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Original Investigation

# Contingency management and motivational enhancement: A randomized clinical trial for college student smokers

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## Abstract

**Introduction:** The efficacy of contingency-management (CM) and motivational enhancement therapy (MET) for college student smoking cessation was examined.

**Methods:** Nontreatment-seeking daily smokers ($N = 110$) were randomly assigned to 3 weeks of CM versus noncontingent reinforcement (NR) and to three individual sessions of MET versus a relaxation control in a $2 \times 2$ experimental design. Expired carbon monoxide (CO) samples were collected twice daily for 3 weeks. Participants earned U.S.$5 for providing each sample; additionally, those randomized to CM earned escalating monetary rewards based on CO reductions (Week 1) and smoking abstinence (Weeks 2–3).

**Results:** Compared with NR, CM resulted in significantly lower CO levels and greater total and consecutive abstinence during the intervention. Those in the CM and MET groups reported greater interest in quitting smoking posttreatment, but rates of confirmed abstinence at follow-up were very low (4% at 6-month follow-up) and did not differ by group.

**Discussion:** Findings support the short-term efficacy of CM for reducing smoking among college students. Future research should explore enhancements to CM in this population, including a longer intervention period and the recruitment of smokers who are motivated to quit.

## Introduction

Over the past 10 years, U.S. smoking rates have increased among young adults, particularly college students, 25%–30% of whom report current smoking (Murphy-Hoefer et al., 2005; Rigotti, Moran, & Weschler, 2005). The rate at which students initiate daily smoking during college also has increased (Rigotti, Lee, & Weschler, 2000; Sax, 1997). Most students believe that their smoking will be limited to their college years (Freeman, Hennessy, & Marzullo, 2001), yet the majority continue to smoke after graduation (Kenford et al., 2005). Despite the difficulties college students have with quitting smoking (Foote et al., 1996), empirically validated tobacco interventions for college students are lacking (Murphy-Hoefer et al., 2005). The present study examined two smoking cessation interventions in college students: contingency-management (CM) and motivational enhancement therapy (MET).

### CM

CM is an empirically based method that decreases substance use by providing reinforcers contingent on abstinence or reduction of substance use to a target level (Higgins & Tidey, 2003). CM typically includes the following components: (a) obtaining objective evidence of abstinence or another target behavior; (b) providing reinforcers, such as money or vouchers, when the target behavior is achieved; and (c) withholding reinforcers when the target behavior does not occur (Petry, 2000). CM interventions

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are consistently effective in reducing smoking in adults (Gilbert, Crauthers, Mooney, McClernon, & Jensen, 1999; Roll, Higgins, & Badger, 1996; Stitzer & Bigelow, 1982, 1985, Stitzer, Rand, Bigelow, & Mead, 1986), although smokers generally return to baseline smoking levels upon withdrawal of contingent reinforcers. However, in two studies with pregnant smokers, not only did CM increase rates of abstinence at the end of pregnancy and 12 weeks postpartum but effects were sustained throughout a 24-week follow-up period (Donatelle, Prows, Champeau, & Hudson, 2000; Higgins et al., 2004).

Emerging research suggests that CM may reduce smoking among younger smokers. In eight adolescent smokers who received 5 days of monetary reinforcement that was or was not contingent on smoking reductions, expired carbon monoxide (CO) levels decreased significantly during the contingency period (Corby, Roll, Ledgerwood, & Schuster, 2000). In a study of CM and psychosocial treatment for adolescent smokers, participants receiving 4 weeks of CM plus cognitive–behavioral therapy had more biochemically verified abstinence in Weeks 1 and 4 compared with those who received only the cognitive–behavioral therapy (Krishnan-Sarin et al., 2006). Another study examining adolescents found that contingently reinforcing smoking reductions for several days prior to reinforcing abstinence enhanced the effects of CM during the abstinence phase (Tevyaw et al., 2007). The only study of CM with college student smokers found that students produced a significantly greater number of abstinent CO readings during contingent versus noncontingent reinforcement (NR) phases in a 3-week ABA design. Greater effects were found for those assigned to high- versus low-reinforcer conditions (Correia & Benson, 2006). Longer term effects were not studied.

## MET

MET was developed based on analyses showing that effective elements for treatment of individuals with alcohol problems included an empathic, nonconfrontational therapist style, emphasis on the client's personal responsibility for change, feedback about the effects of the substance on the client, advice to change, a menu of alternative change methods from which the client could choose, and increasing client self-efficacy for change (Miller & Sovereign, 1989). MET significantly reduced drinking in a number of studies (Bien, Miller, & Tonigan, 1993; Brown & Miller, 1993), including those with college students (Carey, Scott-Sheldon, Carey, & DeMartini, 2007).

Results have been mixed when applying MET to smokers. In an early study with adult smokers, MET resulted in significantly more abstinence from smoking than a comparison treatment (Butler et al., 1999), but effects in varied adult patient groups have been weak (Borrelli et al., 2005; Haug, Svikis, & DiClemente, 2004). Among adolescents, a pilot study by Colby et al. (1998) found MET to double abstinence rates compared with a control condition at 3-month follow-up, but the medium effect size was nonsignificant (*ns*). Larger studies with adolescents have found MET to result in greater smoking reductions, lower cotinine levels (Colby et al., 2005), and greater quitting self-efficacy (Brown et al., 2003) than brief advice, but no effect on smoking abstinence. In a study with college students, 15% of those in MET reported smoking abstinence at 6-month follow-up compared with 0% in the no-treatment condition, but reports of abstinence were not verified biochemically (Herman & Fahnlander, 2003).

