JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1986, 19, 197–202 NUMBER 2 (SUMMER 1986)

CONTINGENT PAYMENT PROCEDURES FOR SMOKING REDUCTION AND CESSATION

MAXINE L. STITZER, CYNTHIA S. RAND, GEORGE E. BIGELOW, AND ANDREW M. MEAD

THE JOHNS HOPKINS UNIVERSITY SCHOOL OF MEDICINE AND FRANCIS SCOTT KEY MEDICAL CENTER

We assessed the ability of a combined contingent reinforcement and intensive monitoring procedure to promote and sustain temporary smoking cessation among 34 hired research volunteers, and the ability of a smoking reduction test to predict the subsequent initiation of abstinence. During the 5-day cutdown test, subjects were paid from $0 to $6 per day depending on the extent of reduction from baseline CO levels. During the abstinence test, breath samples were obtained three times daily and subjects were paid $4 for each CO reading ≤11 ppm. Sixty-eight percent of subjects initiated abstinence. Of the breath samples collected during the abstinence test (91% of scheduled samples), 96.5% were ≤11 ppm and 80.5% were ≤8 ppm. Subjects who earned more money during the cutdown test were more likely to abstain ($r = -0.51$, $p < .001$). Contingent reinforcement and intensive monitoring procedures appear to have usefulness for analog studies of smoking reduction and cessation.

DESCRIPTORS: smoking, contingencies, money, worksite monitoring, carbon monoxide breath level

Breath carbon monoxide (CO) measurements have been used in previous studies to provide feedback about smoking (Bauman, Bryan, Dent, & Koch, 1983; Martin & Frederiksen, 1980) and as a target in contingent payment procedures designed to promote daytime smoking reduction (Stitzer & Bigelow, 1983, 1984, 1985). In previous studies, contingent monetary payment based on breath CO level has resulted in smoking behavior change beyond that produced by instructions and CO feedback. The extent of smoking reduction has been related to the value of monetary reinforcement offered (Stitzer & Bigelow, 1983, 1984) and to the CO reduction target that is reinforced (Stitzer & Bigelow, 1985). Here we extend this previous research in two ways. First, we evaluate the feasibility of using contingent payment and CO monitoring to promote temporary smoking cessation among research volunteers not necessarily committed to modifying their smoking. The intensive monitoring procedures described are designed to overcome limitations associated with the use of CO level as an objective measure of smoking that are due to its short (1–4 hr) half-life in the body. Second, we examine the relationship between cutdown and abstinence test performance among smoking research volunteers to determine whether behavior on a precessation cutdown test is useful for predicting the initiation of subsequent cessation attempts.

Supported by USPHS Research Grant DA03893, Research Training Grant DA07209, and Research Scientist Development Award DA00050 from the National Institute on Drug Abuse.

METHOD

Subjects

Two groups of subjects were recruited from different large metropolitan hospitals by advertisement and word of mouth. One group (Baltimore City Hospitals) had 18 subjects; the other (Mercy Hospital) had 16 subjects. All were female hospital employees, primarily clerical (68%) and nursing (26%), who reported regular cigarette smoking and who had a prestudy CO level >17 ppm. Ages ranged from 21–51 years ($M = 32.7$ years) for the combined group. Subjects had been smokers

for an average of 17.2 years and smoked an average of 19.6 cigarettes per day (SD = 6; range, 9–32) during a baseline assessment period. There were no significant differences (t test for independent samples) between the two hospital groups on prestudy characteristics.

Procedures

Prior to the study, subjects were told that they would participate for 4 weeks, that free cigarettes would be provided, that the minimum compensation for participation would be $40 but that with "full participation" total earnings could be as high as $200, and that they might be requested (but would not be required) to change their smoking behavior during the study. In addition, subjects were informed that the study might require visits to their worksites and homes to collect breath samples.

