

**A Descriptive Study of the Relationships of Craving, Nicotine, and Smoking Topography in  
Adult Smokers**

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Abstract - Accounting for 1 in every 5 deaths, cigarette smoking is the leading cause of preventable death in the United States. Craving, smoking topography, and serum nicotine are all believed to play an important role in maintaining regular smoking behaviors and inhibiting the cessation process for adult smokers attempting to quit. (Purpose) This study characterizes the relationship between serum nicotine levels pre- and post-cigarette, smoking topography parameters, and subjective craving measures pre- and post-cigarette. (Methods) This study was a secondary analysis of an NIH-funded 5-year project in which adult smokers were admitted to the OSU Clinical Research Center for 36 hours. The sample consists of 114 male and female adult smokers. Satisfaction measures were obtained using a “Desire to Smoke” visual analog scale (VAS), plasma nicotine was assayed using high performance liquid chromatography (HPLC), and smoking topography was measured using a flowmeter cigarette holder instrument (Plowshare Technologies, Baltimore, MD). Secondary characteristics including gender, addiction, and age were described. Variables were analyzed using SPSS Statistics Software. (Results) A direct, positive relationship exists between cigarette puff total and pre- and post-cigarette nicotine serum levels. Average daily VAS scores and pre- and post-nicotine levels were positively correlated. Subjective level of addiction and FTND (nicotine dependence) scores were positively correlated with VAS scores and pre- and post-cigarette nicotine levels. Women reported higher craving scores and took more puffs, while men reported lower craving scores and had increased puff volume and puff duration measures. (Discussion) The results illustrate that smokers with higher FTND and level of addiction scores maintain higher levels of serum nicotine and report higher levels of craving throughout the day. Biological and behavioral aspects of smoking interact to influence specific smoking behaviors. (Importance) Results may be utilized to initiate smoking cessation strategies to modify craving levels, nicotine concentrations, and smoking topography parameters.

## **INTRODUCTION**

Tobacco is responsible for nearly 1 in 5 deaths in the United States, and because cigarette smoking is an acquired behavior, smoking remains the most preventable cause of death in our society (American Cancer Society, 2011). The Centers for Disease Control and Prevention (CDC) reported that more than 45.3 million adults in the United States were current smokers in 2010, and 21.5% of men and 17.3% of women were reported regular smokers in 2010 (Centers for Disease Control and Prevention, 2010). In 2010, the CDC also reported that 22% of people aged 25 to 44 years old were current smokers, while only 9.5% of those aged 65 or older were current smokers (Centers for Disease Control and Prevention, 2010).

Cigarette smoking and tobacco use is associated with a number of illnesses and causes of death. The American Cancer Society reveals that about half of all Americans who keep smoking will die because of the behavior, and about 443,000 people in the United States die annually from illnesses related to tobacco use. Cigarette smoking is known to cause cancer, and smoking accounts for at least 30% of all cancer deaths. It is associated with cancer of the lungs, larynx, mouth, tongue, lips, pharynx, stomach, pancreas, esophagus, kidney, bladder, cervix, ovary, colon, and rectum. Lung cancer is the leading cause of cancer death in men and women, and smoking accounts for 80% of lung cancer deaths. Through smoking cessation, lung cancer can be prevented, but it is one of the most difficult cancers to treat after diagnosis. Overall, using tobacco kills more Americans than car accidents, alcohol, AIDS, suicide, homicide, and illegal drugs combined (American Cancer Society, 2011).

Addiction is defined as the emotional and mental dependence on a substance, and it is characterized by the repeated and compulsive seeking of a substance and use of a substance despite unwanted, known consequences and harmful health effects (American Cancer Society, 2011). Nicotine dependence is thought to be a key process underlying the reason for continued

smoking and the difficulty that smokers have when attempting to quit (Donny, Griffin, Shiffman & Sayette, 2007). In 1988, the United States Surgeon General released the first report that concluded cigarettes and other forms of tobacco are addicting and that nicotine is an addictive drug found in cigarettes and tobacco products. Nicotine dependence is the most common form of chemical dependence in the United States, and withdrawal symptoms include anxiety, irritability, difficulty concentrating, and increased appetite (U.S. Department of Health and Human Services, 2011).

Smoking cessation greatly reduces the risk for disease and premature death, and the health benefits are greater for those who stop smoking at an earlier age (U.S. Department of Health and Human Services, 1990). Smoking cessation also reduces the risk of several diseases including chronic obstructive pulmonary disease, coronary artery disease, respiratory problems, infertility, and cancer. Seventy percent of current U.S. adult smokers report that they want to quit smoking completely, and millions of current smokers have attempted to quit (Dugdale, 2011).

Nicotine replacement therapy is an effective aid to assist smokers who are attempting to quit. Nicotine replacement therapy involves the use of low dose nicotine without the harmful toxins found in cigarette smoke. It comes in many forms such as gum, lozenges, inhalers, nasal spray, and transdermal patches. Nicotine replacement therapy has been shown to benefit moderate-to-heavy smokers or those who smoke more than 15 cigarettes per day (Dugdale, 2011). Overall, nicotine replacement therapy is both a popular and successful aid in smoking cessation.

## REVIEW OF LITERATURE

Nicotine craving plays a significant role in tobacco addiction. A single cigarette cannot produce complete satiation with long periods of smoking deprivation. Research has shown that cigarette craving ratings increase significantly within the first 24 hours of abstinence in smokers attempting to quit (Donny, Griffin, Shiffman & Sayette, 2007). Craving is elicited by both abstinence and exposure to smoking cues, and it is a symptom of nicotine dependence. This relationship, however, has been studied very little in previous research. By understanding how craving levels influence the way in which a person smokes, methods to aid cessation attempts through controlling levels of cravings can be created.

In a previous study, craving levels, measured repeatedly during 3 hours of no smoking, were significantly lower after rapid smoking than after self-paced or no smoking (Houtsmuller & Stitzer, 1998). The other measures of topography and smoking behaviors (latency to first cigarette, number of puffs, and number of cigarettes) did not differ across these conditions. Although the results from this study do not suggest that craving scores predict actual smoking behavior and smoking topography, rapid smoking did suppress craving scores. The results from this study support the need to continue to understand the relationship between craving in chronic smokers and their smoking behaviors.

