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Behavioral Filter Vent Blocking on the First Cigarette of the Day Predicts Which Smokers of Light Cigarettes Will Increase Smoke Exposure From Blocked Vents

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Abstract

Filter vent blocking on best-selling light cigarettes increases smoke yield during standard machine testing but not in clinical investigations of smokers. The purpose of the study was to investigate the effect of (a) manipulating cigarette filter vent blocking and (b) blocking status of first cigarette of the day on carbon monoxide (CO) boost. Participants ($n = 25$; Marlboro Lights nonmenthol cigarette smokers, age range 21–60 years, minimum 15 daily cigarettes, and daily smoking for a minimum 5 years) completed the laboratory-based, within-subject, double-blind, cross-over design of 2 smoking sessions, one utilizing a smoking topography device, one without. Each session consisted of smoking 4 cigarettes; 2 with filter vents blocked and 2 with filter vents unblocked. Spent first daily cigarette filters collected between sessions were scored for evidence of filter vent blocking. Smoking cigarettes with blocked filter vents significantly increased CO boost in both laboratory sessions ($p < .001$). Those who blocked their first cigarette of the day ($n = 10$) had significantly greater CO boost when smoking a blocked cigarette, in relation to smoking an unblocked cigarette and in comparison with nonblockers ($p = .04$). Total puff volume was a significant predictor of CO boost when smoking unblocked and blocked cigarettes ($ps < .04$). Blocking filter vents significantly increased smoke exposure in relation to when filter vents are not blocked, particularly for those who block filter vents on their first cigarette of the day. Total puff volume predicted CO boost, and results suggest that smokers adjust their smoking behavior by cigarette blocking status. Those smokers who block filter vents may be increasing their exposure by 30%.

Keywords

smoking; light cigarette; filter vents; topography; carbon monoxide

Cigarette smoking is the single most preventable cause of death in the United States, accounting for approximately 87% of lung cancer deaths (Ries et al., 2004). In particular, the incidence of lung adenocarcinoma has rapidly increased since the 1950s (Thun et al., 1997). Epidemiologic evidence suggests that this increase is due largely in part to the introduction of low-nicotine, low-tar, filter-ventilated cigarettes that facilitate deeper inhalation of smoke (Burns, Major, Shanks, Thun, & Samet, 2001; Thun et al., 1997). Filter vents are tiny bands of perforations typically found 10–15 mm from the proximal end of a cigarette that dilute the concentration of cigarette smoke extracted under Federal Trade Commission (FTC) standard testing procedures (Peeler, 1996). The addition of cigarette filter vents has been the most significant design feature in low-tar cigarettes to reduce constituent yields, including carbon monoxide (CO), during official machine-smoked testing regimens, such as the FTC method (Kozlowski & O'Connor, 2002).

Research on filter vent blocking in smokers indicates that the degree of ventilation affects the degree to which a cigarette is prone to increase CO boost with blocked filters and illustrates how compensatory smoking (i.e., taking bigger, more frequent puffs; Kozlowski, Henningfield, & Brigham, 2000) can negate a potential reduction in exposures when smoking the highest-ventilated, lowest-tar (i.e., ultralight, 1 mg tar) cigarettes (Sweeney & Kozlowski, 1998; Sweeney, Kozlowski, & Parsa, 1999; Zacny, Stitzer, & Yingling, 1986). Two different studies found that blocking vents of a less-ventilated light cigarette such as Marl- boro Lights did not produce an increase in CO boost (Sweeney & Kozlowski, 1998), but machine testing of cigarette yields has shown that blocking 50% of the filter vents in light cigarettes produces increased CO yield (Rickert, Robinson, Young, Collishaw, & Bray, 1983), and so a paradox arises. Machine testing indicates that CO boost in light cigarettes is prone to the effects of filter vent blocking, yet in human smoking studies there is no observed increase in CO boost. The most offered reason is that smokers do not smoke like machines (R. R. Baker & Lewis, 2001; Kozlowski et al., 2000) and decrease their puffing behaviors when smoking a blocked cigarette (Kozlowski et al., 2000).

