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The Effect of Food Deprivation on Cigarette Smoking in Females

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Abstract

Food deprivation is associated with increased self-administration of nicotine and other substances in laboratory animals, although little is known about the effects of food deprivation on substance use in humans. A within-subjects design was utilized to test the primary hypotheses that smoking rate and expired carbon monoxide (CO) levels would be greater among 15 female participants following a 24-hour fasting period than when participants were not food-deprived. Food-deprived participants were also expected to endorse greater negative mood, smoking urges, and pleasure from smoking, as well as less positive mood. Analyses indicated that CO levels were significantly greater in the food-deprived condition than in the non-deprived condition ($p = .05$), although no differences were found in the number of cigarettes smoked during the laboratory session. Participants reported significantly lower vigor-activity in the food-deprived condition ($p = .02$). No differences were found between conditions in urges to smoke or pleasure from smoking. Findings suggest that nicotine intake may increase among females during acute food deprivation.

Keywords

Food Deprivation; Smoking; Tobacco; Dieting; Calorie Restriction

1. Introduction

Dieting and eating disorders are associated with cigarette smoking and other substance use in humans. Longitudinal studies have indicated that dieting predicts the initiation of smoking in children and adolescents (Austin & Gortmaker, 2001; French, Perry, Leon, & Fulkerson, 1994), and cross-sectional research has shown that children and adults who engage in dieting are more likely to report current smoking than those who are not dieting (Kendzor, Copeland, Stewart, Businelle, & Williamson, 2007; Wee, Rigotti, Davis, & Phillips, 2001). The prevalence of substance use has been found to increase with dieting severity (Krahn, Kurth, Demitrack, & Drewnowski, 1992), and there is a high comorbidity between eating disorders

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and substance use disorders (Holderness, Brooks-Gunn, & Warren, 1994). Smoking prevalence, in particular, is high within samples of individuals with Bulimia Nervosa and other eating disorders (Anzengruber et al., 2006; Bulik et al., 1992; Haug, Heinberg, & Guarda, 2001; Welch & Fairburn, 1998). Several explanations for the comorbidity between extreme weight control behaviors and substance use have been suggested including shared personality traits, familial association between eating and substance use disorders, use of substances to reduce weight-related anxiety, and increased sensitivity to the rewarding effects of substances during food deprivation (Wolfe & Maisto, 2000). The latter hypothesis was the focus of the present study.

Studies have demonstrated that food deprivation results in the increased self-administration of nicotine and a variety of other substances in laboratory animals (Carroll, France, & Meisch, 1979; Comer, Turner, & Carroll, 1995; Lang, Latiff, McQuenn, & Singer, 1977; McGregor, Saharov, Hunt, & Topple, 1999). Food deprivation is also associated with reduced extracellular dopamine levels in the nucleus accumbens (Pothos, 2001; Pothos, Creese, & Hoebel, 1995a; Pothos, Hernandez, & Hoebel, 1995b), an area of the brain that plays an important role in drug reward. Several studies have provided evidence of increased dopamine release and reduced dopamine uptake with substance administration in food-deprived animals (Carr, 2002; Pothos, 2001; Pothos et al., 1995a; Zhen, Reith, & Carr, 2006). Thus, it is plausible that substances which increase dopamine concentrations in the brain may be administered with greater frequency during food-deprivation.

A few laboratory studies have examined the effects of food deprivation on substance use in humans. Zacny and de Wit (1990) reported that expired carbon monoxide (CO) levels, but not cigarette intake, were greater among seven individuals following a 24-hour fast than in a normal food intake condition. In a follow-up study, Zacny and de Wit (1992) compared the cigarette consumption, caffeinated beverage consumption, CO levels, and plasma cotinine levels of five males who were placed on a restricted calorie diet of 800 calories per day for three days and a normal diet of 3,000 calories per day for three days. No differences in cigarette consumption, caffeinated beverage consumption, CO, or cotinine levels were found between conditions. Lawson, Bulik, Rodefer, Scanlon, and Borger (1997) compared the effects of three feeding conditions, lasting three days each, on the coffee and cigarette consumption of four women. The feeding conditions were: 1) three meals per day containing the typical energy intake for each participant, 2) one meal per day containing 50% of the typical daily intake, 3) and three meals per day each containing 50% of the typical intake. No differences in expired CO levels, smoking rate, or coffee consumption were found between the food-deprived and non-deprived conditions.