Results from previous studies regarding smoking behaviors and craving provide conflicting conclusions. Specifically, Dallery and others found that craving ratings might not predict differences in smoking if ratings are above a minimum threshold level (Dallery, Housmuller, Pickworth & Stitzer, 2002). The study revealed that modest elevations in craving may predict the likelihood of smoking, and it also revealed that only at higher doses does nicotine play a role in suppressing craving a smoking (Dallery, Housmuller, Pickworth & Stitzer, 2002). Again, this supports the need for research regarding craving and cigarette smoking, as

studies conflict in their conclusion regarding whether or not a significant relationship exists between craving and actual smoking behavior.

A 1981 study analyzed the effect of high and low nicotine content in cigarettes and smoking topography parameters (Epstein et al., 1981). The authors concluded that subjects took significantly more puffs on the low nicotine cigarette, smoked at a faster rate, held each puff longer, smoked the cigarette in less time, took more total volume and more volume per puff compared to the high nicotine cigarette (Epstein et al., 1981). The authors also concluded that smoking topography parameters and smoking behavior was stable across periods of withdrawal, indicating that the subjects did not change their smoking behavior regardless of withdrawal time (Epstein et al., 1981). This study illustrates a relationship between smoking topography parameters and nicotine content of cigarettes. It also reveals aspects of stable smoking behavior and smoking characteristics regardless of withdrawal periods, indicating that smokers maintain unique smoking habits and patterns. The behavioral component of smoking is clearly a significant aspect of smoking patterns.

In a 2007 study titled “The Relationship Between Cigarette Use, Nicotine Dependence, and Craving in Laboratory Volunteers,” dependence was found to predict abstinence-induced craving (Donny, Griffin, Shiffman & Sayette, 2007). Because the Nicotine Dependence Symptom Scale defined “dependence” in this study, it characterizes nicotine dependence in the participants. Thus, a parallel was drawn between nicotine dependence and craving levels, as high nicotine dependence predicted increased craving levels in the participants. Another study found that only at high doses did nicotine levels play a role in acutely suppressing smoking behavior (Dallery, Houtsmuller, Pickworth & Stitzer, 2002). Specifically, the study showed that when cigarettes are smoked at a self-regulated pace, differences in cigarette nicotine content produce

no difference in subsequent craving suppression and smoking behavior. This provides insight into the role of nicotine versus sensory cues in regulating smoking patterns.

The results of the study “Measurement of Smoking Topography During Withdrawal or Deprivation” showed adjustments in smoking behaviors when cigarettes that vary in nicotine delivery were used, but not when serum nicotine was modified by withdrawal or deprivation (Epstein, Ossip, Coleman, Hughes & Wiist, 1981). These results suggest inhalation patterns of individual cigarettes may not be sensitive to fluctuations in serum nicotine, while they are sensitive to cigarettes that vary in nicotine yield and draw resistance. Findings from another study suggest that adolescent smokers do titrate their nicotine intake in response to smoking denicotinized cigarettes, but do so by taking larger puffs or smoking more quickly, not by simply taking more puffs per cigarette (Kassel, Greenstein, Evatt, Wardle, Yates, Veilleux & Eissenberg, 2006).

The purpose of this secondary analysis is to describe the relationship of craving levels pre-cigarette, serum nicotine levels, and smoking topography parameters in adult smokers.

The principal hypotheses addressed in this analysis are as follows:

1. Increased craving levels pre-cigarette will be associated with increased topography parameters.
2. Decreased serum nicotine levels pre-cigarette will be associated with increased topography parameters.
3. There will be an inverse relationship of craving pre-cigarette and serum nicotine levels pre-cigarette.

## **METHOD**

### *Design*

A secondary analysis of a study titled *Menthol, Ethnicity, and Nicotine Dependence*, an NIH-funded 5-year project, was conducted to further understand the relationship between smoking topography, self-reported craving levels, and serum nicotine content in smokers before and after a cigarette smoking bout.

### *Sample Size*

The sample size for the original study was 140 subjects. The sample size is justified with having 81% power to detect medium effect size ( $p < 0.5$ ). The total sample size for this study consisted of 114 subjects. Subjects missing extensive data for topography measures, serum nicotine levels, and/or VAS craving scores were eliminated from this analysis.

### *Inclusion Criteria*

Inclusion criteria includes 18 to 50 years of age; self-identified African American or Caucasian race; regular smoking for at least 1 year in the range of 10 to 40 cigarettes per day; no other tobacco use; no history of liver, endocrine or pulmonary disease; not taking any regularly prescribed medications; not pregnant or lactating; and no drug or alcohol abuse. Health status was determined upon admission history and physical examination and included obtaining past medical history and assessing for drug and alcohol abuse. Progesterone levels were obtained to determine that women were in the mid to late follicular phase of their menstrual cycle. These restrictions regarding age and health are pertinent to reduce biological changes in metabolism, which may confound measures of the variables.

### *Recruitment*

Recruitment was conducted using previous successful strategies including advertisements in newspapers distributed without charge to each community resident, as well as informative flyers

placed in community centers, work settings, clinics, beauty shops, and barbershops in neighborhoods. In order to properly reflect the cigarette smoking population in Ohio, attention to gender occurred during the recruitment process to ensure that half of the sample would be men. Procedures regarding the smoking protocol were described to potential participants during the recruitment process.