A recent study of filter vent blocking investigated changes in smoking topography, a quantifiable assessment of puffing behavior, on CO boost when smoking 1-mg-tar and light cigarettes (Strasser, Ashare, Kozlowski, & Pickworth, 2005). Results for the highly ventilated, 1- mg-tar cigarettes support previous research: Blocking 50% of filter vents increased CO boost. However, a novel finding was that filter vent blocking also increased CO boost in the light cigarettes. We propose that this unexpected finding could be attributable to several sources. First, the procedures used directed smoking requiring eight total puffs with 45-s interpuff intervals. However, this constraint on smoking behavior is not reflective of in vivo smoking behavior and exposures. Second, the smoking topography device mouthpiece may have obfuscated typical smoking behavior, despite research to the contrary (Lee, Malson, Waters, Moolchan, & Pickworth, 2003). Third, participant brand preference may have affected the results, because brand switching studies have

demonstrated changes in smoking behaviors (Benowitz et al., 1986; Dixon, Kochhar, Prasad, Shepperd, & Warburton, 2003). Fourth, no studies have previously accounted for whether smokers were filter vent blockers or nonblockers, which might significantly impact how they smoke a cigarette with blocked filter vents.

The primary aims of the current study were to investigate (a) the effect of blocking cigarette filter vents, using a controlled manipulation in which 50% of the filter vents are covered and (b) the effect of classifying smokers by filter vent blocking status on the first daily cigarette on CO boost. Our hypotheses were that CO boost would be greater when smoking a light cigarette with vents blocked, in relation to CO boost when smoking an unblocked light cigarette. Smokers who block filter vents when smoking their first cigarette of the day will have greater CO boost than do smokers who do not block. The secondary aims of the study were to investigate the association of smoking topography on CO boost and the effect of using a smoking topography device on smoking behaviors. We hypothesized that total puff volume, the cumulative volume of puffing during smoking, would be positively associated with CO boost and that smoking behaviors would not differ between laboratory sessions.

This research has significant public health implications because light cigarettes are currently the best selling U.S. domestic type of cigarette (Substance Abuse and Mental Health Services Administration [SAMHSA], 2008), and if cigarette constituent exposure is actually greater for even a proportion of light cigarette smokers, there is potential to better characterize a significant health risk. Furthermore, the current proposal for Food and Drug Administration (FDA; the Family Smoking Prevention and Tobacco Control Act) regulation of tobacco products includes regulation of design and construction features, and results from this study could provide empirical support for the banning of filter ventilation (H.R. 1108 Waxman–Davis FDA legislation, Section 907).

Method

Participants

Twenty-five current smokers of Marlboro Lights (ML) nonmenthol cigarettes were recruited via community flyers and prior participant lists. Eligibility required an age range of 21–60 years, minimum of 15 daily cigarettes, smoking for a minimum of 5 years, no smoking cessation attempt in the previous 4 months, no current use of nicotine-containing products (e.g., nicotine replacement therapies or smokeless tobacco), consumption of fewer than 25 alcoholic drinks per week, and self-reported smoking of Marlboro Lights cigarettes. Informed consent was obtained at the beginning of the first laboratory session. The study protocol was approved by the university institutional review board. Sessions were conducted from January to December 2006.

Study Design

The study was a within-subject (blocked vs. not blocked filter vents on first daily cigarette), double-blind, cross-over design (50% cigarette filter vents blocked vs. unblocked cigarette filter vents). Participants completed two 2.5-hr laboratory-based sessions; each session separated by 3–7 days, commencing between 10:00 and 18:00 and congruent to within 60

min. Participants entered the biobehavioral smoking laboratory, had procedures and equipment explained, and consented to their participation. There was no disclosure that ML smoking was an inclusion criterion, but participants were informed that only ML cigarettes would be provided during the sessions. Participants were informed of the filter vent blocking manipulation after Session 2.

Participants completed demographic, nicotine dependence, and smoking history questions and provided a baseline CO breath sample. Participants then smoked a study ML cigarette ad libitum every 30 min, providing CO samples before and after each cigarette and completing subjective cigarette ratings after each cigarette.

