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Adherence Across Behavioral Domains in Treatment Promoting Smoking Cessation Plus Weight Control

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The authors tested whether adherence to simultaneous health behavior changes was unitary or domain specific among 76 women who modified smoking, eating, and physical activity to accomplish smoking cessation plus weight control. Random-effects regression analyses showed that adherence to both smoking and diet plans declined linearly and covaried positively; their association tended to grow stronger over time. In contrast, physical activity plan adherence did not change over time and was unrelated to other domains. At the end of treatment, 65%, 30.5%, and 25% adhered well or excellently to smoking, diet, and activity treatments, respectively. Findings support both unitary and domain-specific aspects of adherence and suggest that among smokers, smoking and eating behaviors may have similarities unshared by physical activity.

Keywords: adherence, smoking, diet, physical activity, addictions

Smoking heightens the risk of unhealthful dietary practices and physical inactivity (Abood & Conway, 1994; Emmons, Marcus, Linnan, Rossi, & Abrams, 1994; French, Hennrikus, & Jeffery, 1996; Morabia & Wynder, 1990; Perkins et al., 1993). Poor diet and sedentary lifestyle, in turn, increase risk for chronic disease beyond the liability solely attributable to smoking (Centers for Disease Control and Prevention [CDC], 2000). Although smoking cessation strongly reduces disease risk, it is usually accompanied by weight gain (Klesges et al., 1997; Spring et al., 1995). Post-cessation weight gain may be especially problematic for already overweight individuals in view of evidence that links obesity to cancer mortality (Calle, Rodriguez, Walker-Thurmond, & Thun, 2003). Intervening on several risk behaviors simultaneously (e.g., cigarette smoking, high-fat diet, and sedentary behavior pattern) could promote healthier lifestyles efficiently. However, very little is known about the extent to which people can adhere simultaneously to more than one recommended health behavior change.

Because prescribing more complex changes decreases adherence to medical treatment regimens for disease (Burke, Dunbar-Jacob, & Hill, 1997), requiring several simultaneous behavior changes might also be expected to reduce adherence to health promotion regimens. Ironically though, several studies of preventive interventions have reported success in improving health outcomes by targeting multiple risk behaviors (Institute of Medicine, 2001). Adherence has not usually been the focus of multiple health behavior change investigations, although a few reported adherence averaged across multiple behaviors (e.g., Marcus et al., 1999; Stamler, Rains-Clearman, Lenz-Litzow, Tillotson, & Grandits, 1997).

An important unresolved question about health behavior adherence is whether compliance tends to be *unitary* or *domain specific*. A unitary pattern would be supported if adherence data conform to a "good patient/bad patient" model, such that those who comply with healthful prescriptions in one lifestyle domain (e.g., eating) tend also to adhere to recommendations in other domains (e.g., cigarette smoking). Alternatively, adherence might be more domain specific, such that compliance with lifestyle change recommendations in one domain correlates minimally with following treatment recommendations in other domains.

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Evidence suggesting domain specificity of adherence behaviors derives from findings for patients with chronic obstructive pulmonary disease (Kaplan, Eakin, Ries, Toshima, & Atkins, 1998) and with diabetes (Glasgow & Eakin, 1998; Orme & Binik, 1989). Domain specificity has been thought to arise because each aspect of a multicomponent behavior change regimen requires different skills and motivation, which may in combination overwhelm the individual's ability to cope with all behavioral demands (Bock, Marcus, Rossi, & Redding, 1998; Kavanagh, Gooley, & Wilson, 1993; Kravitz et al., 1993). To date, these observations have been drawn chiefly from medically ill populations, whose coping resources may already be heavily taxed by disease.

Whether healthy, at-risk individuals show similar behavior change limitations has yet to be investigated. Some evidence suggesting domain specificity derives from demonstrations that healthful change in one behavior (smoking cessation) can be accompanied by unhealthful change in another behavior (overeating; Klesges, Meyers, Klesges, & LaVasque, 1989) and vice versa (Hall, Tuskell, Vila, & Duffy, 1992). Simultaneously changing eating and smoking behaviors has been thought to be counterproductive on the basis of Hall et al.'s (1992) observation that relapse rates tend (nonsignificantly) to be higher when smokers undergo simultaneous weight management and smoking cessation treatment. However, because adherence data were not reported, it has not been possible to determine whether adherence to weight control and smoking cessation actually interfered with each other.