### *Procedure*

Participants who met the study criteria were admitted to The Ohio State University Clinical Research Center (CRC) for 36 hours during which they were allowed to smoke cigarettes of their usual cigarette brand *ad lib*. The participants entered the study at 8 pm on Day 1, provided written informed consent, and became acclimated to the unit. The participants completed baseline questionnaires regarding sociodemographic information, smoking history information, and established nicotine dependence measures. Upon admission, complete blood count and GGT (to assess liver function) were obtained. On the morning of Day 2, body weight and body composition were measured, as they may be factors in influencing nicotine metabolism. During Day 2, the time of each cigarette smoked was recorded in a cigarette log, while nursing staff measured cigarette butt lengths. Smoking topography measures as well as CO and nicotine boost of four cigarettes smoking during the day were obtained. Measures were obtained after the first cigarette of the day was smoked as well as the first cigarette smoked in each of the following time intervals: 10 am to 12 pm, 3 pm to 5 pm, and 8 pm to 10 pm. The participants notified CRC nursing staff prior to smoking their first cigarette of the day and the first cigarette in each of the three subsequent time intervals. For each of these 4 cigarettes, urge to smoke (craving) pre and post-cigarette was obtained. The participants were then allowed to smoke their usual number of cigarettes *ad lib* with time and remaining butt length recorded for each cigarette. Based on previous studies with similar protocol, it was found that a minimum of 10 cigarettes per day

provides the patient flexibility in adhering to the protocol. CRC laboratory technicians centrifuged whole blood samples from the participants for nicotine assays and plasma was frozen prior to being hand-carried to the principal investigator's laboratory on campus where the samples remained frozen at -80 degrees Celsius until extracted and assayed.

## **MEASURES**

The data collected in the original study *Menthol, Ethnicity, and Nicotine Dependence* provided the measures for the following three variables: craving, serum nicotine, and smoking topography, as well as sociodemographic and smoking history information, including nicotine dependence and subjective addiction levels.

### *Craving*

In order to address the variable of craving amongst the smokers in the study, “satisfaction” was measured and utilized as a key characteristic in craving. Satisfaction was measured using a “Desire to Smoke” visual analog scale (Schuh & Stitzer, 1995). This 4-item instrument assesses changes in smoking satisfaction pre to post-cigarette. The 4-item instrument addressed how pleasant a cigarette would be right now, how much of an urge or desire to smoke for pleasure is present, the need to smoke for relief right now, and how much the individual wants to smoke at the moment. The items were presented on a computer with a visual analog scale consisting of a line with the following anchors in ascending order: “not at all,” “moderately,” and “very much.” Subjects answered the questions by placing and clicking a computer cursor along the point in the line that corresponds to his/her answer. The percentage of the total length was calculated on this instrument and an average of the four items yielded a summary score on a scale of 0 to 100. Validity of this instrument was demonstrated through

changes on mean desire to smoke ratings as a function of manipulations of the frequency of scheduled smoking during the session.

### *Plasma Nicotine*

Plasma nicotine was assayed using high performance liquid chromatography (HPLC) at J2 Laboratories in Tucson, Arizona.

### *Topography*

Participants notified nursing staff prior to smoking the first cigarette of the day and the first cigarette in each of the three subsequent designated time periods. Participants continued to smoke the remainder of their usual number of cigarettes *ad lib*. Smoking topography was measured using a flowmeter cigarette holder instrument. The subjects smoked the four previously described cigarettes through the flowmeter. This instrument includes the flowmeter cigarette holder attached to a differential pressure transducer and signal is sampled at a rate of 1000 Hz. Software then converted signals to puff flow in ml/sec and integrated the data over time for each puff, thus yielding a puff volume measure. The variables of smoking topography measured included puff volume (ml), puff duration (sec), interpuff interval (sec), and peak flow rate (ml/sec). These variables were measured by the Clinical Research Support System (CCReS) (Plowshare Technologies, Baltimore, MD).

Calibration of the equipment after a 15-minute warm-up period ensured validity. The equipment was calibrated by attaching a 60 ml syringe to the mouthpiece and simulating puffs of 30 ml, 40 ml, and 50 ml, which were then compared to the CReSS volume digital reading. Computed volumes range within  $\pm 1$  ml of the syringe volume, and maximum peak flow rate measured with the CReSS system is 200 ml/sec. Time tag accuracy is  $\pm 5$  milliseconds, ensuring reliability of the instrument. Lastly, puff clean-up utility software (Plowshare Technologies,

Baltimore, MD) was used to eliminate non-puff artifacts in order to eliminate puffs <0.3 seconds duration and <5 ml volume.

### *Biobehavioral Characteristics and Nicotine Dependence*

For this secondary analysis, biobehavioral characteristics and nicotine dependence characteristics were assessed using a variety of instruments including the Fagerström Test for Nicotine Dependence (FTND), Cigarette Dependence Scale, and plasma nicotine and cotinine. The FTND consists of a 6-item instrument with 4 dichotomous responses (scored 0 or 1) and 2 items with 4 responses (scored 0 to 3). Potential total scores range from 0 to 10 with higher scores indicating greater nicotine dependence. A score of 5 is considered moderate nicotine dependence, while a score of 6 to 7 indicates high nicotine dependence (Fagerström, Heatherton & Kozlowski, 1992). The FTND is a better predictor of smoking cessation at the conclusion of treatment for women than for men (Kozlowski & Pillitteri, 1996).

### *Sociodemographic, Smoking History, and Alcohol Consumption*

Sociodemographic data regarding age, gender, employment, income, and marital status as well as smoking history characteristics were obtained. Smoking history information included the age the individual began smoking, current cigarette brand, average number of cigarettes consumed on a weekday, average number of cigarettes consumed on a weekend day, use of other tobacco products, number of previous serious quit attempts, perception of smoking prevalence among peers, percentage of friends who smoke, as well as cigarette smoke exposure in their residence. Alcohol consumption in number of drinks per day was assessed.

## RESULTS

### *Sample Characteristics*

The sample included 114 subjects with an average age of 29 years (SD=8.85), 62 of which were male (54.4%) and 52 were female (45.6%). The average age that participants began smoking was 16 years (SD=3.33), while the average years of regular smoking was 12 years (SD=8.97). Participants reported an average of 16 cigarettes smoked per day (SD=6.50). A summary of the sample characteristics is in Table 1.