Participants were provided resealable plastic bags and were required to return all spent cigarette filters from 3 days between laboratory sessions. They were provided with a red marking pen and instructed to place an X on the first cigarette of the day and to consecutively number subsequent spent filters. Spent filters from the first cigarette of the day were scored for tar stain pattern to determine filter vent blocking after overnight smoking abstinence. All spent cigarette filters served as physical verification of ML smoking and daily cigarette count.

Study procedures were identical for both sessions, with the exception that one session required cigarettes to be smoked with a smoking topography device and the other was videotaped; order was randomized and counterbalanced across participants. At the conclusion of the second session, participants completed a series of questions to assess knowledge of existence and purpose of cigarette filter vents (Kozlowski, Heatherton, Frecker, & Nolte, 1989; Kozlowski, Pillitteri, & Sweeney, 1994; Kozlowski et al., 1996).

Cigarette Preparation

Marlboro Lights (ML) 100s hard pack were purchased on the day of each laboratory session. This brand and type of cigarette has been used in similar research and has an advantage over a king-size (85 mm) length to allow for alterations in burn time and smoking behavior from the filter vent blocking manipulation (Strasser et al., 2005; Sweeney & Kozlowski, 1998). Blocked (BL) cigarettes were prepared by placing a 13-mm-long single piece of transparent tape over the filter vents, representing 50% of the cigarette circumference and 50% of filter blocking (Strasser et al., 2005; Sweeney et al., 1999). Fifty-percent blocking was selected as indicative of a realistic upper range of filter vent blocking observed in smokers, and because of its previous use in filter vent blocking studies (Baker & Lewis, 2001; Sweeney et al., 1999). Previous testing of this manipulation indicates that ventilation level changes from 29% for the unblocked ML to 14% for the blocked ML (Strasser et al., 2005). Unblocked (UN) cigarettes had no alterations made. All four cigarettes (2 BL and 2 UN) were uniquely color coded for ease of participant reference during ratings. Both participant and technician were unaware of blocking condition; order of cigarette presentation was randomized and counterbalanced across participants.

Cigarette Filter Scoring

Three research technicians were trained to measure the degree of filter vent blocking with a transparent scoring template developed by Kozlowski and colleagues (1994; Kozlowski,

Frecker, Khouw, & Pope, 1980), used by others (Sweeney et al., 1999), and that is well suited for detecting the presence of filter vent blocking (Baker & Lewis, 2001). The template divides the proximal end of the spent cigarette filter into eight wedges, and technicians record the frequency of wedges with tar stain reaching the cigarette paper or outer edge, indicating blocking. Scoring was performed in standard-lit rooms with the aid of a 2× magnification handheld lens. Raters were university students who underwent approximately 2 hr of training on test cigarette filters. The filters of the 75 first cigarettes of the day were scored for degree of filter vent blocking. Cigarette filters scoring 0–2 wedges were considered unblocked, 3–5 partially blocked, and 6–8 blocked (Kozlowski et al., 1989).

The first cigarette of each day was scored for evidence of filter vent blocking because an overnight period of smoking abstinence would represent the longest duration without smoking and thus most susceptible to filter vent blocking. Also, prior evidence suggests that smoking severity, increased subjective and physiological response, and acute tolerance relate to the first cigarette of the day (Niaura, Shadel, Goldstein, Hutchinson, & Abrams, 2001; Pillitteri, Kozlowski, Sweeney, Heatherton, 1997). Time to first cigarette of the day is a strong single-item predictor of nicotine dependence and difficulty quitting (T. B. Baker et al., 2007), further supporting the examination of the first daily cigarette.

Primary Outcome: Carbon Monoxide Boost

Two CO samples were taken 4 min prior to cigarette smoking and 4 min post cigarette smoking. Participants were instructed to inhale deeply, exhale fully, inhale again, and hold their breath for 10 s. Participants then exhaled fully, and the highest reading on the device, measured in parts per million (ppm), was recorded (Vitalograph, Lenexa, KS; Strasser, Lerman, Sanborn, Pickworth, & Feldman, 2007; Strasser et al., 2005).