In sum, MET has shown efficacy for reducing alcohol use in college students and other populations, and it appears to have beneficial effects on smoking-related behaviors and cognitions but not abstinence in young people. CM specifically promotes abstinence and has produced greater smoking abstinence than control conditions in a small number of experimental trials with adolescents and college students. The present study examined whether the combination of MET and CM would have greater efficacy for promoting abstinence than either approach alone. We hypothesized that participants randomized to CM would achieve more abstinence than participants randomized to NR during abstinence reinforcement and that MET and CM combined would result in more smoking abstinence than either intervention alone at follow-up. Secondary hypotheses were that CM and MET, compared with their control conditions, would result in greater interest in quitting, greater readiness to change, more quit attempts, and reduced intensity of smoking at follow-up.

# Methods

## Participants

**Eligibility.** Participants ($N = 110$) were recruited from colleges and universities in a northeastern U.S. state. Participants had to be enrolled as students, daily smokers, 18–24 years old, and English literate. To ensure sufficient smoking levels appropriate for a CO-based CM intervention, participants were required to have a breath CO level of at least 10 parts per million (ppm) at screening. Students who had participated in a pilot CM smoking study conducted by this research group were excluded. Enrollment spanned January 2005 to November 2006, and follow-up was completed between March 2005 and June 2007. The study was described as a project involving cash rewards for providing breath CO samples and did not require interest in quitting smoking. Advertisements were posted in campuses, in campus newspapers, and on the Internet (e.g., on Craigslist). Interested students contacted the project to be screened for eligibility.

## Procedure

All study procedures were reviewed and approved by the Brown University Institutional Review Board. No adverse events occurred during the study. Participant flow through each research stage is presented in Figure 1. Participants completed informed consent for providing a breath sample to determine CO eligibility. Those determined eligible for the randomized trial were invited to participate, and informed consent was obtained for that. Students were informed that the study was designed to determine whether providing cash incentives for smoking abstinence helps to decrease smoking rates. After obtaining consent, a research therapist conducted a 60-min individual baseline assessment for which students earned U.S.$75.

**Design.** The study used a 2 × 2 design (psychosocial condition × reinforcement condition). The psychosocial condition compared three individual sessions of MET to three individual sessions of progressive muscle relaxation control (REL) treatment. The reinforcement condition compared 3 weeks of CM to 3 weeks of NR. Participants were randomly assigned to one of four conditions (MET + CM; MET + NR; REL + CM; REL + NR).

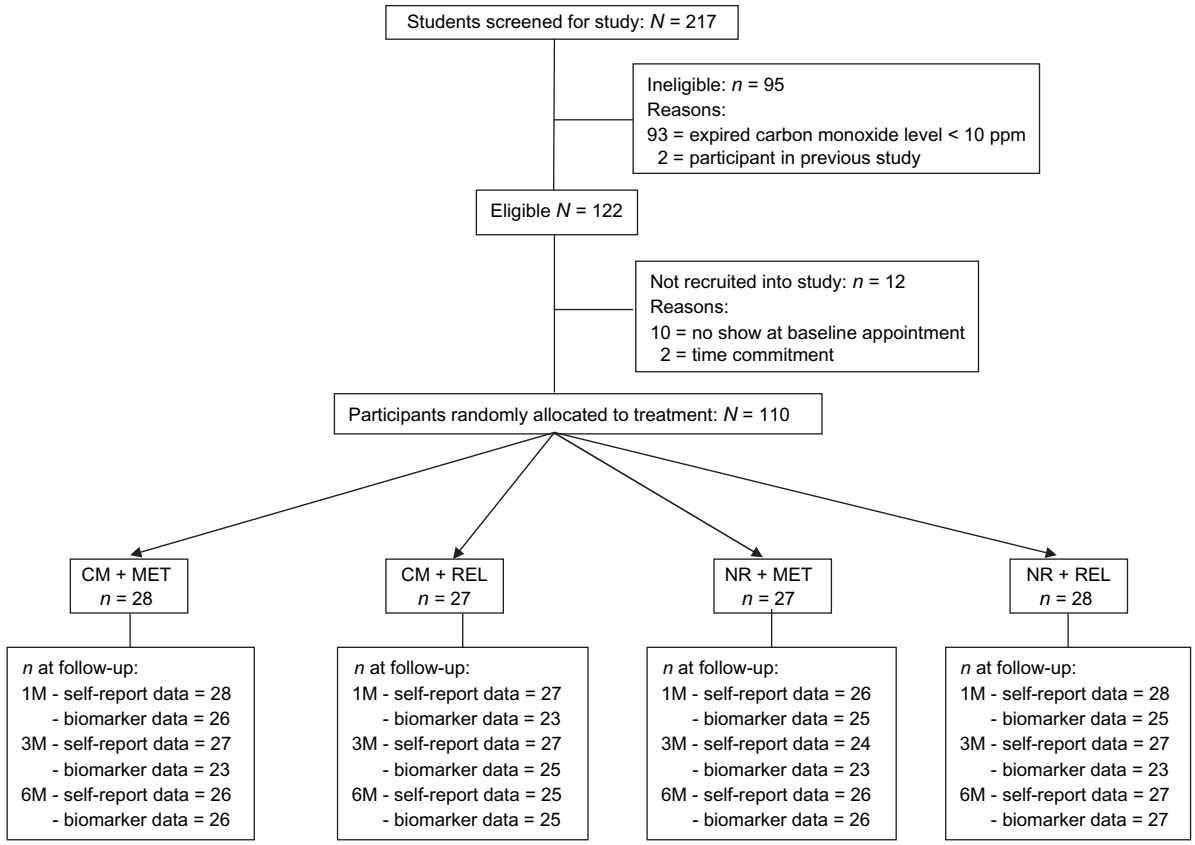


**Figure 1.** Flow of participants through each stage of the research. CM, contingency management; NR, noncontingent reinforcement; MET, motivational enhancement therapy; REL, relaxation control; 1M, 1-month follow-up; 3M, 3-month follow-up; 6M, 6-month follow-up.