Most recently, Cheskin, Hess, Henningfield, & Gorelick (2005) examined the smoking behavior of 17 individuals who were placed on four diets of varying calorie and carbohydrate levels for six days each in an inpatient hospital setting. The diet conditions were: 1) normal calorie (2,000–2,800 kcals per day), 2) low calorie (700 kcal deficit per day), 3) low carbohydrate/normal calorie ($\leq 20\%$ kcals from carbohydrates), and 4) low carbohydrate/low calorie ($\leq 20\%$ kcals from carbohydrates). Results indicated that participants smoked approximately eight percent more cigarettes and produced expired CO levels that were 11% higher in the low-calorie diet conditions than in the normal-calorie diet conditions. This study provided preliminary evidence that smoking rate and intake of nicotine and other smoke constituents increase in humans during prolonged food deprivation.

Two studies have examined the impact of food deprivation on substance use in women with Bulimia Nervosa, a disorder characterized by dieting and self-imposed food deprivation. Bulik and Brinded (1993) compared the alcohol consumption of five women with Bulimia Nervosa and five healthy controls after a 19-hour fast and in a non-deprived state. No differences in the

amount of alcohol consumed or calories consumed from alcohol were found between the food-deprived and non-deprived conditions, and females in the Bulimia Nervosa and control groups consumed equivalent amounts of alcohol. Unexpectedly, breath alcohol levels were greater in the non-deprived conditions than in the food-deprived conditions. Bulik, Brinded, and Lawson (1995) compared the coffee consumption of four women with Bulimia Nervosa and six healthy controls after a 19-hour fast and in a non-deprived state. Results indicated that participants consumed significantly more coffee when food-deprived than when not deprived. This effect was more pronounced in the women with Bulimia Nervosa, who consumed more than twice as much coffee in the food-deprived condition than in the non-deprived condition.

Unfortunately, findings across studies have been equivocal and the ability to draw conclusions about the relationship between acute food deprivation and substance use in humans has been limited by methodological problems. In particular, studies of the effects of acute food deprivation (i.e., ≤ 24 hours) on substance use have utilized very small samples sizes ranging from four to seven participants (Bulik & Brinded, 1993; Bulik et al., 1995; Zacny & de Wit, 1990). Further, only one of these studies has examined the effects of acute food deprivation on nicotine consumption specifically (Zacny & de Wit, 1990). In addition, studies of acute and prolonged food deprivation have failed to control for time and order effects with counterbalancing techniques (Lawson et al., 1997) and hormonal variations related to the menstrual cycle (Bulik & Brinded, 1993; Bulik et al., 1995; Cheskin et al., 2005; Zacny & de Wit, 1990). In the present study, we attempted to extend previous findings by addressing these methodological limitations in order to better understand the relationship between acute food deprivation and cigarette smoking in human females.

The main purpose of the present study was to test the hypotheses that females would smoke a greater number of cigarettes and exhibit greater CO levels during a 24-hour fasting period than when not deprived of food. It was also anticipated that participants would 1) rate their urges to smoke as stronger, 2) rate the cigarettes that they smoked as more pleasurable, 3) endorse greater negative mood, and 4) endorse less positive mood during the final six hours of a 24-hour period of food deprivation.

2. Method

2.1 Participants

Participants were recruited via fliers posted on the campus of a large university, local newspaper advertisements, and through the subject pool in which students were able to participate in research for course credit. Individuals were eligible to participate if they were female, ≥ 18 years of age, reported smoking at least 10 cigarettes per day, and had CO levels of $\geq$ six parts per million (ppm). In addition, only participants who were within the normal or overweight range of body mass index (BMI; 18.5–29.9) were included in the study, as this group may be more representative of individuals who engage in fasting for weight control purposes. Individuals were excluded from the study if they were within the underweight or obese ranges of BMI (≤ 18.4 or ≥ 30), diabetic or hypoglycemic, or possessed a health condition for which fasting would be contraindicated. Individuals who indicated symptoms consistent with a diagnosis of Bulimia Nervosa on a self-report screening questionnaire were provided with a referral for further evaluation and possible treatment, although they were not excluded from participation.