Other evidence suggests that adherence to multiple lifestyle changes might be unitary and coherent. For example, smokers who quit and maintain abstinence begin to make other positive health behavior changes. Their diet and physical activity profiles grow more similar to those of people who have never smoked than to smokers (French et al., 1996; Morabia & Wynder, 1990; Perkins et al., 1993; Stamler et al., 1997; Thompson & Warburton, 1992). Ex-smokers increase their physical activity and/or fruit and vegetable intake, showing a generalized progression toward a healthy lifestyle (Abood & Conway, 1994; Perkins et al., 1993). Also suggesting coherence across health behavior domains, Marcus et al. (1999) found that addition of a vigorous exercise program improved cessation outcomes and did not undermine sedentary women's attendance at smoking cessation treatment sessions. Findings from another multicomponent smoking cessation study even suggest possible synergisms across several health behaviors. Pirie and colleagues (1992) observed greater adherence among smokers receiving a combination of behavioral cessation treatment, nicotine gum therapy, and behavioral weight management than among those receiving cessation treatment only. Perhaps being able to adhere to one health behavior regimen boosts self-efficacy and motivation to adhere to behavior change prescriptions in other health domains (Emmons et al., 1994; Epstein & Cluss, 1982; Marcus et al., 2000).

No prior studies have, to our knowledge, examined the temporal patterning of adherence to multiple health behaviors among people who are not yet ill. In order to determine whether adherence is domain specific or unitary, in the present study we examined adherence over time to three different behavioral regimens: smoking cessation, dietary control, and exercise. The primary hypothesis was that adherence to behavior change demands in the domains of smoking, eating, and exercise would represent a unitary construct. The alternative hypothesis was that adherence would be domain specific.

Method

Participants

Participants were female smokers who were a subset of a larger study (Spring et al., 2004) that randomized 315 women to three treatment conditions aimed at smoking cessation plus weight control. In all conditions, participants received 16 weeks of a cognitive–behavioral smoking cessation intervention. One group received a weight management module (diet and exercise) that required making simultaneous changes in smoking, eating, and activity during the first 8 weeks of treatment. Another group sequenced the changes, receiving weight management during the final 8 weeks, after the smoking quit date. Controls focused on smoking cessation throughout 16 weeks and received weight counseling at the final session. Data for the present study were derived from the 79 women randomized to simultaneously modify diet, exercise, and smoking during the first 8 weeks of treatment.

Participants, ranging in age from 20 to 75 years, were recruited from the Chicago metropolitan area via flyers, newspaper, and radio announcements of a free quit-smoking program for women who also wanted to minimize weight gain. To qualify for enrollment, candidates were required to have smoked at least 10 cigarettes per day for at least the past year, be willing and able to participate in smoking cessation treatment, follow a prepackaged meal plan and a physical activity program, and be willing to accept assignment into any of three treatment conditions. Exclusion criteria ruled out participants who were pregnant, lactating, currently abusing substances, or currently using nicotine replacement therapy, appetite suppressants, or beta-blockers. Also excluded were those who received alcohol or drug abuse treatment within the past year or had a history of diabetes, hypoglycemia, psychosis, surgery for obesity, or eating disorders. Candidates who were currently dieting or had strong biases against or prior experience with the NutriSystem meal plan were also excluded. Women with current medical conditions, such as cardiovascular or gastrointestinal disease, needed physician authorization to participate.

Measures

Demographic characteristics. Information about demographic characteristics was recorded on a telephone screening form and on questionnaires returned by mail from interested individuals.

Body mass index (BMI). BMI was calculated by dividing the participant's weight in kilograms by the square of her height in meters (Garrow & Webster, 1985).

Nicotine dependence. The Fagerstrom Tolerance Questionnaire (FTQ; Fagerstrom, 1978) is an eight-item questionnaire that assesses nicotine dependence. Scores on the FTQ range from 0 to 11, with scores of 7 or greater indicating physical dependence on nicotine. The FTQ correlates with other proposed measures of nicotine dependence (nicotine and cotinine), supporting the validity of the scale (Fagerstrom & Schneider, 1989).