On the first study day, subjects completed a 25-item Smoking Behavior and Attitudes questionnaire, which included a report of their current quit plans (Do you plan to quit smoking at the present time?). Throughout the study, subjects reported on weekdays to a convenient hospital site between 3:00 and 5:00 p.m. Cigarettes were distributed when appropriate, and a breath sample was collected by having subjects inhale, hold their breath for 20 s, exhale partially, then expire the remaining lung air into a 1-liter polyvinyl bag. All breath samples were analyzed at the study site for carbon monoxide level using a MiniCO (Catalyst Research Corp., Baltimore, MD, Model 1000).

Baseline data were collected during the first study week. In the second week, a cutdown test was implemented in which subjects could earn money on a sliding scale for reducing their afternoon CO readings from baseline levels. Payment for each subject was based on percentage reduction from her own average baseline CO value. Payments ranged from $1 for a 30% reduction to $6 for reductions of 80% or more. Subjects were paid immediately after sample analysis at the daily afternoon worksite study contact. The extent of smoking reduction during this cutdown test was entirely voluntary. On the final day of the cutdown test, subjects were informed that during the last 2 study weeks they could earn $12 per day if they quit smoking and their CO readings were consistent with abstinence. Participation in the abstinence test was voluntary. Those who wished to participate were told to begin abstaining on Monday morning of study week 3 and to continue as long as they could. Those who did not wish to participate returned to baseline data collection procedures.

Subjects electing to join the abstinence test provided breath samples to research assistants three times each workday: in the morning at their worksite (9:00–11:00 a.m.), at the regular afternoon study visits (3:00–5:00 p.m.), and in the evening at their homes (8:00–10:00 p.m.). Morning and evening samples were analyzed in the smoking laboratory so that immediate feedback was not available to subjects. On the one weekend during the abstinence test, subjects came to the study site each day to provide a single afternoon sample. Cigarettes were not distributed to abstaining subjects during the test. Payment was made once daily and was based on the previous three CO readings. On weekdays, a $4 payment was available for each CO reading of $\leq$11 ppm. On weekends, subjects received a $10 bonus for attendance plus a $4 payment for each qualifying sample. Although an abstinence criterion of $\leq$11 ppm is less stringent than the 6–8 ppm that has been characteristic of nonsmokers' CO levels in other studies (Petitti, Friedman, & Kahn, 1981; Vogt, Selvin, Widdowson, & Hulley, 1977), the higher level was chosen to include a margin of error that gave subjects the benefit of the doubt on questionable readings. The $12 per day payment was based on data from previous studies in which daily payments of $10–$12 had resulted in maximal changes in daytime smoking by research volunteers (Stitzer & Bigelow, 1983, 1984). A 3-week follow-up was conducted with abstinence test subjects. These subjects were visited weekly at their worksites on an unannounced basis; their smoking status was assessed by self-report and a breath sample collected for CO analysis.

RESULTS

Descriptive Analysis

Subjects were divided into two groups based on their afternoon CO readings on Day 1 of the abstinence test. Subjects whose readings were ≤11 ppm were classified as abstainers and those with higher readings were classified as nonabstainers. Three subjects who dropped out of the study on the first day of abstinence were classified as nonabstainers, although objective data were absent.

Twenty-three of the 34 subjects (68%) attempted abstinence during the 2-week paid abstinence test. Percent abstaining at the two hospital sites was 67% and 69%. Three subjects (9%) dropped out of the study on Day 1 of the abstinence test; the remaining eight subjects (23%) smoked at their normal level and made no attempt to alter their smoking behavior. Figure 1 shows mean afternoon CO readings during successive study phases for the abstainers and nonabstainers. During the 1-week baseline, these subgroups had similar afternoon CO levels of about 30–35 ppm. During the subsequent contingent payment cutdown week, average afternoon CO decreased for both groups, dropping to 15 ppm for abstainers and to 24 ppm for nonabstainers. During the 2-week abstinence test, average afternoon CO readings for abstainers were 5–7 ppm, whereas those for nonabstainers (excluding study dropouts) were about 25 ppm. These differences persisted for the entire 12-day test; only one abstinent subject relapsed (on Day 8) and dropped out of the study on Day 10.