2.2 Measures

The Demographics and Health Questionnaire—(DHQ) is a self-report questionnaire that inquires about demographic characteristics and health information including sex, race, age, daily smoking rate, preferred brand of cigarette, and health problems. Height and weight

were measured by the experimenters and noted on the questionnaire, and measurements were converted to BMI (kg/m^2).

The Fagerström Test for Nicotine Dependence—(FTND; Heatherton, Kozlowski, Frecker, & Fagerström, 1991) is a six-item self-report questionnaire that was administered to assess the degree of nicotine dependence among the participants. Possible scores on the measure range from zero to 10, with higher scores suggesting greater nicotine dependence.

Expired Carbon Monoxide—(Vitalograph Incorporated, Lenexa, KS, USA) levels were measured with a portable Vitalograph ecolyzer. According to the Society for Research on Nicotine and Tobacco (SRNT) Subcommittee on Biochemical Verification (2002), CO levels of $\geq$ eight ppm suggests recent cigarette smoking with a sensitivity and specificity of approximately 90 percent for heavier smokers. However, the half-life of CO may range from one to eight hours depending on a variety of factors including time of day, daily smoking rate, recency of smoking, and physical activity levels (SRNT Subcommittee on Biochemical Verification, 2002). Therefore, a slightly lower minimum criteria of $\geq$ six ppm was utilized in the present study given that the target population was expected to include lighter smokers and CO levels were occasionally measured in the morning.

The Geiselman Menstrual Cycle Interview—(P. J. Geiselman, personal communication, December 19, 2007) was administered to facilitate the scheduling of the laboratory sessions during the luteal phase of the menstrual cycle among participants who were not taking oral contraceptives. The luteal phase of the cycle was operationalized as beginning 11 days prior to the onset of menses and continuing until the day before the onset of menses. Participants were scheduled for both laboratory sessions during the same phase of the menstrual cycle in an attempt to control for hormonal variations that have the potential to impact smoking behavior.

The Eating Inventory—(EI; Stunkard & Messick, 1985; Stunkard & Messick, 1988) is a 51-item self-report measure of eating behavior. Three factors of the EI have been derived through factor analysis: Cognitive Restraint of Eating, Disinhibition, and Hunger (Stunkard & Messick, 1985).

The Bulimia Test – Revised—(BULIT-R; Thelen, Farmer, Wonderlich, & Smith, 1991) is a 36-item self-report questionnaire that was used to identify possible eating disorders and to measure symptoms of Bulimia Nervosa. Scores of 104 or greater suggest the possibility of a Bulimia Nervosa diagnosis.

The Visual Analogue Scales—(VAS) are self-report measures on which participants were asked to indicate their responses to specified questions by drawing a vertical line through a 100 mm horizontal line. Each participant was asked to respond to the question “How strong is your urge to smoke right now?” prior to smoking each cigarette, and to the question “How pleasurable was it to smoke this cigarette?” after smoking each cigarette. These ratings were utilized to provide subjective indices of the strength of smoking urges and the pleasure derived from smoking. Additionally, participants were asked to rate their hunger three times during each experimental condition by responding to the question “How hungry are you right now?” Hunger ratings were utilized to provide a subjective index of hunger and to serve as a manipulation check for fasting compliance.

The Profile of Mood States—(POMS; McNair, Lorr, & Droppleman, 1992) is a 65-item self-report questionnaire, which lists adjectives that describe an individual’s mood. Individuals were asked to rate, on a five-point scale, the extent to which each adjective described their

mood “right now.” Six factors of the POMS have been derived through factor analysis: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor-Activity, Fatigue-Inertia, and Confusion-Bewilderment. A Total Mood Disturbance score was calculated by summing the scores of the negative affect subscales and subtracting the Vigor scale.

Ketone Test Strips—(Bayer HealthCare LLC, Mishawaka, IN, USA) were used to measure urinary ketone concentrations. Studies have indicated that ketone levels begin to rise in the first few days of fasting, and plateau within three to five days (Balasse, 1979; Balasse & Fery, 1989). After an overnight fast, the average concentration of ketone bodies has been reported to be approximately one to four mg/dl (Balasse & Fery, 1989). Although ketone concentrations cannot be used to verify an individual’s compliance with a short-term fast, the presence of ketones in some of the urine samples collected during food deprivation provides some evidence that the sample complied with the fasting instructions.