Physical activity level. To assess baseline exercise level, we asked participants to quantify the number of times in the past 7 days that they had engaged in physical activity that was at least moderate in intensity (e.g., brisk walks) and the average number of minutes exercised per session. Total minutes of physical activity were calculated for each participant. Because preliminary analyses revealed that the distribution of this variable was nonnormal (skewness = 2.17, SE = .28; kurtosis = 4.96, SE = .56) and because logarithm and square root transformations did not improve normality, the data were recoded into categories that corresponded to the physical activity adherence ratings (see below). The recoding procedure improved both skewness (.42) and kurtosis (−1.56) of the baseline exercise variable and allowed a test of whether the intervention increased physical activity.

Smoking status. Participants were classified as abstinent if they reported smoking no cigarettes in the past week and their carbon monoxide (CO) was <8 ppm. They were classified as smokers if they reported smoking >5 cigarettes in the past week and/or their CO concentration was

>15 ppm. Participants were categorized as chippers if they reported smoking <5 cigarettes in the past week and/or their CO concentration was between 9 and 14 ppm.

Smoking cessation program adherence. Counselors assessed weekly adherence to the smoking cessation program on the basis of individual interviews and group therapy observations. Using a preestablished protocol, they assigned a rating that reflected both group attendance and completion of homework that involved monitoring, recording, and/or modifying smoking behavior. Ratings were made on a 6-point scale ranging from 0 (*no telephone call or attendance*) to 5 (*attended group and did homework*). Participants also rated their own adherence by using the same scale. Participants' and counselors' ratings of adherence to the smoking cessation program indicated high agreement at every visit (intraclass correlation coefficients [ICCs] ranged from .83 to .96). Therefore, discrepancies between counselors' and participants' adherence ratings were resolved by calculating an average of the two. The same procedure was also used for dietary and exercise adherence.

Dietary plan adherence. Counselors interviewed participants weekly to assess adherence to the prescribed eating plan. They reviewed how many of the breakfast, lunch, dinner, and snack items ordered for the previous week were eaten and how consumption was distributed across the week. They also asked about departures from prepackaged meals, including foods eaten in restaurants, and estimated the degree to which participants' intake deviated calorically from meal plan guidelines. On the basis of the interview, counselors assigned a rating that reflected the percentage of occasions on which the participant ate the prepackaged foods as recommended, as well as the number of occasions on which she deviated (overeating by >300 kcal). Ratings were made on a 6-point scale ranging from 0 (*not compliant with NutriSystem meal plan*; >6 deviations of ≥300 kcal) to 5 (*80%–100% compliant with NutriSystem meal plan*; no deviations >300 kcal). ICCs ranged from .51 to .77 for counselors' and participants' agreement on ratings of adherence to the dietary plan.

Activity plan adherence. To assess adherence to the activity plan, counselors interviewed participants weekly and assigned a rating that reflected both the number of days on which participants engaged in at least 30 min of moderate-intensity activity and the total number of bouts of continuous brisk activity participants accomplished. Ratings were made on a 6-point scale ranging from 0 (*not compliant with physical activity plan*; 0 days self-report of >30-min accumulated moderate activity and no brisk walk or other acceptable activity lasting for target duration) to 5 (*compliant with physical activity plan*; self-report of >5 days of >30-min accumulated moderate activity, including >2 brisk walks or other acceptable activity lasting for target duration). Counselors and participants showed good agreement on their ratings of adherence to the physical activity plan (ICCs ranged from .77 to .95).

Procedure

Screening. Screening to determine study eligibility began with a telephone interview to assess demographic, smoking, and health characteristics. Eligible candidates were then mailed questionnaires about medical history, tobacco and alcohol use, depression, diet, and weight cycling. Those who returned the questionnaires were invited to attend a screening visit at which they provided informed consent, were measured for height and weight, and were interviewed with the Structured Clinical Interview for the third, revised edition of the *Diagnostic and Statistical Manual of Mental Disorders* (Spitzer, Williams, Gibbon, & First, 1992). A nutrition assistant then trained participants to record 4-day food diaries that were used to measure baseline caloric intake.