Secondary Outcome: Total Puff Volume

Smoking topography was assessed with the Clinical Research Support System (CReSS) desktop system (Plowshare, Baltimore MD), calibrated per the manufacturer's instructions. The device uses a sterilized mouthpiece to hold the cigarette. The mouthpiece is attached to a pressure transducer that measures pressure changes during puffing, and software converts the signal to airflow (in milliliters per second) in real time (in seconds) and characterizes smoking behavior. The device provides a reliable and valid means of assessing smoking behavior (Lee et al., 2003; Strasser et al., 2005). Total puff volume, defined as the sum of all puffs taken, was a priori selected as the outcome measure for analyses. Consistent with our previous work and others' research (Benowitz et al., 2005; Strasser et al., 2007), total puff volume is a reasonable between-subjects metric to assess smoking behavior because of individual differences in means of compensatory smoking, such as taking more puffs or larger puff volumes.

Conventional Smoking Session

Conventional smoking sessions, which did not use the smoking topography device, were videotaped to assess smoking behavior. Participant videotaped sessions were scored for total number of puffs, interpuff interval between each puff, and total time the cigarette was lit.

Intraclass correlation coefficient analysis was performed to compare these smoking behavior characteristics to the same data from the smoking topography sessions, which are recorded by the computer software.

Subjective Measures: Visual Analog Scale

After each cigarette, participants rated the cigarette they had just smoked on 14 characteristics with a 100-mm visual analog scale. Items have been used previously in similar research (Kozlowski et al., 2000; Strasser et al., 2005, 2007; Philip Morris, www.pmdocs.com). Items consisted of cigarette strength, harshness, heat, draw, good versus bad taste, satisfaction, burn time, mild tasting, too mild, smoke harshness, after taste, staleness, smoke strength, and smoke pleasantness.

Analytic Plan

Descriptive statistics were used to characterize study participants. *T* tests (continuous) and chi-squared (nominal) analyses were used to identify associations between descriptive measures and filter vent blocking, with those $p < .2$ retained as covariates. Interrater correlations were determined for reliability of detecting degree of filter vent blocking in the cigarettes collected between sessions, as well as comparing smoking behaviors between smoking topography and conventional (videotaped) smoking sessions. The primary hypothesis was tested using a repeated-measures analysis of covariance (ANCOVA) in which CO boost was the outcome measure and smoker blocking status (blocker vs. nonblocker) and cigarette condition (50% filter vent block vs. 0% filter vent block) were factors. The second hypothesis was tested using regression analysis in which CO boost was the outcome measure, total puff volume was the predictor measure, and identical covariates were as above.

Results

Descriptive Statistics and Covariates

All 25 participants who entered the study completed both sessions. The participant sample was 60% female ($n = 15$), mainly Caucasian ($n = 24$; $n = 1$ African American); 8% identified themselves as Hispanic or Latino, irrespective of race. Ninety-six percent were high school graduates; 76% had completed some college. Participants were on average 44.5 years old ($SD = 9.8$; range 22–57), had started smoking at age 16.6 ($SD = 3.2$; range 11–25), smoked approximately a pack of cigarettes per day ($M = 20.5$; $SD = 4.0$; range 15–30), had moderate nicotine dependence scores as measured by the Fagerstrom Test for Nicotine Dependence (Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991; $M = 5.4$, $SD = 1.7$; range 2–9), and were on average overweight (body mass index [BMI] = 29.3 kg/m^2 , $SD = 7.6$). Self-reported daily cigarette consumption from waking until beginning of the study session did not differ by day (8.3, $SD = 4.5$, vs. 8.4, $SD = 4.2$; $t = -.79$, $p = .44$), nor did baseline CO levels (32.8 ppm, $SD = 10.5$, vs. 33.6 ppm, $SD = 13.9$; $t = -.71$, $p = .48$). Cigarette lengths were mostly 100s ($n = 16$), followed by king size ($n = 9$). All participants produced a 0.00 breath alcohol reading prior to each session.