2.3 Procedure

Telephone Screening—Individuals who called in response to fliers or newspaper advertisements were briefly screened over the telephone to ensure that they met basic inclusion criteria (e.g., age, smoking rate, health). If callers met the initial inclusion criteria, they were invited to attend an in-person screening session at a psychological health clinic on campus.

In-Person Screening—Women who signed up for the experiment through the subject pool or who met the initial criteria during the telephone screening were scheduled for an in-person screening session. Informed consent was obtained and the DHQ, FTND, EI, and BULIT-R were administered. Additionally, CO levels, height, and weight were measured. Women who participated in the screening session were given either a \$20 payment or course credit that could be applied to their Psychology coursework.

Eligible individuals were asked to participate in two additional six and a half hour sessions, one of which required a 24-hour fast. Participants who were not using oral contraceptives were scheduled for both experimental sessions during the luteal phase of their menstrual cycle. This was done primarily to maintain similar hormone levels between conditions, and also to capitalize on research suggesting that cigarette craving and smoking rate increase during the luteal phase (e.g., Allen, Hatsukami, Christianson, & Nelson, 1996; DeBon, Klesges, & Klesges, 1995). Similarly, participants who were using oral contraceptives were scheduled for both sessions during the same phase of their birth control pill packs to maintain similar hormone levels between conditions. No menopausal or post-menopausal women participated in the study. The experimental sessions were scheduled at least one day apart, and the order of the deprived and non-deprived conditions was counterbalanced in order to control for potential effects of time and session order.

Food-Deprived Condition—Participants were instructed to fast for 18 hours prior to their scheduled appointments at 9:00 a.m. Participants were asked not to eat or drink anything containing calories after 3:00 p.m. the night before the study, although they were encouraged to consume as much water as desired. Participants were each asked to sign an agreement stating that they would adhere to the fasting instructions, and they were informed that a urine sample would be collected during the study session for verification of fasting. When questioned at the beginning of the study session, all participants reported that they had complied with the fasting instructions. Participants were provided with one pack of their preferred brand of cigarettes, a lighter, and an ashtray at the beginning of the study session. Participants were encouraged to smoke as often as they liked, and they were told that they would be allowed to keep any remaining cigarettes that were left in the pack at the end of the session. Participants were instructed to rate the strength of their urges to smoke prior to smoking each cigarette, and to

rate the degree of pleasure experienced from smoking each cigarette using the VAS. Participants were provided with unlimited access to bottled water throughout the study session, and were allowed to engage in a quiet activity of their own choosing (e.g., reading, completing homework assignments). Individuals were asked to complete the POMS and VAS hunger ratings at 9:00 a.m., 12:00 p.m., and 3:00 p.m. The number of cigarettes smoked during the six-hour laboratory session was counted at 3:00 pm. The measurement of cigarette smoking in the laboratory began after the completion of 18 hours of fasting (9:00 a.m.) to ensure adequate food deprivation during the measurement period, and measurement continued through 24 hours of fasting (3 p.m.). The six-hour measurement period in the laboratory allowed for the direct observation and more precise measurement of cigarette smoking, and limited situations that might interfere with smoking (i.e., attending class, working). CO levels and urinary ketone concentrations were measured between 3:00 p.m. and 3:30 p.m. Participants were provided with a nutritional bar at the conclusion of the experimental session.

There are a few important considerations with regard to the interpretation of the CO and urinary ketone levels. In particular, the measurement of CO levels after the 24-hour fasting period in the present study is not likely to reflect pre-fasting smoking levels given that the half-life of CO in a sedentary person is approximately two to three hours and is even less among physically active participants (SRNT Subcommittee on Biochemical Verification, 2002). It should be also emphasized that ketone concentrations do not reflect compliance with the fasting instructions at the individual level after a period of only 24 hours. Many individuals begin to produce ketones after 24 hours of fasting, thus the presence of ketone concentrations among some of the participants provides some evidence of sample compliance. A negative test for urinary ketone concentrations does not indicate noncompliance with the fasting instructions, as many individuals do not produce ketones after only 24 hours of food deprivation.