**Table 1.** Descriptive findings of sample characteristics and addictive behaviors (N=114)

	<i>Min.</i>	<i>Max.</i>	<i>Mean</i>	<i>Std. Deviation</i>
Years of Regularly Smoking	1	35	12.31	8.97
Age Began Smoking	10	31	16.03	3.33
Cigarettes Smoked Per Day	4	40	15.63	6.50
Age	18	50	29.43	8.85
Gender	<i>Frequency</i>		<i>Percent</i>	
Male	62		54.4	
Female	52		45.6	

### *Variable Characteristics*

Descriptive statistics for both the behavioral characteristics and smoking characteristics of the sample are summarized in Table 2. Craving (VAS) scores can range from 0 to 100, with 0 being no craving and 100 being the highest level of craving. Average craving (VAS) scores in this analysis ranged from 6.56 to 100.00 with a mean craving score of 57.47. Subjective ratings of addiction ranged from 0 to 100, with 0 indicating that the participant feels no nicotine addiction and 100 indicating that the participant feels complete nicotine addiction, with a mean rating of addiction of 72.42. FTND scores ranged from 2 to 10, with a score of 10 indicating high nicotine dependence and 0 indicating no nicotine dependence. The average FTND score was 4.92 for the sample. A summary of these descriptive characteristics can be found in Table 2

**Table 2.** Descriptive statistics for behavioral characteristics (addiction and VAS craving scores) and biological smoking characteristics (pre- and post-nicotine serum levels, puff volume, puff duration, and total puffs)

	<i>N</i>	<i>Min.</i>	<i>Max.</i>	<i>Mean</i>	<i>Std. Dev.</i>
VAS Pre-Cigarette 1 Average	114	0.75	100.00	54.82	25.93
VAS Pre-Cigarette 2 Average	114	0.25	100.00	58.47	22.93
VAS Pre-Cigarette 3 Average	114	0.00	100.00	57.70	23.62
VAS Pre-Cigarette 4 Average	114	0.50	100.00	58.87	23.31
VAS Pre-Cigarette Average	114	6.56	100.00	57.47	19.10
Addiction Rating	113	0	100	72.42	26.36
FTND Score	108	2	10	4.92	1.762
Cigarette 1 Volume Average	114	10.82	174.60	66.25	28.78
Cigarette 1 Duration Average	114	0.56	3.28	1.63	0.55
Cigarette 4 Volume Average	114	10.61	246.75	69.70	33.64
Cigarette 4 Duration Average	114	0.62	3.49	1.61	0.56
Cigarette 1 Puff Total	114	5.00	31.00	13.41	4.37
Cigarette 2 Puff Total	114	5.00	29.00	13.72	4.58
Cigarette 3 Puff Total	114	2.00	34.00	13.62	4.72
Cigarette 4 Puff Total	114	4.00	28.00	14.26	4.72
Nicotine Pre Cigarette 1	111	0.01	62.00	3.50	6.48
Nicotine Post Cigarette 1	110	0.01	101.00	15.26	12.84
Nicotine Pre Cigarette 2	110	0.01	39.00	9.07	7.02
Nicotine Post Cigarette 2	110	0.01	67.00	19.89	12.43
Nicotine Pre Cigarette 3	109	0.01	38.00	11.11	8.32
Nicotine Post Cigarette 3	111	3.00	86.00	21.90	13.95
Nicotine Pre Cigarette 4	111	0.01	47.00	14.76	10.15
Nicotine Post Cigarette 4	113	4.00	84.00	27.53	15.55

Average craving scores increased from cigarette 1 to cigarette 2, decreased from cigarette 2 to cigarette 3, and increased again from cigarette 3 to cigarette 4. Average craving scores are depicted in Figure 1.

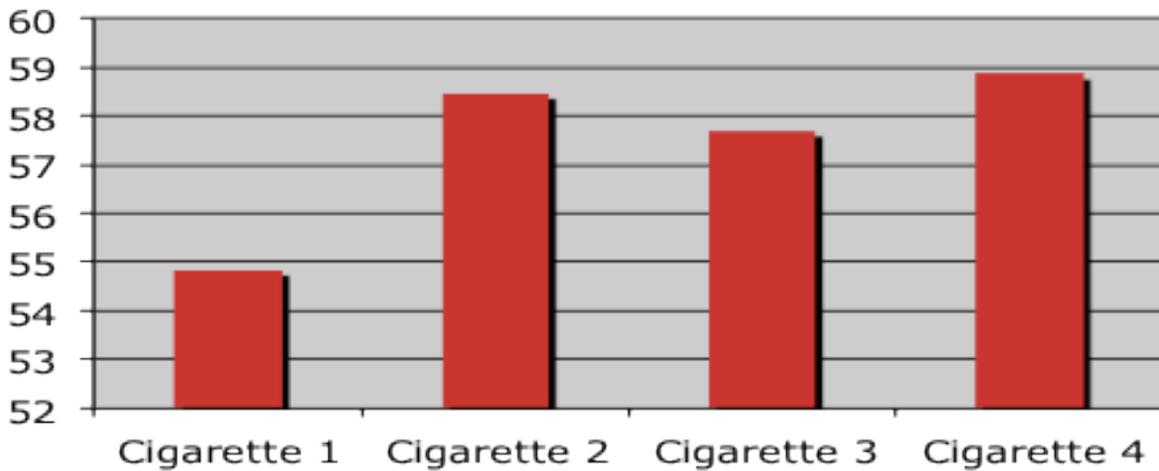


Figure 1. Craving Scores

Table 3 illustrates the correlations between VAS craving scores pre-cigarette and pre- and post-cigarette nicotine levels. A significant correlation ( $p < 0.05$ ) exists with pre-cigarette craving scores for the first cigarette of the day and serum nicotine levels post-cigarette 2 as well as both pre- and post-cigarette 3 and 4. Significant correlations ( $p < 0.05$ ) also exist with pre-cigarette craving scores for cigarette 2 and post-nicotine levels for cigarette 3 and 4. Although not significant, correlations ( $p < 0.1$ ) exist with pre-cigarette craving scores for cigarette 2 and post-nicotine for cigarettes 1 and 2. The total average pre-cigarette VAS craving scores correlate ( $p < 0.1$ ) with post-cigarette nicotine for cigarette 2, pre- and post-cigarette nicotine for cigarette 3, and post-cigarette nicotine for cigarette 4.