Treatment. Participants received 16 weekly sessions of group cognitive–behavioral therapy aimed at smoking cessation and relapse prevention. They continued in subsequent treatment regardless of whether they succeeded in quitting smoking on the scheduled quit date (Visit 5). Counselors used a written treatment manual (available upon request) that for the participants described here integrated weight management training into the first 8 weeks of treatment.

The weight management module incorporated food provision via a prepackaged meal plan (NutriSystem meals and high-carbohydrate, low-fat snacks) and a moderate-intensity physical activity plan. The meal plan was designed to help participants maintain their weight by preserving calorie intake at baseline minus a reduction of 150 kcal/day to compensate for metabolic slowing due to nicotine withdrawal (Perkins, Epstein, Marks, Stiller, & Jacob, 1989). The integrated activity program followed CDC and American College of Sports Medicine (ACSM) guidelines (ACSM, 1990) by encouraging participants to accumulate at least 30 min of moderate-intensity activity on most, preferably all, days of the week. To model and promote an active lifestyle, counselors led participants on a brisk group walk after weekly treatment sessions.

One week before the start of treatment, participants attended an orientation session at which group members were introduced and given an overview of the treatment program. Prior to orientation, a nutrition assistant consulted with each study member to devise an individualized weight-management plan. At orientation, participants sampled NutriSystem foods and a nutrition assistant explained how to follow the meal plan. Participants then placed food orders, so that a 1-week supply of prepackaged foods could be distributed at the first treatment session. Adherence to the diet, exercise, and smoking plans was assessed from Visit 2 through Visit 8. To maximize adherence, counselors called participants who failed to attend a treatment session and conducted make-up sessions in person or by telephone.

Analytic plan. The pattern of change over time in adherence to each behavior domain was examined via random-effects regression modeling (RRM), as were patterns of association across the three behavior domains. RRM was chosen as the analytic approach because it allows for missing data, serial correlation between repeated observations, and time-varying independent and dependent variables (Gibbons et al., 1993; Hedeker, Flay, & Petraitis, 1996). These models are also known as hierarchical linear models (Raudenbush & Bryk, 2002), multilevel models (Goldstein, 1995), and mixed models (Verbeke & Molenberghs, 2000). Even though RRM accommodates missing data, participants who have only a single data point provide no information on within-subjects change over time. Therefore, because our interest focused on within-subjects change, we excluded from the analyses three cases that had data for only one of the seven possible time points, resulting in 76 cases available for analyses.

For each adherence domain, we compared the fit of two primary RRM models of within-subjects change by using likelihood ratio chi-square tests that assess the improvement in fit between two models in which one model is nested within the other (Silvey, 1975). The two models were (a) the random intercepts model, which assumes that each individual has her own intercept that reflects how she deviates from the population trend, and (b) the random intercepts and trends (RIT) model, which allows both an intercept and a slope-specific deviation for each individual (Gibbons et al., 1993). After selecting the random intercepts model or RIT, we checked for serial correlations of the residuals, specifically testing for a first-order stationary or nonstationary autoregressive process [AR(1)], whereby model residuals are more correlated the closer they are in time (Gibbons et al., 1993). Results are presented only for those models determined to best fit the data.

Baseline BMI, nicotine dependence, and exercise were included as time-invariant, individual-level covariates in all initial models, and smoking status was included as a time-varying covariate. Although RRM analysis does not exclude cases that have missing data on a dependent variable (DV) or time-varying covariate, RRM does exclude cases with missing data on time-invariant covariates. FTQ data were missing for 1 participant, and baseline exercise data were missing for 4 participants. To retain these cases in the analyses, we imputed the missing variables by using the means of all cases on the corresponding variable (Tabachnick & Fidell, 1996). All significant covariate effects on the DV are reported; nonsignificant covariates were dropped from subsequent models. No significant quadratic time trends were found; thus, all results represent linear change over time.