**Motivational enhancement therapy.** Sessions were scheduled to coincide with key timepoints in the reinforcement component. Session 1 took place the day before the start of the reinforcement condition; Session 2 took place after 1 week of reduction reinforcement and prior to 2 weeks of abstinence reinforcement. Session 3 took place at the conclusion of the 2 weeks of abstinence reinforcement when contingencies were withdrawn. The same therapist conducted all three sessions.

MET incorporated the central principles described by Miller and Rollnick (1991). The first session (60 min) focused on enhancing motivation to cut down and quit smoking. The therapist followed four steps: establishing rapport, assessing motivation for change, motivational enhancement, and establishing goals for change. After providing a session overview and establishing rapport, the therapist initiated a discussion about the student's perceived pros and cons of cigarette smoking. This was followed by a review of computer-generated, personalized feedback from the student's baseline assessment data, including age- and gender-specific normative smoking data, degree of physical dependence on cigarettes, and current consequences related to smoking. Students received a copy of the feedback forms and information about smoking effects, coping with withdrawal symptoms, and strategies for quitting. The therapist next asked the student to imagine what would happen if his or her smoking stayed the same or if he or she decided to quit. Barriers to change were discussed, with problem solving. The therapist and student developed an action plan for behavior change. The student was shown a menu of possible goals and strategies and developed short- and long-term goals for cutting down or quitting smoking. Finally, the therapist focused on enhancing self-efficacy by eliciting discussion about the student's past personal successes and personal characteristics that demonstrate ability to change.

Sessions 2 and 3 (each ~30 min) followed a common format, using MET principles, focusing on progress made toward changing smoking behaviors and planning for the future. The therapist began by reviewing the prior session and addressing questions. The therapist then reviewed the student's CO levels from the prior 7 or 14 days, discussing progress toward goals and barriers to change encountered, problem solving, and setting new goals for behavior change as needed. Triggers for smoking were identified and relevant coping skills were discussed.

**REL.** REL treatment has been shown to have effects equal to no treatment (Fiore et al., 2000). It was matched to MET for contact time and designed to control for nonspecific therapeutic factors. Students were told that because smokers often report smoking to relax and calm down, learning methods of REL may help them to cope with negative feelings and could be used as an alternative to smoking. Therapists followed a standardized manual to implement the REL sessions. In Session 1, therapists guided the participant through progressive muscle REL exercises. Muscle REL techniques were then practiced during Sessions 2 and 3.

**Reinforcement component.** Twice-daily CO breath samples were collected from students between 7:30 a.m. and 10:30 a.m. and between 4.30 p.m. and 7.30 p.m. Staff traveled to participants' campuses to collect CO samples at prearranged locations.

**NR.** Participants in the NR condition received $5.00 for providing each of 42 breath samples, regardless of CO level (total = $210.00), plus a bonus of $10.00 for attending at least 80% of the CO readings for each week ($30.00 across 3 weeks); a total of $240.00 could be earned. NR payments were provided to promote session attendance and to minimize differences in attendance between the CM and the NR groups. Payments were delivered in cash immediately after each reading.

**CM.** Participants in the CM groups received $5.00 cash payments for each sample regardless of CO level to encourage participants to provide samples, whether or not they had smoked recently. Contingent reinforcement for reduction or abstinence was provided above and beyond those payments. During Week 1, CM participants earned cash contingent on CO reductions of 25% or greater from their baseline levels (Stitzer et al., 1986): $1.00 for a 25%–49% reduction, $2.00 for a 50%–74% reduction, and $3.00 for a reduction of 75% or greater. During Weeks 2–3, those in the CM groups earned cash contingent on a CO level indicative of abstinence (≤5 ppm) in an escalating schedule of reinforcement (Roll et al., 1996). Payments began at $3.00 for the first abstinent sample and increased by $0.50 for each consecutive abstinent sample. Participants received a $1.00 bonus for two consecutive abstinent samples. If a participant had a CO reading higher than 5 ppm during Weeks 2–3, he or she did not receive the abstinence-contingent payment for that reading, and payment for the next abstinent sample was reset to $3.00 (unexcused missed samples were treated as non-abstinent and resulted in a reset to $3.00). After a reset, if a participant provided four consecutive abstinent samples, the value of the abstinence-contingent payment was returned to the level before the reset. The total amount that could be earned in CM was $523.50 ($210 for providing the samples, plus $30 for attendance bonuses, plus $283.50 for contingent reinforcers).

We selected the CO abstinence criterion of 5 ppm, based on data from Alessi, Badger, and Higgins (2004), which indicated that some CM participants were able to smoke between thrice-daily CO readings and still meet a criterion of 8 ppm. Because smoking reduction and abstinence were assessed with a CO criterion, participants were informed about non-cigarette sources of CO exposure (e.g., marijuana, secondhand smoke, car exhaust) and advised to avoid these sources throughout the reinforcement phase to avoid false-positive readings.

**Therapist training and supervision.** Three female bachelor-level therapists conducted the psychosocial interventions. The therapists had 1–7 years of clinical experience in adolescent and young adult substance abuse treatment. The first author, a licensed clinical psychologist, provided weekly group and individual supervision. Training in MET conducted by the first author and other faculty members involved 40 hr of intensive workshops with didactic material, role-playing, and feedback. Training in REL conducted by the first author required approximately 10 hr of didactic material, role-playing, and observation of mock REL sessions. Both MET and REL were administered in individual sessions. Adherence ratings were completed following treatment by the therapist and the student separately.