**Table 3.** Correlations of VAS craving scores with pre- and post-nicotine levels

VAS Pre-Cigarette	Nicotine Cigarette 1		Nicotine Cigarette 2		Nicotine Cigarette 3		Nicotine Cigarette 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Cigarette 1								
Pearson Correlation	-.012	.109	.128	.243	.295	.195	.264	.190
<i>p</i> value	.899	.255	.184	.009**	.002**	.040**	.005**	.043**
Cigarette 2								
Pearson Correlation	.008	.180	.022	.160	.145	.211	.144	.215
<i>p</i> value	.931	.059*	.820	.095*	.133	.027**	.133	.022**
Cigarette 3								
Pearson Correlation	-.078	.073	.116	.112	.046	.131	.068	.096
<i>p</i> value	.415	.449	.228	.246	.636	.170	.479	.311
Cigarette 4								
Pearson Correlation	-.042	-.046	-.089	-.003	.046	.028	-.084	.020
<i>p</i> value	.663	.634	.355	.974	.636	.772	.381	.836
Total Average								
Pearson Correlation	-.039	.100	.058	.165	.172	.178	.129	.165
<i>p</i> value	.688	.300	.546	.084*	.074*	.061*	.179	.081*

\*\**p*<0.05\**p*<0.1

### Serum Nicotine

Pre- and post-cigarette serum nicotine levels gradually increased over the course of the four cigarettes smoked throughout the day that were measured in the specified time intervals. Figure 2 depicts the pre- and post-cigarette serum nicotine levels for each of the four cigarettes smoked throughout the day. Pre-cigarette 1 serum nicotine increased fivefold post-cigarette 1. Serum nicotine for cigarettes 2, 3, and 4 increased approximately twofold from pre-cigarette to post-cigarette.

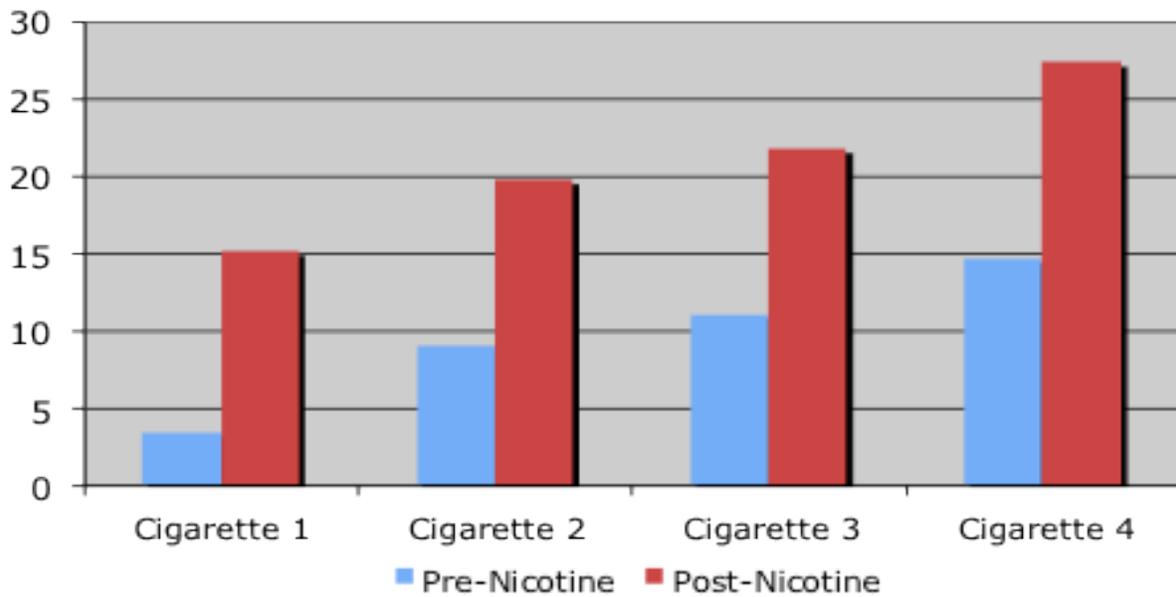


Figure 2. Serum Nicotine Levels (ng/mL)

Table 4 illustrates the correlations of the smoking topography parameter of number of puffs with pre- and post-cigarette serum nicotine levels. Significant correlations ( $p < 0.05$ ) exist with the number of puffs for cigarette 2 and pre- and post-cigarette serum nicotine levels for all 4 cigarettes except pre-cigarette 3 serum nicotine ( $p < 0.1$ ). The number of puffs for cigarette 1 significantly correlate with serum nicotine levels pre-cigarette 4. Number of puffs for cigarette 3 and 4 correlate with pre-cigarette serum nicotine levels for cigarette 4. The total average number

of puffs for each of the 4 cigarettes smoked throughout the day significantly correlate with pre-cigarette serum nicotine levels for cigarette 2, post-cigarette serum nicotine levels for cigarette 3, and pre-cigarette serum nicotine levels for cigarette 4. The remainders of the relationships are summarized in table 4.

**Table 4.** Correlations of smoking topography parameter (number of puffs) with pre- and post-cigarette serum nicotine levels

Number of Puffs	Nicotine Cigarette 1		Nicotine Cigarette 2		Nicotine Cigarette 3		Nicotine Cigarette 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Cigarette 1								
Pearson Correlation	.046	.064	.098	.078	.067	.065	.269	.082
<i>p</i> value	.631	.508	.310	.415	.490	.499	.004**	.368
Cigarette 2								
Pearson Correlation	.238	.235	.219	.212	.181	.244	.435	.167
<i>p</i> value	.012**	.013**	.021**	.026**	.060*	.010**	.000**	.004**
Cigarette 3								
Pearson Correlation	.112	.117	.139	.110	.139	.168	.311	.117
<i>p</i> value	.244	.223	.148	.253	.150	.078*	.001**	.219
Cigarette 4								
Pearson Correlation	.128	.105	.233	.131	.080	.189	.325	.131
<i>p</i> value	.179	.273	.014**	.172	.408	.047**	.000**	.168
Total Average								
Pearson Correlation	.151	.149	.199	.152	.134	.194	.383	.143
<i>p</i> value	.115	.121	.037**	.113	.166	.042**	.000**	.130

\*\**p*<0.05

\**p*<0.1

Average number of puffs taken on the cigarette increased from cigarette 1 to cigarette 2, decreased slightly from cigarette 2 to cigarette 3, and increased from cigarette 3 to cigarette 4. Figure 3 illustrates the average number of puffs taken on each of the 4 cigarettes smoked throughout the day.