Results

Demographic Characteristics

The sample was 65.8% Caucasian and 34.2% African American and averaged 40.7 (SD = 8.7) years of age. Participants smoked a mean of 20.1 (SD = 8.1) cigarettes per day at baseline and were moderately dependent on cigarettes (FTQ M = 5.9, SD = 1.9). Approximately 20% had a high school education, 21% completed some college, 46% graduated college, and 13% provided no data on education. Approximately 33% of participants were single, 39% were married, 25% were divorced, and 3% reported no marital status. BMI ranged from 18.3 to 40.0 (M = 27.4, SD = 5.0). According to CDC (2003) guidelines, 35.5% of participants were of desirable weight (BMI < 25), 36.9% were overweight (25 ≤ BMI < 30), and 27.6% were obese (BMI ≥ 30). At baseline, 39.5% were sedentary, 13.2% met CDC and ACSM guidelines for 5 days of 30 min of accumulated moderate activity, and the remainder had intermediate levels of activity.

Behavioral Adherence Patterns Over Time

Table 1 shows ratings of adherence to the smoking cessation program, the meal plan, and the physical activity plan across the seven measured time points. Whether behavioral adherence changed significantly over time was tested in three sets of RRMs, with time as the independent variable (IV) and each of the adherence measures as time-varying DVs.

Adherence to the smoking cessation program. RIT was the best fitting model, indicating that participants varied significantly with respect to both their initial level of program adherence and their rate of change in adherence over time. Adherence to the smoking cessation program declined significantly across time (estimate = −.18), $t(75) = -5.24$, $p < .0001$. Out of a maximum possible rating of 5, the average participant began with an adherence score of 4.57 (intercept estimate = 4.57), $t(75) = 48.94$, $p < .0001$, and declined by 0.18 points per visit. At Visit 2, the vast majority of the sample (90.8%; n = 69/76) exhibited adherence to smoking treatment that was either good (adherent to 60.0%–79.0% of the requirements) or excellent (adherent to >80.0% of the requirements), and only 1.3% (n = 1/76) were rated nonadherent (did not come to group and did not make telephone contact). The proportion of good and excellent adherers declined after the quit week (Visit 5), and the number of nonadherent participants increased. By Visit 8, 65.3% (n = 49/75) of participants demonstrated good or excellent adherence, and 17.3% (n = 13/75) were nonadherent.

Adherence to the dietary plan. RRMs also revealed a significant decrement in the dietary plan adherence over time (estimate = −.19), $t(75) = -6.03$, $p < .0001$. That the best fitting model was RIT with AR(1) indicates that participants varied in both initial dietary adherence and trends over time and additionally showed serial correlation between temporally proximal dietary adherence ratings. Out of a maximum possible score of 5, the average participant began with a dietary plan adherence score of 3.77 (intercept estimate = 3.77), $t(75) = 29.83$, $p < .0001$, and decreased by 0.19 points per visit. At Visit 2, 56.2% of participants (n = 41/73) demonstrated good or excellent dietary adherence, which decreased to 30.5% (n = 18/59) for those who continued through Week 8.

Adherence to the activity plan. For activity plan adherence, RRMs again showed RIT as the best fitting model. Here, however, the time effect was nonsignificant (estimate = −.08), $t(71) = -1.59$, $p = .12$, indicating that adherence to the activity plan remained fairly constant throughout the program. Baseline level of exercise was a significant covariate (estimate = .35), $t(311) = 4.90$, $p < .0001$, indicating that a higher level of physical activity at study entry was predictive of greater adherence to the activity plan over the course of treatment. The effect of smoking status was also marginally significant (estimate = −.20), $t(311) = -1.86$, $p = .06$, suggesting that throughout treatment, increased levels of smoking were associated with lower adherence to the activity plan. Those who continued to smoke after the quit date tended to be less adherent to the activity plan (mean adherence Weeks 5–8 = 1.70) when compared with chippers (M = 2.21), who were in turn less adherent than abstainers (M = 2.72). The proportion of participants who exhibited good or excellent adherence was 21.4% at Visit 2 (n = 15/70) and 25% at Visit 8 (n = 15/60). Overall, these levels suggest minimal change from baseline, when 23.6% (n = 17/72) of the sample already met or approached CDC and ACSM physical activity guidelines. That is, they already exhibited exercise levels equivalent to those we scored as indicating excellent (i.e., 5 days of 30 min of accumulated moderate activity per week) or good (i.e., 4 days of 30 min of accumulated moderate activity per week) adherence to the study activity plan.