A total of 652 samples was collected from 23 abstainers during the 2-week abstinence test, representing 91.4% of all scheduled samples. Among the collected samples, 96.5% were ≤11 ppm, and 80.5% were ≤8 ppm. Only 3.5% of delivered samples failed to qualify for contingent payment. Four subjects (including the early relapser) accounted for 57% of the readings above 11 ppm; the others were single readings from 10 individual subjects. Thus, 83% of abstaining subjects (n = 19) delivered one or fewer samples that failed to qualify for payment during the abstinence test.

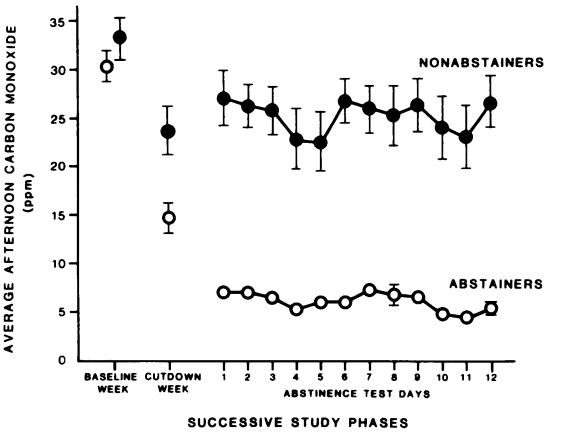

Figure 1. Mean afternoon carbon monoxide readings during successive study phases are shown separately for abstainers (n = 23) and nonabstainers (n = 11 during baseline and cutdown weeks, n = 8 during the abstinence test). Data for baseline and cutdown weeks were obtained during five weekday afternoon worksite contacts; data for the abstinence test were obtained during 10 weekday and two weekend (days 6 and 7) afternoon contacts. Brackets are ±1 *SE*.

Individual subject performance was further examined using a stringent definition of abstinence in which all missing samples as well as samples reading >8 ppm were taken to represent nonabstinence. Individual subjects were classified as abstinent on 35.5% (for the relapsing subject) to 96.8% of sample delivery occasions (M = 73.6% of occasions). Among the 23 abstinence test participants, 70% were classified as abstinent on more and 30% on fewer than 67% of sample delivery occasions; 39% of subjects were classified as abstinent on 80% or more of occasions.

Follow-up

A 3-week follow-up assessment of the 22 abstainers (excluding the subject who relapsed and dropped out during the abstinence test) found a variable pattern of relapse to smoking following withdrawal of the contingent reinforcement intervention. Four subjects (18% of abstainers, 12% of the full group) reported smoking no cigarettes during the follow-up period and had abstinent CO readings (mean CO = 6.4 ppm); eight subjects (36% of abstainers, 24% of the full group) re-

Table 1
Average Dollars Per Day Earned During a Voluntary Smoking Cutdown Test

Plan to quit	Abstinence test participant	
	Yes	No
Yes	2.95 (n = 20)	1.20 (n = 4)
No	4.47 (n = 3)	0.92 (n = 7)

ported smoking between 1 and 104 total cigarettes during the 3-week follow-up but had daytime CO readings in the abstinence range (mean CO = 6.3 ppm); a third group of 10 subjects reported smoking between 81 and 370 total cigarettes during the follow-up and had nonabstinent readings (mean CO = 26.1 ppm). The two outcome measures, mean follow-up CO and total cigarettes smoked, were highly correlated (r = .77, p < .001).

Abstinence Predictors

Performance during the preliminary cutdown test was found to be predictive of later smoking status. The more successful subjects were during the cutdown test (as measured by average daily payment), the more likely they were to abstain during the 2-week abstinence test (r = .51, p < .001). Nonabstainers earned an average of only $0.98 per day during the cutdown test, indicating a 30% reduction in afternoon CO levels. In contrast, abstainers earned an average of $3.03 per day, indicating an average 50% reduction from baseline in afternoon CO levels. It was also noted that 87% of abstainers versus 36% of nonabstainers responded "yes" to the prestudy question "Do you plan to quit smoking at this time?" (r = .52, p < .001) despite the fact that no information had yet been given to the subjects about the subsequent abstinence test. Quit plans and cutdown test performance were independent predictors of abstinence test initiation; together they accounted for 46% of the variance in abstinence test status. The relationship among these three variables is shown in Table 1.