Non-Deprived Condition—Participants were instructed to eat and drink as usual prior to their scheduled appointments at 9:00 a.m. In order to ensure that participants were not deprived of food, breakfast was provided at 9:00 a.m. and lunch was provided at 12:00 p.m. Breakfast contained approximately 525 calories, and included a cereal bar, yogurt, banana, and orange juice. Participants chose one of several microwaveable frozen meals for their lunch, which was accompanied by water or another non-caloric beverage. The lunch food choices ranged from 600 to 680 calories. All other aspects of the session were the same as in the food-deprived condition described above. Upon completion of both of the study sessions, participants received course credit that could be applied to their psychology coursework or a \$130 payment. All study procedures were approved by the Louisiana State University Institutional Review Board.

3. Results

3.1 Participant Characteristics

A total of 15 individuals completed the study, and the sample was 60% Caucasian, 33.3% African American, and 6.7% Asian. Eleven participants reported that they were not using oral contraceptives, three reported monophasic oral contraceptive use, and one participant reported triphasic oral contraceptive use. The mean age of the participants was 27.40 years (± 9.30), and the mean BMI was 23.88 (± 1.97). Participants smoked an average of 18.27 (± 7.26) cigarettes per day for 10.12 (± 8.42) years, and the mean FTND score was 4.73 (± 2.91). The mean CO level of participants at the screening session was 16.13 (± 10.54). Mean scores on the EI Cognitive Restraint, Disinhibition, and Hunger scales were 7.33 (± 4.69), 7.13 (± 2.92), and 6.00 (± 3.14) respectively. The mean score on the BULIT-R was 55.80 (± 13.34), and none of the participants scored at or above the BULIT-R screening cutoff score of 104 for Bulimia Nervosa. See Table 1 for individual participant characteristics.

3.2 Hunger Ratings

The experimental conditions were counterbalanced to control for time and session order in all analyses. Average hunger ratings within each condition were compared to verify that self-reported hunger was greater in the food-deprived than in the non-deprived condition. Repeated measures analysis of variance (ANOVA) indicated that average hunger ratings were significantly greater in the food deprived condition than in the non-deprived condition, $F(1, 14) = 46.04, p < .01$, one-tailed. These findings provide evidence that participants complied with the instructions to fast prior to the session. Means, standard deviations, and effect sizes for hunger ratings are presented by condition in Table 2.

3.3 Urinary Ketone Concentrations

Urinary ketone concentrations were measured to confirm that some individuals in the food-deprived condition would test positive for ketones following the 24-hour fasting period. A total of 40% of participants tested positive for urinary ketones in the food deprived condition. These findings provide some evidence that participants complied with the fasting instructions, as they are similar to the findings of previous studies indicating that a 24-hour hour fasting period was associated with the presence of urinary ketone bodies in approximately 42–43% of urine samples (Zacny & de Wit, 1989; Zacny & de Wit, 1990).

3.4 Nicotine Self-Administration

Repeated measures ANOVAs were conducted to test the hypotheses that the total number of cigarettes smoked during each experimental session and CO levels collected at the conclusion of each session would be significantly greater in the food-deprived condition than in the non-deprived condition. As hypothesized, participants had significantly greater CO levels in the food-deprived condition than in the non-deprived condition, $F(1, 14) = 3.04, p = .05$, one-tailed. CO levels were 21.78% (4.4 ppm) higher in the food-deprived condition than in the non-deprived condition. It is notable that 66.67% ($n = 10$) of the participants had greater CO levels in the food-deprived condition, while 20% ($n = 3$) had greater CO levels in the non-deprived condition, and 13.33% ($n = 2$) showed no differences in CO levels between conditions. No significant differences were found between conditions in the total number of cigarettes smoked during the laboratory sessions. Hunger ratings were not significantly associated with total cigarettes smoked or CO levels during the laboratory session in either experimental condition. Means, standard deviations, and effect sizes for CO and smoking rate are presented by condition in Table 2.