Age and sex were retained as covariates because blockers tended to be younger (40.0 years, $SD = 9.4$, vs. 47.6 years, $SD = 9.2$; $t = 1.99$, $p = .06$) and male (60% vs. 27%; $\chi^2 = 2.8$, $p = .09$). Daily cigarette consumption for nonblockers did not differ from that for blockers, 20.5 ($SD = 4.8$) and 20.5 ($SD = 2.5$), respectively.

Filter Vent Blocking Status

All participants were compliant with returning used cigarette filters from days between sessions and identifying their first daily cigarette with an X. A significant positive correlation between self-report daily cigarette consumption at Session 1 and returned spent cigarette filters suggests that most cigarette filters were returned ($r = .91$, $p = .001$). Interrater reliability alpha among three raters on degree of tar stain exceeded 0.91 (excellent). Participants whose filters scored 0–2 were labeled *nonblockers* ($n = 15$); those whose filters scored 6–8 were labeled *blockers* ($n = 9$). One participant scored 5, 5, and 6 and was labeled a blocker. This inclusion did not affect significance for statistical testing of hypotheses.

Primary Outcome Measure: CO Boost

Mean CO boost measures were 4.67 ppm ($SD = 2.2$) and 5.21 ppm ($SD = 2.1$) for the UN and BL ML cigarettes conventional session and were 5.22 ppm ($SD = 2.4$) and 6.28 ppm ($SD = 2.6$) for the UN and BL ML cigarettes topography session (see Figure 1). Significant main effects indicate that the cigarette blocking condition significantly increased CO boost ($F = 15.2$, $p = .0007$), as did session ($F = 4.3$, $p = .049$), where greater CO boosts were observed when using the topography device. During conventional smoking, blockers smoking a BL ML cigarette had a significantly greater CO boost than when blockers smoked an UN ML and when nonblockers smoked BL or UN ML cigarettes, 6.13 ppm ($SD = 1.1$), 4.75 ppm ($SD = 1.6$), 4.60 ppm ($SD = 2.5$), and 4.61 ppm ($SD = 2.5$), respectively, $F(1, 23) = 4.3$, $p = .04$; see Figure 2.

Secondary Outcome Measure: Smoking Topography

Regression analyses indicated a significant association between total puff volume and CO boost when smoking the unblocked cigarettes ($\beta = 0.004$, $SE = .002$, $R^2 = .18$, $p = .037$), and when smoking the blocked cigarettes ($\beta = 0.005$, $SE = .002$, $R^2 = .22$, $p = .017$). Mean total puff volume measures were 784.5 mL ($SD = 250$) and 716.5 mL ($SD = 223$) for the UN and BL ML cigarettes, respectively ($F = 6.7$, $p = .02$), consistent with previous research of smokers taking larger puffs on greater ventilated cigarettes (12 and 28). Blockers smoking a BL ML cigarette took 737.5 mL total puff volume ($SD = 191$), and smoking an UN ML took 830 mL total puff volume ($SD = 228$); nonblockers smoking a BL ML took 703.0 mL total puff volume ($SD = 247$), and smoking an UN ML took 755.5 mL total puff volume ($SD = 267$), on average, $F(1, 23) = 0.5$, $p = .47$.

Comparison of Smoking Sessions

Intraclass correlation (ICC) coefficient analyses for absolute agreement were conducted to compare smoking behaviors between study sessions. Number of puffs ICC = .80 (95% CI = .68 – .90, $p = .005$), total time cigarette was lit ICC = .56 (95% CI = .38 – .73, $p = .01$), and interpuff interval ICC = .62 (95% CI = .46 – .78, $p = .01$) exceeded the minimum for good

range (.40 < ICC < .75), suggesting that the smoking topography device was not altering participant smoking behavior. CO boost between sessions was significantly correlated ($r = .40, p = .004$).