## Measures

**Demographics.** Basic demographic data were assessed at baseline.

**Biochemical confirmation of abstinence.** Expired CO levels were obtained using a Bedfont Micro Smokerlyzer. CO was assessed at baseline, twice daily during the intervention trial, and at each follow-up. Saliva samples were obtained at baseline and at each follow-up. Cotinine concentration was determined via gas chromatography at an external laboratory.

**Timeline followback.** The timeline followback (TLFB) interview was used to assess daily cigarette smoking and other substance use (Sobell & Sobell, 1992, 1995). It was scored for number of days of smoking, alcohol, and marijuana use; number of cigarettes smoked per day; and duration of continuous abstinence from tobacco. A 30-day TLFB was used at baseline and the 1-month follow-up, a 60-day TLFB was used at the 3-month follow-up, and a 90-day TLFB was used at the 6-month follow-up.

**Other tobacco use.** Past 30-day use of other forms of tobacco was assessed at baseline for the sample description.

**Contemplation ladder.** The 10-point contemplation ladder provided a single continuous measure of motivation (readiness) to quit smoking at baseline and at each follow-up assessment. The ladder has been shown to have good reliability and validity (Abrams & Biener, 1992; Biener & Abrams, 1991).

**Modified Fagerström Tolerance Questionnaire.** This seven-item measure (Prokhorov, Pallonen, Fava, Ding, & Niaura, 1996) indexed nicotine dependence at baseline. Adapted for adolescents from the Fagerström Tolerance Questionnaire (Fagerström, 1978), its reliability and validity have been demonstrated (Prokhorov et al., 1996).

**Attendance and reinforcement.** Attendance at the three intervention sessions and the 42 CO readings were recorded along with CO level and amount of cash received at each reading.

**Treatment adherence, satisfaction, and interest in quitting smoking.** Students and therapists separately rated which of 19 possible session elements (15 MET elements and 4 REL elements) had been completed at posttreatment. Additionally, students used 4-point scales (1 = strongly disagree to 4 = strongly agree) to rate various therapist qualities and a 5-point scale (0 = not at all to 5 = very much) to rate the extent to which they were satisfied with their treatment. Finally, students responded to the item, "At this point, how much would you like to quit smoking?" on a 5-point scale (0 = not at all; 5 = very much).

## Assessment procedures

Assessments were conducted in person in individual sessions. Therapists and research assistants received training on standardized nonjudgmental interviewing and protection of human research participants. Baseline assessment was conducted by a therapist immediately prior to Session 1 of the psychosocial treatment; posttreatment assessments were completed during Session 3. Follow-up interviews were conducted by research assistants 1, 3, and 6 months following end of treatment (Day 21).

Participants were compensated $25.00, $35.00, and $75.00 for these assessments, respectively, and earned a $40.00 bonus at the final follow-up for timely completion of all three assessments. Research assistants were blind to psychosocial treatment assignment at follow-up. Due to staffing constraints and data collection demands, all available research assistants were involved in collection of CO samples for CM and NR; therefore, research assistants were not blind to reinforcement condition at follow-up. Participants outside the geographical area at follow-up were interviewed by telephone (15% at 1 month, 26% at 3 months, and 15% at 6 months) and received mailed materials for provision of saliva samples; 90% sent in saliva samples. Cotinine concentrations in mailed saliva samples have been shown to be accurate and stable (Greeley, Valois, & Bernstein, 1992), and prior research supports their validity for confirmation of smoking status in randomized trials (Sexton, Nowicki, & Hebel, 1986).

## Data analyses

**Primary outcomes.** Participants randomized to intervention were followed up and included in analyses regardless of how much of each intervention they completed. Group differences in attendance rates were examined using *t* tests. To evaluate intervention effects on percentage of abstinent CO readings, consecutive abstinent readings, and average CO levels during Weeks 2–3, we carried out separate 2 × 2 (reinforcement × psychosocial component) analyses of covariance, covarying baseline CO level. At posttreatment and each follow-up, group differences in confirmed point prevalence abstinence rates were examined using chi-square analyses.

Missing CO data during the reinforcement component were handled in one of two ways, depending on reinforcement condition. For NR, the mean of all obtained NR readings at the same reading time (a.m. or p.m.) was imputed as the missed reading. Because missing data in CM may have reflected noncompliance due to smoking, the average of all failed CM readings at the same reading time (a.m. or p.m.) was imputed as the missed reading. If there were no failed readings at the same time, the other time was used. If there were no failed readings at the other time, the screening CO level was used. Because different contingencies were in effect for Week 1 (reduction) versus Weeks 2–3 (abstinence), data imputations were conducted separately within each period. If all readings were missing within a time period, actual CO values were not estimated but all the readings were coded as non-abstinent. Missed readings that were excused (e.g., conflicting medical appointment, severely inclement weather, equipment failure) were neither estimated nor coded as non-abstinent.

All 7-day point prevalence abstinence reports were confirmed biochemically at follow-up. Participants who self-reported abstinence but provided no biomarker data for verification, or who provided biomarker data that were inconsistent with abstinence (salivary cotinine ≥ 15 ng/ml or CO > 8 ppm), were coded as non-abstinent. Other sources of biomarkers were assessed and were not found to account for discrepancies between self-report and biomarker data.

**Posttreatment.** Treatment adherence data were analyzed using *t* tests (MET vs. REL), comparing the number of treatment elements reportedly covered during the intervention. Posttreatment ratings of satisfaction were examined using *t* tests comparing MET versus REL.

