White men also reported having smoked more cigarettes than the number of cigarettes recorded in the device (*difference* = 1.96, *SD* = 2.43). However, the number of cigarettes that were missing did not differ between the two.

Topography data revealed that Koreans smoked fewer cigarettes (*difference* = 3.6, $t_{51} = 2.67$, $p = 0.01$) than White men during the 24-hour record period. None of cigarette type (nicotine yield), negative moods (depression and anxiety), and workplace smoking restriction had a significant association with any of the topography measures (results are not shown here). Controlling for the number of cigarettes recorded in the device (Table 2), Koreans had higher average puff flows (*difference* = 4.99, $t = 1.96$, $p = 0.05$), higher peak puff flows (*difference* = 9.23, $t = 2.29$, $p = 0.02$) and shorter interpuff intervals (*difference* = −11.51, $t = -5.05$, $p < 0.001$) than Whites. However, no differences were found in puff counts, puff volumes, puff durations, and times to peak puff flows.

DISCUSSION

To our knowledge, this is the first study comparing smoking topography measures between Korean American and White men. Koreans had higher puff flows and shorter interpuff intervals than Whites. Williams et al. [50] found that shorter interpuff intervals are associated with greater nicotine intake and higher cotinine levels in smokers. On the other hand, no difference was found in puff volume, puff counts, and puff durations between the two. Based on these findings, Korean American and White men in this study might have been exposed to similar amounts of harmful tobacco toxins even though Koreans smoked fewer cigarettes per day and were more likely to smoke ultra-low/low nicotine-yield cigarettes than Whites.

Compared to White men, Korean men were more likely to smoke low-yield cigarettes. Koreans were also more likely to work in indoor areas where smoking was completely banned. However, cigarette type and workplace smoking restriction were not related to any topography measures. Depression and anxiety also failed to show a significant association with topography measures, which might be related to the small sample or lack of variety among participants in this study. Of note, we excluded smokers who received any treatments including pharmacotherapy for mental illness in the past year.

Findings from the present study should be interpreted with caution. First, the sample size was small, which might have delimited finding other significant factors of topography measures. More studies are needed with large samples. Second, we did not use the structured clinical interview for the assessment of depression and anxiety although the PHQ-9 and GAD-7 scales that we used were found to be a valid measure for these disorders [47, 48]. Third, Korean men who had limited English proficiency completed the study instruments with assistance from the first and second authors, which might have impacted the validity and reliability. Fourth, the study duration was relatively short over a 24-hour period. However, topography measures have shown a regular pattern over days while they vary by time of day [51, 52]. We believed that the measures reported in this study would not be different from those assessed over a longer period. Finally, participants in this study were foreign-born Korean Americans and U.S.-born Whites. Thus, findings might not be applicable to U.S.-born Korean Americans and White immigrants.

In conclusion, this study is the first of its kind comparing smoking topography between Korean American and White men. Compared to Whites, Koreans had higher puff flows and shorter interpuff intervals. Furthermore, the two did not differ in puff volumes, puff counts, and puff durations. Thus, Koreans might have been exposed more to the tobacco-related risk factors than what was expected based on the report that they smoked low-yield cigarettes and fewer cigarettes per day than Whites. More studies are warranted with large samples while controlling for variables such as cigarette type and workplace smoking policy that may affect differently smoking topography between the two groups. In addition, future studies of Korean American men should investigate how their intensive smoking behavior affects blood nicotine levels and cessation outcomes.

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Table 1

Demographic and psychosocial variables between Korean American and White male smokers

	Korean (n = 27)	Whites (n = 26)	p-value
	Mean ± SD or %	Mean ± SD or %	
Age (years)	37.3 ± 9.7	39.2 ± 10.1	0.50
Education (years)	15.6 ± 3.9	12.1 ± 1.0	< **0.001**
Marital status (= married)	44.4%	19.2%	0.08
Family income			0.09
< $20,000	14.8%	26.9%	
$20,000–59,999	48.1%	53.8%	
$60,000–99,999	25.9%	11.5%	
≥$100,000	11.1%	7.7%	
Employment status (= yes)	85.2%	73.1%	0.51
Acculturation (score range: 1–5)	3.5 ± 1.5	NA	NA
Main work area (= indoors)	92.6%	46.2%	< **0.01**
Indoor smoking restriction (=complete ban)	74.1%	23.1%	< **0.001**
Age at smoking onset (years)	18.5 ± 3.0	17.7 ± 4.5	0.41
Carbon monoxide level (ppm)	18.0 ± 6.9	25.5 ± 14.0	**0.02**
Number of cigarette smoked per day			0.11
≤10	25.9%	7.7%	
11–20	63.0%	65.4%	
≥21	11.1%	26.9%	
Cigarette type			< **0.001**
Regular (tar: >15mg)	0.0%	19.2%	
Low (tar: 7–15mg)	40.7%	73.1%	
Ultra-low (tar: < 7mg)	59.3%	7.7%	
Nicotine dependence (0–10)	4.6 ± 2.1	5.8 ± 2.1	**0.04**
Depression (≥ 10)	0.0%	14.8%	0.11
Anxiety (≥ 10)	0.0%	26.9%	< **0.01**

Note. SD = standard deviation, NA = not applicable; and Bolded values denote significant findings.

Table 2

Comparison of topography measures between Korean American and White men using a hierarchical linear model

Variable	Korean (N = 27)		White (N = 26)		p-value
	Mean	SE	Mean	SE	
Puff volume (ml)	59.59	3.01	57.21	2.69	0.55
Puff count/cigarette	13.77	0.69	12.25	0.61	0.10
Average puff flow (ml/second)	42.11	1.91	37.12	1.70	**0.05**
Peak puff flow (ml/second)	61.87	3.01	52.64	2.68	**0.02**
Puff duration (second)	1.47	0.07	1.61	0.06	0.10
Interpuff interval (second)	13.51	1.70	25.02	1.52	< **0.001**
Time to peak (second)	0.52	0.04	0.50	0.03	0.72

Note. Mean = estimated mean, SE = standard error; and Bolded values denote significant findings.