DISCUSSION

Results showed that expired breath carbon monoxide readings can be used simultaneously as an objective measure of smoking abstinence and a target for contingent reinforcement interventions designed to promote and maintain abstinence. Because of carbon monoxide's short half-life, frequent monitoring is required for continual assessment of smoking status. We collected breath samples three times each day. Frequent sample collection was feasible in part because the study was conducted at a worksite where subjects could be readily contacted during the day. However, evening home visits may be important for monitoring and maintaining smoking abstinence; others have reported that craving is highest during the evening hours (Schneider & Jarvik, 1984) and that relapse is most likely to occur at these times (Marlatt & Gordon, 1980).

Although carbon monoxide has important advantages as a measure of smoking behavior for use in procedures that require immediate feedback of results, the frequent sample collection needed to obtain an accurate picture of smoking status is admittedly a cumbersome and labor-intensive undertaking. An optimal sample analysis system for use in abstinence monitoring and contingent reinforcement programs might use the immediate feedback provided by CO and add a sensitive abstinence verification marker such as cotinine or thiocyanate that assesses smoke exposure over a more prolonged period. Cotinine, which has a half-life of about 19 hr (Benowitz, Kuyt, Jacob, Jones, & Osman, 1983), appears to be a more sensitive and specific biological marker of tobacco smoke exposure than is thiocyanate (Bliss & O'Connell, 1984).

Once initiated, smoking abstinence generally persisted throughout the 12-day payment period (Figure 1), although considerable relapse to smoking was observed afterward. The abstinence group as a whole maintained an average CO level of 6.9 ppm (mean of all collected samples) during the paid abstinence test, and 70% of subjects initiating abstinence consistently (i.e., on more than two-

thirds of occasions) delivered samples with readings of ≤8 ppm. These observations demonstrate the ability of payment and monitoring procedures to promote sustained smoking abstinence. However, the occasional observation of readings >8 ppm suggests that some smoking may have occurred during the abstinence test in spite of frequent monitoring and payment. Smoking slips and relapses during early phases of cessation represent a ubiquitous and signifiant clinical phenomenon.

Additional studies will be needed to assess the role of contingent reinforcement and intensive monitoring procedures for promoting and sustaining abstinence, as these treatment components were not separately evaluated in this study. Subjects reported that the frequent contacts were helpful rather than intrusive. They expressed pleasure in their low CO readings and reported that they were able to avoid smoking knowing that in a few hours they would be contacted again. This suggests that the monitoring was important for maintaining abstinence. However, previous studies have shown that CO feedback alone has little consistent effect on smoking behavior (Bauman et al., 1983; Martin & Frederiksen, 1980), and that contingent payment specifically influences the extent of smoking behavior change over and above the effects of instruction and monitoring (Stitzer & Bigelow, 1983, 1984). Thus, it seems unlikely that many of our smokers would have quit for 12 days without the monetary incentive provided. However, it is also likely that the incidence and stability of quitting would depend on the parameters of the intervention including the amount of money offered and the frequency of monitoring.

We noted that self-report information about current quit plans predicted subsequent behavior with regard to participating or not participating in a voluntary abstinence test procedure. However, the extent of smoking reduction observed during a paid cutdown test added significantly to predictive power of the self-report measure, with the two measures together accounting for 46% of the variance in abstinence initiation. The behavioral consistency observed across the smoking reduction and abstinence test procedures suggests that similar variables were operating to determine smoking behavior change. It would be interesting to determine whether the behavioral cutdown test could be used to predict the initiation and/or duration of smoking cessation in samples of smokers who express interest in cessation programs.