**Secondary outcomes.** Posttreatment interest in quitting smoking was examined using a 2 × 2 (reinforcement × psychosocial component) analysis of variance (ANOVA). Because this variable was not administered at baseline, change from baseline could not be evaluated. Change in readiness to quit smoking from baseline to the 1-, 3-, and 6-month follow-ups was analyzed using separate 2 × 2 × 2 (reinforcement component × psychosocial component × time) ANOVAs with contemplation ladder scores as the dependent variable. To examine the effect of treatment on continuous smoking outcomes (cigarettes per day, percentage of smoking days, CO, and cotinine level) at 1, 3, and 6 months, analyses were conducted using generalized estimating equations (GEEs; Liang & Zeger, 1986) using PROC GENMOD in SAS. Covariates included baseline contemplation ladder score, modified Fagerström Tolerance Questionnaire score, and the baseline value of the corresponding dependent variable; a linear effect of time was included. Each treatment factor was dummy coded (CM = 1 vs. NR = 0; MET = 1 vs. REL = 0). In the second step, the interaction between the treatment factors was added. Finally, interactions between treatment condition and time were tested to determine whether the effects of treatments were attenuated at later follow-ups.

**Effect sizes.** Consistent with Cohen (1992), effects derived from ANOVA and GEE were calculated as *d*; effects from chi-square tests were calculated as *h*. Guidelines for interpreting effect magnitude are as follows: .20 = small effect, .50 = medium effect, and .80 = large effect (Cohen, 1992).

# Results

Variables were checked for distributional assumptions. Baseline percentage of smoking days (per TLFB) and CO at 1-month follow-up were log transformed to correct skewness. Two cotinine values were outliers based on the criterion of exceeding three *SDs* above the sample mean; each was recoded to the maximum of the other values plus 1 (cf. Tabachnick & Fidell, 1996).

## Sample characteristics

Of the 110 students enrolled, most (105) were recruited from seven in-state public and private colleges and universities; another five attended college out of state and were recruited during school breaks. Baseline demographic and substance use variables are presented in Table 1 and did not differ significantly between groups. Contemplation ladder scores averaged between 5 (I often think about quitting smoking but have no plans to quit) and 6 (I definitely plan to quit smoking in the next 6 months); 51% of participants reported no plans to quit smoking at baseline. In addition to smoking cigarettes, 58% reported use of other tobacco products in the prior 30 days, including clove cigarettes (33%), cigars (33%), snuff (13%), chewing tobacco (3%), and bidis (3%).

## Attendance rates

**Reinforcement component.** Participants attended an average of 79% of 42 CO readings. Those in the CM groups had higher attendance rates ($M = 83.8\%$, $SD = 21.0$) than did those in the NR groups ($M = 73.5\%$, $SD = 27.4$), $F(1, 106) = 4.86$, $p < .05$; a medium effect ($d = 0.42$).

## Table 1. Baseline sample description

| Variable | CM + MET ($n = 28$) | CM + REL ($n = 27$) | NR + MET ($n = 27$) | NR + REL ($n = 28$) | Entire sample ($N = 110$) |
|---|---|---|---|---|---|
| Gender (% female) | 53.6 | 29.6 | 37.0 | 32.1 | 38.2 |
| Age, years; *M* (*SD*) | 19.4 (1.3) | 19.7 (1.6) | 19.6 (1.5) | 20.3 (1.5) | 19.7 (1.5) |
| Race (%) | | | | | |
| White | 75.0 | 77.8 | 74.1 | 82.1 | 77.3 |
| Black | 7.1 | 0.0 | 14.8 | 3.6 | 6.4 |
| Asian/Pacific Islander | 0.0 | 7.4 | 3.7 | 3.6 | 3.6 |
| Hispanic/Latino | 10.7 | 11.1 | 7.4 | 3.6 | 8.2 |
| Other/multiple | 7.1 | 3.7 | 0.0 | 7.1 | 4.5 |
| Expired CO level, parts per million; *M* (*SD*) | 17.8 (6.1) | 19.9 (8.7) | 18.4 (10.5) | 19.1 (9.4) | 18.8 (8.7) |
| Salivary cotinine, ng/ml; *M* (*SD*) | 154.17 (96.97) | 142.05 (88.28) | 176.17 (139.90) | 207.12 (151.42) | 170.01 (122.95) |
| Cigarettes per day; *M* (*SD*), past 30 days | 11.6 (4.9), range = 3.7–19.8 | 11.6 (5.8), range = 2.9–23.3 | 11.8 (8.4), range = 1.5–40.7 | 14.0 (7.8), range = 3.1–31.2 | 12.3 (6.8), range = 1.5–40.7 |
| Modified Fagerström Tolerance Questionnaire score; *M* (*SD*) | 3.7 (1.3) | 3.3 (1.7) | 3.4 (1.4) | 4.2 (1.7) | 3.6 (1.6) |
| Contemplation ladder score; *M* (*SD*) | 5.64 (1.7) | 5.81 (1.8) | 5.26 (1.5) | 5.46 (1.14) | 5.55 (1.54) |
| Used alcohol, past 30 days (%) | 96.4 | 92.6 | 100 | 96.4 | 96.4 |
| Days used alcohol; *M* (*SD*), past 30 days | 11.0 (6.5) | 10.3 (6.2) | 12.9 (6.2) | 11.3 (5.9) | 11.4 (6.2) |
| Used marijuana, past 30 days (%) | 78.6 | 51.9 | 74.1 | 53.6 | 64.5 |
| Days used marijuana; *M* (*SD*), past 30 days | 10.3 (10.7) | 7.6 (10.9) | 9.0 (9.6) | 8.6 (10.5) | 8.9 (10.3) |

*Note.* CM, contingency management; NR, noncontingent reinforcement; MET, motivational enhancement therapy; REL, relaxation control; CO, carbon monoxide. There were no significant group differences on any variable at baseline assessment.