3.5 Urges to Smoke and Pleasure from Smoking

Repeated measures ANOVAs were conducted to test the hypotheses that participants would rate the strength of their urges to smoke (prior to smoking) and the subjective pleasure experienced from smoking (after smoking) as greater in the food-deprived condition than in the non-deprived condition. Participants completed VAS urge ratings prior to smoking each cigarette, and completed VAS pleasure ratings after smoking each cigarette. VAS urge and pleasure ratings were averaged across all cigarettes smoked within each condition. Non-significant differences were found between the food-deprived and non-deprived conditions on strength of self-reported urges to smoke, $F(1, 14) = 2.16, p = .08$, one-tailed, although they were in the opposite direction than expected. No differences were found between the food-deprived and non-deprived conditions in self-rated pleasure from smoking. Means, standard deviations, and effect sizes for smoking urges and pleasure from smoking are presented by condition in Table 2.

3.6 Positive and Negative Mood

The six subscales of the POMS, Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor-Activity, Fatigue-Inertia, and Confusion-Bewilderment, were averaged across three time points within each condition. Repeated measures ANOVAs were conducted to identify differences between conditions on each of the POMS scales. Analyses indicated that Vigor-Activity scores were significantly lower in the food-deprived condition than in the non-deprived condition, $F(1, 14) = 4.65, p = .02$, one-tailed. Differences between conditions on the Fatigue-Inertia, $F(1, 14) = 2.22, p = .08$, one-tailed, and Total Mood Disturbance, $F(1, 14) = 2.21, p = .08$, one-tailed, scales approached significance. No significant differences were found between conditions on the remaining POMS subscales. See Table 2 for POMS subscale means, standard deviations, and effect sizes by condition.

4. Discussion

The findings of the present study suggest that females may alter their smoking behavior in order to increase their nicotine intake during food deprivation. Expired CO levels were nearly 22% greater among women after a 24-hour fasting period than when they were not deprived of food, although no differences in the total number of cigarettes smoked were found between conditions. In addition, food deprivation was associated with significantly reduced positive mood (i.e., Vigor-Activity) during food deprivation. The results of this study add to the preliminary evidence that nicotine intake increases during periods of acute (Zacny & de Wit, 1990) and more prolonged periods (Cheskin et al., 2005) of food deprivation in humans.

Surprisingly, no differences between conditions were found in the strength of participants' self-reported urges to smoke or the subjective pleasure experienced from smoking. These findings are inconsistent with previous research indicating that cigarettes may be more reinforcing during food-deprivation (Bulik & Brinded, 1994). Perhaps smoking serves another function, such as the attenuation of hunger, negative affect, stress, or decreased positive affect. It is also possible that smoking urges may been equivalent between conditions due to stronger urges to smoke following meals in the food-deprived condition balanced with stronger urges to smoke due to food deprivation in the food-deprived condition. Finally, the VAS measure may not be the optimal means by which to measure self-reported urges or pleasure experienced from smoking. Alternative measures of smoking urges and pleasure should be utilized in future studies to confirm the present findings.

It is possible that the results of this study may have implications for individuals with eating disorders, chronic dieters, and those who suffer from inadequate caloric consumption due to impoverishment. Specifically, food-deprived individuals may be at greater risk for smoking initiation, increased smoking rates, nicotine dependence, and relapse following smoking cessation. In addition, greater consumption of smoke constituents may increase risk for the development of tobacco-related diseases.

The present study has several strengths. The strengths include the use of a within-subjects design and the recruitment of a sample that is more than twice as large as the samples utilized in other studies of acute food deprivation. Moreover, the sample was limited to women and an attempt was made to control for hormonal variation across conditions. Finally, several strategies were utilized to encourage and verify participant compliance with the fasting instructions. Participants were informed in advance that they would be asked to provide a urine sample to verify that they had complied with the fast. Further, hunger ratings and ketone concentrations were measured to provide evidence of fasting.

Study limitations include the provision of a monetary payment for participation, which may have encouraged false reports of fasting compliance. It is also unclear to what degree the sample

utilized in the study reflects the population of females who smoke, given that many of the participants were college students. All of the women who participated in the present study were within the normal to overweight ranges of BMI; therefore findings may not generalize to women who fall within the obese range. In addition, the use of substances other than nicotine prior to the experimental sessions was not measured. Thus, it is possible that substance use may have influenced smoking behavior during course of the study. In addition, participants spent some of their time eating breakfast and lunch during the laboratory session in the non-deprived condition only, which may have taken time away from smoking. Finally, despite efforts to encourage compliance with fasting, a more sensitive method of verifying compliance at the individual level was not feasible. Therefore, non-compliance with the fasting instructions is a possibility.