In studies seeking to characterize the nature, prevalence, and severity of the tobacco withdrawal syndrome, investigators have paid smokers to give up cigarettes temporarily during inpatient research participation (Benowitz, Kuyt, & Jacob, 1984; Hatsukami, Hughes, Pickens, & Svikis, 1984) or have studied smoking cessation treatment patients in the community during the initial days of abstinence (Hughes et al., 1984; Shiffman & Jarvik, 1976). This study has demonstrated the feasibility of another approach to smoking cessation research that involves paying smokers who are not seeking cessation treatment to precipitate voluntary abstinence. The contingent payment procedures described, which incorporate frequent subject monitoring and data collection opportunities, could provide an analog model of smoking cessation useful for studying the physiological and subjective effects of tobacco smoking abstinence and other factors associated with cessation and relapse.

REFERENCES

Bauman, K. E., Bryan, E. S., Dent, C. W., & Koch, G. G. (1983). The influence of observing carbon monoxide level on cigarette smoking by public prenatal patients. *American Journal of Public Health,* **73,** 1089–1090.

Benowitz, N. L., Kuyt, F., & Jacob, P. (1984). Influence of nicotine on cardiovascular and hormonal effects of cigarette smoking. *Clinical Pharmacology and Therapeutics,* **36,** 74–81.

Benowitz, N. L., Kuyt, F., Jacob, P., Jones, R. T., & Osman, A. L. (1983). Cotinine disposition and effects. *Clinical Pharmacology and Therapeutics,* **34,** 604–611.

Bliss, R. E., & O'Connell, K. A. (1984). Problems with thiocyanate as an index of smoking status: A critical review with suggestions for improving the usefulness of biochemical measures in smoking cessation research. *Health Psychology,* **3,** 563–581.

Hatsukami, D., Hughes, J. R., Pickens, R. W., & Svikis, D. (1984). Tobacco withdrawal symptoms: An experimental analysis. *Psychopharmacology,* **84,** 231–236.

Hughes, J. R., Hatsukami, D. K., Pickens, R. W., Krahn, D., Malin, S., & Luknic, A. (1984). Effect of nicotine

on the tobacco withdrawal syndrome. *Psychopharmacology,* **83,** 82–87.

Marlatt, G. A., & Gordon, J. R. (1980). Determinants of relapse: Implications for the maintenance of behavior change. In P. O. Davidson and S. M. Davidson (Eds.), *Behavioral medicine: Changing health lifestyles* (pp. 410–452). New York: Brunner/Mazel.

Martin, J. E., & Frederiksen, L. W. (1980). Self-tracking of carbon monoxide levels by smokers. *Behavior Therapy,* **11,** 577–587.

Petitti, D. B., Friedman, G. D., & Kahn, W. (1981). Accuracy of information of smoking habits provided on self-administered research questionnaires. *American Journal of Public Health,* **71,** 308–311.

Schneider, N. G., & Jarvik, M. E. (1984). Time course of smoking withdrawal symptoms as a function of nicotine replacement. *Psychopharmacology,* **82,** 143–144.

Shiffman, S. M., & Jarvik, M. E. (1976). Smoking withdrawal symptoms in two weeks of abstinence. *Psychopharmacology,* **50,** 35–39.

Stitzer, M. L., & Bigelow, G. E. (1983). Contingent payment for carbon monoxide reduction: Effects of pay amount. *Behavior Therapy,* **14,** 647–656.

Stitzer, M. L., & Bigelow, G. E. (1984). Contingent reinforcement for carbon monoxide reduction: Within subject effects of pay amount. *Journal of Applied Behavior Analysis,* **17,** 477–483.

Stitzer, M. L., & Bigelow, G. E. (1985). Contingent reinforcement for reduced breath carbon monoxide levels: Target-specific effects on cigarette smoking. *Addictive Behaviors,* **10,** 345–349.

Vogt, T. M., Selvin, S., Widdowson, G., & Hulley, S. B. (1977). Expired air carbon monoxide and serum thiocyanate as objective measures of cigarette exposure. *American Journal of Public Health,* **67,** 545–549.

Received April 10, 1985
Final acceptance January 14, 1986