**Psychosocial component.** Most participants (83%) attended all three intervention sessions; 1% attended zero, 8% attended one session, and 8% attended two sessions. Those in MET attended more sessions ($M = 2.9$ sessions, $SD = 0.5$) than those in REL ($M = 2.6$, $SD = 0.8$), $t(108) = 2.09$, $p < .05$. This size of this effect also was medium, $d = 0.40$.

## Money earned

Participants earned an average of $224.25 during the reinforcement component. Those in CM earned more ($M = \$297.50$, $SD = \$121.80$) than did those in NR ($M = \$151.00$, $SD = \$56.70$), $F(1, 106) = 65.02$, $p < .001$. This effect was very large, $d = 1.54$.

## Abstinence reinforcement effects

Group means for consecutive abstinent readings, percentage of abstinent readings, and average CO levels during the abstinence reinforcement phase (Weeks 2–3) are presented in Figure 2. Findings for all three dependent variables followed the same pattern, with large main effects favoring CM over NR. There were no significant interaction effects or main effects of psychosocial condition. Students in CM had a greater number of consecutive abstinent readings ($M = 10.1$ readings, $SD = 8.9$) than did those in NR ($M = 2.1$ readings, $SD = 3.5$), $F(1, 105) = 37.92$, $p < .001$, $d = 1.17$; a higher percentage of abstinent readings ($M = 55.2\%$, $SD = 36.5$) compared with those in NR ($M = 17.9\%$, $SD = 26.4$), $F(1, 105) = 38.29$, $p < .001$, $d = 1.18$; and lower average CO levels ($M = 5.8$ ppm, $SD = 4.6$) than did those in NR ($M = 12.3$ ppm, $SD = 7.5$), $F(1, 96) = 27.99$, $p < .001$, $d = 1.05$.

**Point prevalence abstinence.** Only three participants had verified 7-day point prevalence abstinence at the conclusion of the reinforcement component (one in CM + MET, two in CM + REL). There were no significant differences between groups. Of those in CM, 6.1% (3/49) were abstinent, versus 0% (0/43) in NR, $\chi^2(1, N = 92) = 2.72$, *ns*, $h = 0.50$. Abstinence rates in MET (2.0%) and REL (4.8%) were comparable, $\chi^2(1, N = 92) = 0.55$, *ns*, $h = 0.16$.

## Posttreatment effects

**Treatment adherence.** Therapist ratings indicated good discrimination of content by treatment condition; they reported covering an average of 14.9 ($SD = 0.4$) of the 15 MET components and 0 ($SD = 0.1$) of the 4 REL components during MET. Therapists reported covering all four ($M = 4$, $SD = 0$) of the REL components and less than one ($M = 0.7$, $SD = 0.5$) of the MET components during REL. Student ratings indicated somewhat less discrimination of content across conditions, reporting that therapists covered an average of 14.3 ($SD = 1.3$) of the 15 MET components and 1.6 ($SD = 1.5$) of the 4 REL components during MET sessions; they also reported that therapists covered 3.3 ($SD = 1.1$) of the 4 REL components and 6.3 ($SD = 5.3$) of the 15 MET components during REL sessions.

**Treatment ratings.** Students in MET and REL found their therapists equally easy to talk to ($M = 3.9$ and 3.8, respectively; $SD = 0.3$ and 0.5), $t(89) = 0.78$, *ns*, and concerned about them ($M = 3.6$ and 3.4, respectively; $SD = 0.6$ and 0.7), $t(89) = 1.17$, *ns*. Consistent with the MET strategy of supporting self-efficacy, students in MET found their therapists better at promoting the belief that they could quit smoking ($M = 3.7$, $SD = 0.6$) than those in REL ($M = 3.1$, $SD = 0.8$), $t(89) = 3.73$, $p < .001$. Students in MET rated their therapists as more supportive of their choices about smoking ($M = 3.8$, $SD = 0.4$) than did those in REL ($M = 3.2$, $SD = 0.7$), $t(89) = 4.53$, $p < .001$, consistent with MET's emphasis on client responsibility for decisions about change. Student ratings of treatment satisfaction were high across both conditions but were higher for those in MET ($M = 4.5$, $SD = 0.8$) than for those in REL ($M = 4.2$, $SD = 0.7$), $t(89) = 2.09$, $p < .05$.