Subjective Measures

Participants generally did not discern between cigarette blocking conditions. Participants rated the UN ML cigarettes as having less heat ($p = .04$) and easier draw ($p = .05$) than the BL ML cigarettes. The observed minimal differences in subjective ratings for a light brand are consistent with previous results (Strasser et al., 2005; Sweeney & Kozlowski, 1998). Nonblockers rated both cigarettes more harsh than did the blockers rating their cigarettes ($p = .01$). There were no significant interactions.

Most (92%) participants responded that they feel more of a reaction to the first cigarette of the day in comparison with subsequent cigarettes; 8% responded about the same. However, participants typically reported “not at all” when asked whether the first cigarette of the day made them: dizzy (60%), lightheaded (68%), high (56%), buzzed (40%), ill (92%), or nauseous (92%). Nonblockers and blockers did not differ.

Knowledge of Filter Vents

When asked, “What makes a light cigarette a light?”, 48% reported filter vent holes, 68% reported mild tobacco, 12% reported fast-burning paper, and 8% reported relatively little tobacco. However, no participants reported ever intentionally blocking the filter vents. When asked whether light cigarettes were better for you than were regular cigarettes, 48% reported not at all, 28% reported a little better, 12% reported moderately better, 8% reported a lot better, and 4% did not know.

Discussion

Results from this study demonstrate, for the second time, that filter vent blocking can alter CO boost when smokers smoke Marlboro Lights cigarettes. Similar patterns of results were observed in sessions with and without the topography device. Characterizing smokers by how they block filter vents is critical to understanding the effect of filter vent blocking on tobacco exposure. Previous work on smokers had demonstrated that blocking filter vents on highly ventilated ultralight cigarettes significantly increased CO boost but not for less-ventilated light cigarettes (Sweeney et al., 1999; Sweeney & Kozlowski, 1998). However, when light brands were smoked by machine testing utilizing intense puffing methods, such as those used by the Commonwealth of Massachusetts or Health Canada, filter vent blocking significantly increased CO yields. Both intense methods include blocking filter vents, 50% and 100%, respectively. By identifying those smokers who block their first daily cigarette, we were able to identify a sample of the smoking population that is prone to increased exposure, to quantify the magnitude of increased exposure, and to identify a likely mechanism, which was total puff volume.

For blocking smokers, results indicate a 30% increase in CO boost when smoking a light with 50% filter blockage in relation to the UN cigarette condition. Interestingly, when examining change from in vivo filter vent blocking status, blockers had an average 14%

increase in total puff volume when smoking the UN cigarette in comparison with the BL cigarette. Conversely, nonblockers had an average 6% decrease in total puff volume when smoking the BL cigarette in comparison with the UN cigarette ($t = -2.2$, $p = .04$). Despite blockers taking approximately 100 mL larger total puff volume when smoking the UN cigarette, it did not produce increases in CO boost, further illustrating the impact that blocking filter vents has on increasing the concentration of cigarette smoke. In the case of the nonblockers, although a total puff volume decrease of 6% is modest, this is an average decrease in 45 mL, which is greater than a 35-mL puff taken during FTC testing. Furthermore, 13 of the 15 nonblockers had a decrease in total puff volume when smoking the BL cigarette, a consistent adjustment in smoking behavior of nonblockers.

In their review on the incidence and consequence of filter vent blocking, R. R. Baker and Lewis (2001) reported ranges from 15% to 24% when using a saliva-staining technique to 50% when using the tar stain pattern technique used in this study. Of note, the existence of filter vent blocking is not disputed. Additionally, the percentage of filter vents blocked in a cigarette appears to have an upper end limit of approximately 50%. R. R. Baker and Lewis concluded that filter vent blocking has only a minor effect on human smoke yields, because smokers will take smaller or fewer puffs when smoking a blocked cigarette to adjust for increased smoke concentration. Therefore, machine yields are deceptive because smokers do not smoke like machines. Our results support this hypothesis of decreased puffing, but importantly only for those who do not block vents on the first cigarette of the day. An investigation replicating smokers' smoking topography under machine-testing while measuring exposures has been informative (Djordjevic, Stellman, & Zang, 2000), but it did not consider assessing vent blocking status.