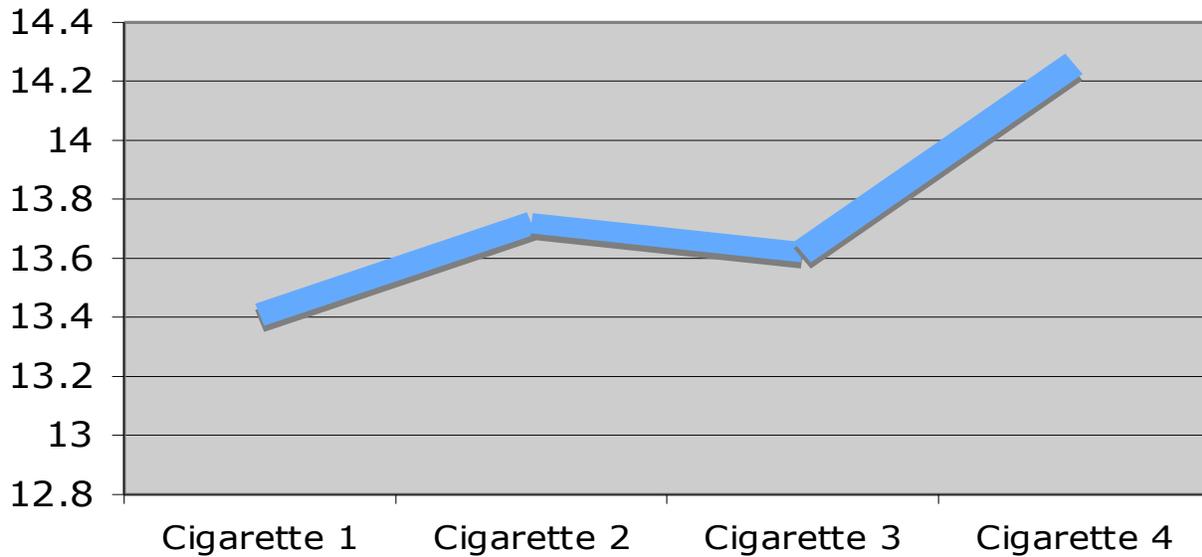


Figure 3. Number of Puffs

Puff duration (sec) and puff volume (ml) were unrelated to craving scores and serum nicotine levels (ng/ml) pre-cigarette. Craving scores pre-cigarette significantly correlated with number of puffs taken on the cigarette. Average craving scores positively correlated with number of puffs taken on the cigarette with higher craving scores resulting in more puffs taken on the cigarette. Average craving scores in relation to average puff totals is illustrated in Figure 4. Craving scores for cigarette 3 significantly correlated with number of puffs on cigarette 3. Cigarettes 1, 2, and 4 paralleled this relationship, but results were not significant. The relationship between craving levels pre-cigarette for cigarette 3 and number of puffs taken on cigarette 3 is illustrated in Figure 5.