Future studies must examine the relative impact of acute versus prolonged food deprivation on nicotine intake and smoking topography. Although dietary restraint was measured in the present study, the sample size was not large enough to examine the impact of the interaction between dietary restraint and acute food deprivation on cigarette smoking. Individuals who exhibit elevated dietary restraint may smoke at higher rates than those with lower restraint because they are in chronic state of self-imposed food deprivation. Weight is also likely to be an important factor, given that lower body weight may reflect greater dietary restraint and food deprivation. In addition, more research is needed to determine whether there is a stronger association between food deprivation and increased substance use among those with eating disorders. Finally, future research must elucidate the physiological mechanisms by which food deprivation may produce increases in substance use in humans.

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Table 1

Individual Participant Characteristics at screening

	Race/Ethnicity	Age	CPD	FTND	BMI	EL-R	ELD	BULIT-R
1*	C	24	15	6	26.70	15	10	71
2	AS	20	11	5	23.03	10	6	62
3	C	22	11	1	24.18	15	10	86
4	C	22	20	2	23.79	10	12	56
5*	C	24	20	3	22.98	10	11	62
6	C	22	15	3	24.27	6	4	38
7*	AA	20	17	4	21.43	5	4	52
8	C	21	12	2	19.24	8	7	58
9	C	19	18.5	1	26.62	6	6	54
10	AA	44	40	10	25.39	3	3	42
11	AA	39	20	9	24.03	1	7	52
12*	C	22	12	4	24.63	4	3	35
13*	AA	34	25	9	22.32	2	7	70
14	C	47	17.5	6	23.62	2	10	52
15	AA	31	20	6	25.98	13	7	47

Note. AA = African American; AS = Asian; C = Caucasian; CPD = Cigarettes per Day; FTND = Fagerstrom Test for Nicotine Dependence; BMI = Body Mass Index; EL-R = Eating Inventory Cognitive Restraint; ELD = Eating Inventory Disinhibition; BULIT-R = Bulimia Test – Revised.

* Participant did not show an increase in expired carbon monoxide level in the food-deprived condition.

Table 2
Smoking Variables, Hunger, and Mood Ratings by Experimental Condition.

	Food-Deprived	Non-Deprived	Partial η^2	<i>p</i> (1-tailed)
CO (ppm) ^a	24.60 (± 10.46)	20.20 (± 8.00)	.18	.05
Cigarettes Smoked ^b	6.27 (± 2.09)	6.60 (± 1.76)	.05	<i>ns</i>
Profile of Mood States				
Tension-Anxiety	9.03 (± 5.45)	7.86 (± 6.37)	.10	<i>ns</i>
Depression-Dejection	6.87 (± 8.81)	6.15 (± 9.58)	.02	<i>ns</i>
Anger-Hostility	5.14 (± 6.21)	3.96 (± 6.11)	.10	<i>ns</i>
Vigor-Activity	10.09 (± 4.17)	11.93 (± 4.32)	.25	.02
Fatigue-Inertia	8.90 (± 5.79)	7.38 (± 5.84)	.14	.08 (<i>ns</i>)
Confusion-Bewilderment	5.97 (± 4.69)	6.04 (± 5.41)	.00	<i>ns</i>
Total Mood Disturbance	25.81 (± 29.19)	19.46 (± 33.36)	.14	.08 (<i>ns</i>)
Visual Analogue Scales				
Hunger (mm)	76.31 (± 12.06)	48.56 (± 16.53)	.77	<.01
Urge to Smoke (mm)	58.07 (± 18.85)	61.88 (± 18.69)	.13	.08 (<i>ns</i>)
Pleasure from Smoking (mm)	65.83 (± 14.83)	67.25 (± 13.46)	.02	<i>ns</i>

Note. Means and standard deviations are presented unless otherwise specified. CO = expired carbon monoxide level; ppm = parts per million.

^aExpired CO level was measured at the conclusion of each laboratory session following a 24-hour fasting period.

^bTotal number of cigarettes includes all cigarettes smoked during each six hour laboratory session.