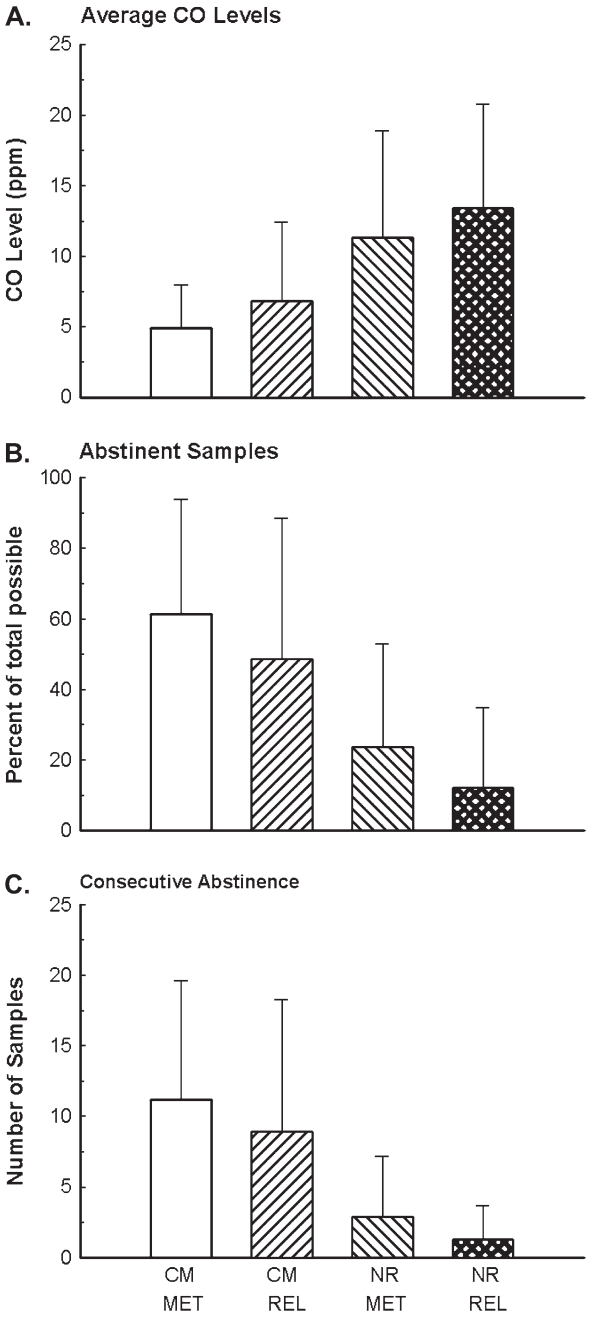


**Figure 2.** Smoking outcomes during the contingent-abstinence phase for each group. CM, contingency management; NR, noncontingent reinforcement; MET, motivational enhancement therapy; REL, relaxation control.

**Interest in quitting.** At posttest, students in MET scored higher on wanting to quit smoking ($M = 3.84$, $SD = 1.08$) than did those

in REL ($M = 3.32$, $SD = 1.19$), $F(1, 87) = 5.41$, $p < .05$, and students in CM scored higher on this item ($M = 3.82$, $SD = 1.09$) than did students in NR ($M = 3.36$, $SD = 1.19$), $F(1, 87) = 4.30$, $p < .05$. Both of these were medium effects ($d = .49$ and .44, respectively). The interaction effect was not significant.

## Follow-up effects

Follow-up retention rates were high (99% at 1 month, 95% at 3 months, 95% at 6 months) and did not differ by treatment group.

**Readiness to quit smoking.** Contemplation ladder scores increased from the baseline ($M = 5.54$, $SD = 1.4$) to the 1-month follow-up ($M = 6.10$, $SD = 1.8$), $F(1, 96) = 9.50$, $p < .01$, $d = .44$, but group differences and group by time interactions were not significant. At the 3-month and 6-month follow-ups, ladder scores were not significantly higher than at baseline.

**Quit attempts.** We found no group differences in self-reported quit attempts. Some 18% reported one or more quit attempts for the period preceding the 1-month follow-up. Corresponding values for the 3-month and 6-month follow-ups were 28% and 26%, respectively.

**Point prevalence abstinence.** Rates of verified abstinence at each follow-up were low: 6.4% (7/109) were confirmed abstinent at 1 month, 4.8% (5/105) at 3 months, and 3.8% (4/104) at 6 months. Groups did not differ at 1 or 3 months. At the 6-month follow-up, those in MET were more likely to have verified abstinence than were those in REL, 4/52 vs. 0/52, $\chi^2(1, N = 104) = 4.16$. Whereas, the Pearson chi-square statistic was significant ($p < .05$), the effect size was medium ($h = .56$), and Fisher's exact test (appropriate based on low expected cell counts) was *ns*.

**Smoking intensity.** GEE analyses indicated that intervention effects on cigarettes per day, percentage of smoking days, CO, and cotinine across all follow-ups were *ns*. For cigarettes per day, a small MET effect approached significance, with those in MET reporting fewer cigarettes per day ($M = 7.3$ cigarettes, $SD = 5.5$) than those in REL ($M = 9.3$ cigarettes, $SD = 6.4$), $B = -1.26$, $SE = 0.67$, $p = .06$, $d = 0.21$. We found no significant effects of time, interactions between CM and MET, or treatment by time interactions.

# Discussion

As hypothesized, contingent incentives for abstinence significantly increased within-trial total and consecutive abstinence in college student smokers, indicating that smoking in this group was sensitive to the contingencies. On average, CM participants achieved 10 consecutive abstinent samples, equivalent to 5 days of smoking abstinence. The average longest period of abstinence in the NR groups was 1 day. However, contrary to our hypotheses, CM had no significant effect on abstinence at the end of treatment or at any follow-up point. Although 26%–28% of participants reported having made quit attempts preceding the 3- and 6-month follow-ups, only 4%–5% of participants were abstinent at these follow-ups, and abstinence was not affected by the contingent incentives. Thus, CM was effective at promoting short periods of abstinence during the trial, but it did not increase cessation.

A small number of studies have reported effects of CM on smoking in college students (Correia & Benson, 2006) and younger adolescents (Corby et al., 2000; Krishnan-Sarin et al., 2006). Two of these studies (Corby et al., 2000; Correia & Benson, 2006) used ABA, within-subjects, laboratory-analog designs, in which participants provided samples at the laboratory, twice daily, for three 5-day periods (Monday to Friday). In transitioning from laboratory analog to treatment trial, we implemented a longer intervention period (3 weeks), used a more stringent abstinence criterion (CO $\leq$ 5 ppm), collected CO samples every day including weekends, aimed to reduce participant burden, and evaluated effects on longer term abstinence.