Interpretation of these results should be tempered by a few study limitations. First, classification for blocker status was based on first daily cigarette and does not necessarily mean all cigarettes would be blocked. First daily cigarette was used because of previous work on the subjective responses to this cigarette and because this would be the most nicotine-deprived state. The stability of classification was high across days. However, because each participant provided a varying number of spent cigarette filters (range = 15–30), and related issues such as time of each cigarette being smoked was not assessed, creating a composite blocking score or daily blocking pattern was not practical in this study. High throughput digital imaging techniques of filter vent blocking (O'Connor et al., 2007) with portable smoking topography devices may permit this type of assessment. Furthermore, this study was limited by measuring only one marker of exposure. CO is a practical, often-used sensitive assessment for exposure from a single cigarette. Associations between CO and smoking topography have been well established (U.S. Department of Health & Human Services, 1988). CO levels have been positively correlated with carcinogen and tar exposure (Djordjevic et al., 2000), including 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanol (NNAL) and 1-hydroxypyrene during investigations in smokers over extended duration.

Marlboro Lights is the best-selling domestic cigarette and thus was a reasonable cigarette brand choice to initially examine. Use of the same cigarette in study sessions as the participant typically smokes allows better external validity of results and permits us to control for the effects of brand switching. However, tar stain ratings have been successfully

performed on many types of filter-ventilated cigarettes (Prignott & Jarmart, 2005), and most light brands use similar filter vent technologies to dilute smoke concentrations. It is reasonable to hypothesize the observation of similar results in other light brand cigarettes. Investigation of smokers of several types of light brands over an extended duration assessing multiple biomarkers is ongoing.

Study results have meaningful public health implications. Light brands currently account for approximately 80% of total domestic cigarette sales (SAMHSA, 2008). The vast majority of these utilize filter vents to achieve low yields. Twenty percent of the U.S. adult population smoke (Centers for Disease Control & Prevention, 2008), approximately 43.5 million smokers. If the majority of smokers are smoking ventilated light brands and the estimates of the incidence of filter vent blocking ranges from 15% to 50% (40% in this study), then a significant proportion may be at risk for increased exposures owing to filter vent blocking. Results from our knowledge items suggest that smokers are aware of filter vents on light brand cigarettes and to their purpose, yet none self-reported blocking filter vents when they smoked. Informing about the dangers of blocking filter vents may not suffice if smokers are unaware of their behavior (Kozlowski et al., 1996).

Recently, the FTC has elected to halt reporting results from testing cigarettes, acknowledging that the testing method is flawed and may mislead smokers to believe that there is decreased exposure when smoking light cigarettes. Furthermore, current proposed regulation of tobacco products (Food & Drug Administration [FDA]: H.R. 1108 Waxman–Davis FDA legislation, Section 907) includes regulation of design and construction features, and results from this study provide empirical support for consideration of the banning of filter ventilation. Results from the current study support the consideration of banning filter vents, which is the reason light cigarettes produce low yields during testing. Blocking filter vents on light cigarettes increases CO exposure in smokers, particularly for those smokers who block filter vents after overnight smoking abstinence.

Cigarette filter vents create an elasticity that permits a light cigarette to test low during standard machine testing yet produce greater yields when puffed vigorously by smokers. Some have proposed a banning of cigarette filter vents (Kozlowski & O'Connor, 2002; Kozlowski et al., 2006) because the vents permit the cigarette to produce low yields and make the cigarette taste lighter, supported with less heat and easier draw subjective ratings in this study. However, the effect of filter vent blocking on smoke exposure during light cigarette smoking had not been observed until recently (Strasser et al., 2005). Results from the current study are the second to provide empirical support for the effect that filter vent blocking can have when smoking light brand cigarettes and the first to identify those at greatest risk.

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Figure 1.

Effect of filter vent blocking on carbon monoxide (CO) boost when smoking light cigarettes, with a smoking topography device and without. Values reported are mean plus or minus standard error; ppm = parts per million.

Figure 2. Effect of filter vent blocking on carbon monoxide (CO) boost in blockers and nonblockers when smoking a light brand cigarette. Values reported are mean plus or minus standard error; ppm = parts per million.