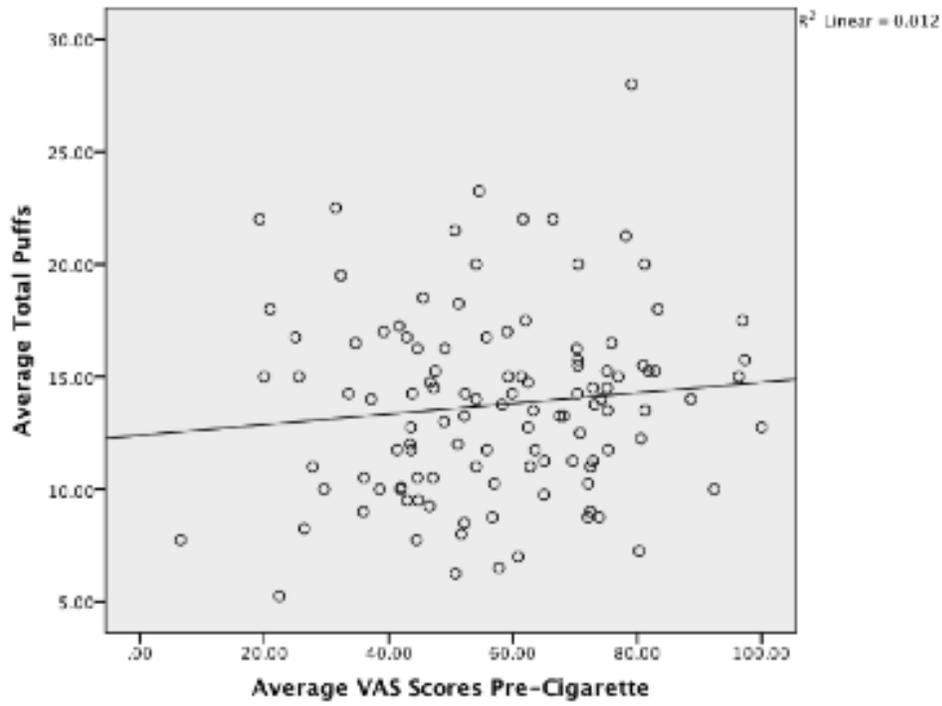


Figure 4. Average VAS Craving Scores and Average Total Puffs for Cigarettes 1-4

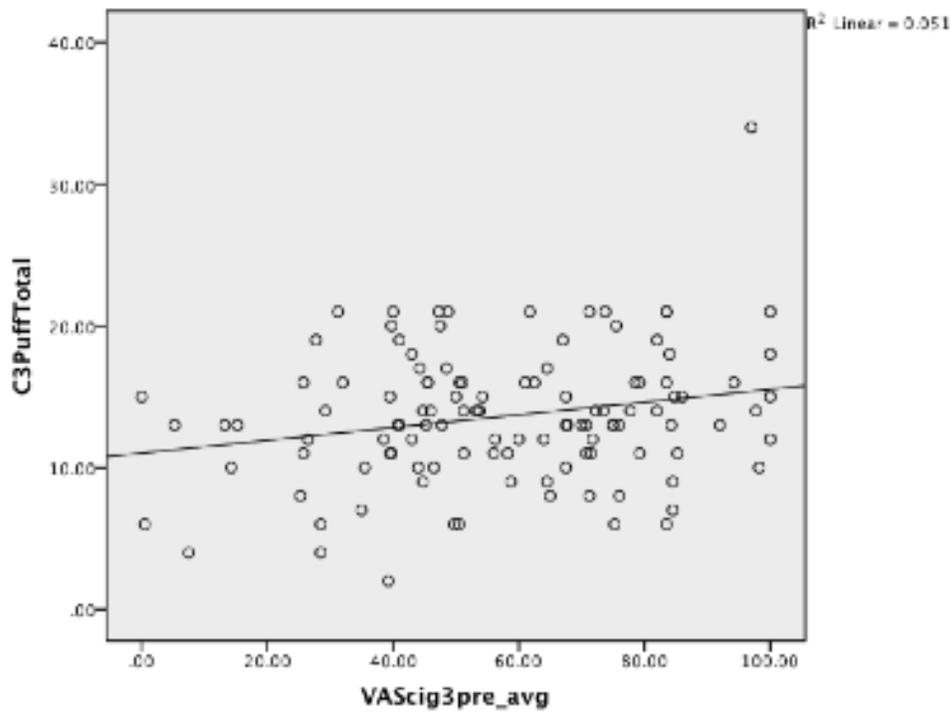


Figure 5. Cigarette 3 VAS Craving Scores and Puff Total

Women reported higher craving scores and took more puffs on the cigarette, while men reported lower craving scores and had increased puff volume (ml) and puff duration (sec) measures. This parallels a similar study that found considerable differences in puff topography of men and women. Females, on average, took one extra puff per cigarette while males took significantly larger puffs than females (Hammond et al., 2005).

Subjective reports of addiction and FTND (nicotine dependence) scores positively correlated with both craving scores and pre- and post-cigarette nicotine levels. Subjects with higher ratings of addiction and higher FTND scores maintained higher serum nicotine levels for each of the 4 measured cigarettes throughout the day and reported higher craving levels compared to subjects with lower addiction ratings and FTND scores.

## **CONCLUSION/DISCUSSION**

In a 1998 study where craving levels were measured repeatedly during 3 hours of no smoking before smoking a cigarette, craving did not predict smoking behaviors or influence smoking topography parameters (Housmuller & Stitzer, 1998). In contrast, the current study revealed a relationship, although not significant, between craving and the number of puffs taken on a cigarette. Participants with higher craving scores subsequently took more puffs on the cigarette. Therefore, craving was a predictor of smoking behavior in relation to the number of puffs taken on a cigarette. Puff volume and puff duration, however, were unrelated to craving measures.

A 1981 study analyzed the effect of high and low nicotine content in cigarettes on smoking topography parameters (Epstein, Ossip, Coleman, Hughes & Wiist, 1981). The study revealed that subjects took significantly more puffs on the low nicotine cigarette, smoked at a faster rate, held each puff longer, smoked the cigarette in less time, took more total volume and

more volume per puff compared to the high nicotine cigarette (Epstein, Ossip, Coleman, Hughes & Wiist, 1981). Although the current study did not account for the nicotine content of the cigarette, subjects with higher serum nicotine levels subsequently took more puffs on the cigarette than subjects with lower serum nicotine levels pre-cigarette. This may be due to the fact that subjects with higher addiction ratings and FTND scores maintained higher serum nicotine levels throughout the day, and these subjects were found to take more puffs on the cigarette than those with lower addiction ratings and serum nicotine levels. Smokers with higher addiction ratings and FTND scores may have developed smoking behaviors in which they took more puffs on the cigarette in order to maintain a higher serum nicotine level. The increased serum nicotine levels in these subjects may also be due to tolerance developed over time while smoking cigarettes. Therefore, the smokers may modify their smoking behavior by taking more puffs in order to maintain a higher serum nicotine level.

In a 2007 study titled “The relationship between cigarette use, nicotine dependence, and craving in laboratory volunteers,” nicotine dependence was found to predict abstinence-induced craving (Donny, Griffin, Shiffman & Sayette, 2007). Because the FTND scale defined “dependence” in this study, it characterizes nicotine dependence in the participants. Thus, a parallel was drawn between nicotine dependence and craving levels, as high nicotine dependence predicted increased craving levels in the participants. The current study reveals similar results in which increased nicotine dependence scores (FTND scores) and subjects’ addiction ratings significantly correlated with increased craving measures. Another study found that only at high doses did nicotine levels play a role in acutely suppressing smoking behavior (Dallery, Houtsmuller, Pickworth & Stitzer, 2002). The current study revealed that higher serum nicotine levels actually led to increased smoking behavior as the subjects took more puffs on the cigarette when serum nicotine levels were higher pre-cigarette.

Because craving scores pre-cigarette 2 correlated with post-cigarette serum nicotine for all 4 measured cigarettes throughout the day, cigarette 2 serves as an appropriate marker for serum nicotine levels throughout the day. Higher craving scores pre-cigarette 2 was associated with higher serum nicotine levels post-cigarette for each of the 4 cigarettes measured. This reveals a possible pattern of smoking behavior, as serum nicotine levels were influenced by the craving scores pre-cigarette 2. Nurses may use the craving scores before late morning cigarettes as markers of serum nicotine levels in the clinical setting. Further research is necessary to explore the characteristics of this relationship between craving scores and subsequent serum nicotine levels over the course of a day.