Achieving 2–3 weeks of smoking abstinence has clinically relevant benefits, including reducing nicotine withdrawal symptoms and craving to non-abstinent levels, increasing confidence in future abstinence and the likelihood of future abstinence, and decreasing the reinforcing effects of smoking once it recurs (Alessi et al., 2004; Heil, Alessi, Lussier, Badger, & Higgins, 2004; Lussier, Higgins, & Badger, 2005; Shiffman et al., 2006). Whereas our 3-week CM period produced 5 days of abstinence but not longer term abstinence, an extended period of CM that achieves 2–3 weeks of abstinence might have greater efficacy for promoting successful quitting. For example, longer term CM promoted smoking cessation among pregnant smokers (Donatelle et al., 2000; Higgins et al., 2004), and longer term CM targeting other substances, such as cocaine and opiates, effectively promotes abstinence from those substances (Silverman et al., 1996, 1998). Indeed, the vast majority of CM interventions for substance use lasts 8 weeks or longer (Lussier, Heil, Mongeon, Badger, & Higgins, 2006).

Including weekends in a college-smoking CM intervention is important because student smoking levels tend to increase on weekends (Dierker et al., 2006). Reducing participant burden related to CM also may enhance feasibility. We collected 79% of scheduled samples during CM by meeting participants at their campuses rather than requiring participants to come to the laboratory. Krishnan-Sarin et al. (2006) similarly facilitated sample collection for participants. Other innovations that reduce participant burden in smoking CM include transitioning from a CO-based abstinence criterion to a cotinine-based criterion, which permits less frequent sampling due to longer biomarker half-life (Higgins et al., 2004; Krishnan-Sarin et al., 2006) and use of Internet-based abstinence reinforcement, which involves participant self-assessment and transmission of test results via web camera (Dallery, Glenn, & Raiff, 2007).

An important aim of this intervention was to increase longer term abstinence, which is necessary for reducing smoking-related morbidity and mortality (U.S. Department of Health and Human Services, 1990). Consistent with this aim, both CM and MET were associated with greater posttreatment interest in quitting smoking than the control conditions. However, quit rates in all groups were low, and our hypothesis that the combination of CM and MET would produce differentially better smoking outcomes was not supported.

Motivational enhancement interventions have demonstrated efficacy for alcohol and other substance use problems, yet a growing literature suggests that similar interventions for smokers may have limited efficacy. Recent reviews (Dunn et al., 2001; Grimshaw & Stanton, 2006) concur that although the research

base is small, it is not suggestive of positive effects on smoking cessation. Our findings included indications that MET may be associated with increased interest in quitting posttreatment, increased abstinence at 6-month follow-up (both medium effects), and decreased cigarettes per day at follow-up (a small effect). However, cessation rates were too low to have confidence in the MET effect on abstinence, and the reduction in cigarettes per day is too small to be clinically meaningful. Thus, our results appear consistent with others in providing only equivocal support for MET for smoking.

Consistent with many CM studies and MET studies, participants in the present study were not necessarily interested in quitting smoking at the time of enrollment. We are aware of only two CM studies for smoking cessation that enrolled participants interested in quitting (Donatelle et al., 2000; Higgins et al., 2004), both of which investigated CM with pregnant smokers. Both studies found that CM effects were sustained through 24-week postpartum follow-up; perhaps, CM has greater efficacy when implemented with smokers who are already motivated to quit at enrollment.

To enhance generalizability, we limited exclusion criteria and recruited from a large number of colleges and universities. Still, most students were White and attended college within one New England state. Findings may not generalize to dissimilar students. Because we used a CO-based abstinence criterion in CM, the study was limited to daily smokers with CO levels of at least 10 ppm. Findings may not be relevant to lighter or less regular smokers. Interpretation of the findings is limited by potential biases, including that CM and MET were better attended than NR and REL, and those in MET were more satisfied with treatment than were those in REL. Nevertheless, overall treatment attendance was good, students received distinct interventions, follow-up rates were high, and abstinence outcomes were verified biochemically.

A limitation of intervention approaches to date, including ours, is that they may not adequately consider the unique characteristics of college smokers. For example, college student smoking is linked to alcohol and other substance use (Dierker et al., 2006; Patterson, Lerman, Kaufmann, Neuner, & Audrain-McGovern, 2004). In our sample, 94% of students were drinkers and 65% were marijuana users; it may be necessary to address the use of these substances and their potential role in relapse when treating college student smokers. Concurrent marijuana and non-cigarette tobacco use also complicates implementation of CM since use of these substances elevates one or more commonly used biomarker levels. Thus, non-abstinent samples cannot be attributed to cigarette smoking. Given the diversity of tobacco products used by college students, intervention approaches that target all forms of tobacco use should be pursued. Other correlates of smoking in college that may benefit from intervention focus include weight concerns, inactivity, and stress (Patterson et al., 2004; Stromberg, Nichter, & Nichter, 2007).

The empirical literature on college student smoking is predominantly cross-sectional and descriptive (Patterson et al., 2004). The relevant intervention literature is remarkably limited, given the public health significance of increased smoking among college students. In this context, the present study provides an important contribution to research on college smokers. We found CM to be efficacious for promoting short-term abstinence among student smokers, but cessation rates were very low. Future research directions should include testing longer term CM interventions, combining CM with other psychosocial or pharmacological intervention, and tailoring interventions to address specific characteristics of college student smokers.

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## Declaration of Interests

*None declared.*

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