Lack of tolerance for slight serum nicotine decreases may explain the increased craving scores and increased number of puffs in subjects with high addiction ratings and FTND scores. Because subjects with higher addiction ratings and higher FTND scores maintained higher serum nicotine levels throughout the day, they may compensate for slight dips in serum nicotine by taking more puffs on the cigarette. They may also feel increased craving levels as a result of the serum nicotine dips.

Research with adults has shown that nicotine-dependent smokers tend to self-regulate their nicotine intake by taking longer and larger puffs at the beginning of smoking a cigarette, with a decrease in volume and duration over the course of smoking a cigarette (Veilleux, Kassel, Heinze, Braun, Wardle, Greenstein, Evatt, & Conrad, 2011). However, findings of the current study indicated that nicotine levels were unrelated to puff volume and puff duration, but smokers with higher serum nicotine levels did take more puffs on the cigarette. Furthermore, women took more puffs on the cigarette, while men took longer puffs and higher volume puffs. Further research is needed to characterize the smoking differences in men and women, and to understand the specific relationship between nicotine levels and smoking behaviors.

There are several limitations of the current study. Tobacco industry research shows that the relationship between puff volume and yield is nonlinear and varies across brands (Hammond et al, 2005). The current study did not account for differences in cigarette brand and cigarette yield when analyzing smoking topography parameters, serum nicotine levels, and craving parameters.

The results of this study have significant implications for nursing practice. In order to improve the overall health of patients, a goal of nursing practice is to assist and support patients to be successful with quitting smoking. Nicotine replacement therapy (NRT) has been successful in the clinical setting in helping patient to quit smoking. Nicotine replacement therapy may be used to maintain stable serum nicotine levels and lower nicotine cravings. Nurses may use a patient's craving scores, addiction ratings, and FTND scores as markers for serum nicotine levels in the clinical setting as it is both inefficient and costly to draw serum nicotine levels in the clinical setting. Because increased serum nicotine levels was significantly related to a smoker to increase their puffs on the cigarette, and high craving scores, addiction ratings, and FTND scores are correlated with high serum nicotine levels, nurses may use these self-reports as markers of serum nicotine levels in their patients. Furthermore, patients assessed as having strong nicotine dependence and high addiction ratings may need higher initial doses of NRT to maintain stable serum nicotine levels and suppress cravings, as they maintain higher serum nicotine levels throughout the day. Further research is necessary in order to discover if craving levels, addiction ratings, and FTND scores serve as appropriate markers of serum nicotine levels in the clinical setting.

## Works Cited

- American Cancer Society. *Cigarette smoking*. 2011. Accessed at <http://www.cancer.org/Cancer/CancerCauses/TobaccoCancer/CigaretteSmoking/cigarette-smoking-toc> on December 10, 2011.
- Centers for Disease Control and Prevention (CDC). *Smoking cessation*. 2010. Accessed at [http://www.cdc.gov/tobacco/data\\_statistics/fact\\_sheets/cessation/quitting/index.htm](http://www.cdc.gov/tobacco/data_statistics/fact_sheets/cessation/quitting/index.htm) on December 10, 2011
- Dallery, J., Housmuller, E.J., Pickworth, W.B., & Stitzer, M.L. (2002). Effects of cigarette nicotine content and smoking pace on subsequent craving and smoking. *Psychopharmacology*, 165, 172-180.
- Donny, E.C., Griffin, K.M., Shiffman, S., & Sayette, M.A. (2007). The relationship between cigarette use, nicotine dependence, and craving in laboratory volunteers. *Nicotine & Tobacco Research* 10(3), 447-455.
- Dugdale, D. C. (2011, February 21). *Nicotine replacement therapy*. Retrieved from <http://www.nlm.nih.gov/medlineplus/ency/article/007438.htm>
- Epstein, L.H., Ossip, D.J., Coleman, D., & Hughes, J., Wiist, W. (1981). Measurement of smoking topography during withdrawal or deprivation. *Behavior Therapy* (12), 507-519.
- Fagerström, K.O., Heatherton, T.F., & Kozlowski, LT. (1992) Nicotine addiction and assessment. *Ear Nose Throat Journal*, 11, 763-767.
- Hammond, D., Fong, G.T., Cummings, K.M., & Hyland, A. (2005). Smoking topography, brand switching, and nicotine delivery: Results from an *In vivo* study. *Cancer Epidemiology, Biomarkers & Prevention*, 14(6), 1370-1375.

- Kassel, J.D., Greenstein, J.E., Evatt, D.P., Wardle, M.C., Yates, M.C., Veilleux, J.C., & Eissenberg, T. (2006). Smoking topography in response to denicotinized and high-yield nicotine cigarettes in adolescent smokers. *Journal of Adolescent Health* 40, 54-60.
- Kozlowksi, L.T. & Pillitteri, J.L. (1996). Compensation for nicotine smokers of lower yield cigarettes. In *The FTC Cigarette Test Method for Determining Tar, Nicotine, and Carbon Monoxide Yields of U.S. Smoking and Tobacco Control Monograph No. 7*, 161-172.
- U.S. Department of Health and Human Services. *How tobacco smoke causes disease: The biology and behavioral basis for smoking-attributable disease: A report of the Surgeon General*. 2011. Accessed at [http://www.tobacco/data\\_statistics/sgr/2010/index.htm](http://www.tobacco/data_statistics/sgr/2010/index.htm) on December 10, 2011.
- U.S. Department of Health and Human Services. *The health benefits of smoking cessation: A report of the Surgeon General*. 1990. Accessed at <http://profiles.nlm.nih.gov/NN/B/B/C/T/> on December 10, 2011.
- Veilleux, J. C., Kassel, J. D., Heinze, A. J., Braun, A., Wardle, M. C., Greenstein, J., Evatt, D. P., & Conrad, M. (2011). Predictors and sequelae of smoking topography over the course of a single cigarette in adolescent light smokers. *Journal of Adolescent Health*, 48(2), 176-181.