Table 1
Means, Standard Deviations, and Sample Sizes for Rated Adherence to the Smoking Program, the Dietary Plan, and the Physical Activity Plan Across Seven Time Points

	Adherence rating								
	Smoking cessation plan			Dietary plan			Physical activity plan		
Week	M	SD	n	M	SD	n	M	SD	n
2	4.44	0.99	76	3.67	1.32	73	2.28	1.79	70
3	4.30	1.17	76	3.76	1.09	75	2.37	1.74	74
4	4.39	1.10	76	3.37	1.38	75	2.42	1.86	74
5	4.15	1.40	76	3.30	1.31	71	2.26	1.89	73
6	3.78	1.60	76	2.89	1.50	65	2.43	2.05	65
7	3.71	1.69	75	2.83	1.48	62	2.24	1.95	70
8	3.36	1.94	75	2.72	1.57	59	2.22	1.89	60

Associations Between Behavioral Adherence Domains

Three sets of RRMs were generated to test the association between any two domains of adherence and whether the association varied as a function of time.

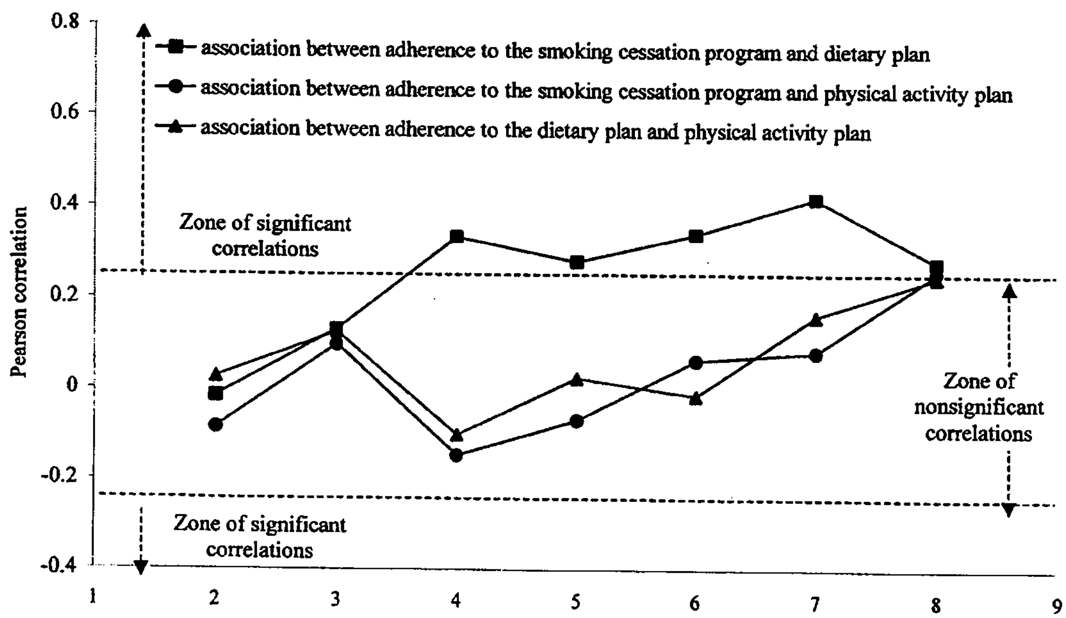
Relationship between smoking cessation program and dietary plan adherence behaviors. We conducted the first set of RRMs with smoking cessation adherence as the (time-varying) DV and with time and time-varying dietary adherence as the IVs. We incorporated the interaction of dietary adherence with the linear effect of time into the model in order to examine the degree to which the association between dietary adherence and smoking cessation adherence varied across time. Results for the RIT model revealed significant main effects of time (estimate = −.12), $t(75) = -2.14$, $p = .03$; and a marginally significant effect of dietary adherence (estimate = .12), $t(326) = 1.94$, $p = .05$. Furthermore, the interaction between dietary adherence and time was marginally significant (estimate = .03), $t(326) = 1.89$, $p = .06$, suggesting that the behavioral domains of smoking adherence and dietary adherence covaried positively and that the strength of their association tended to grow stronger over time, increasing by 0.03 points per visit. Figure 1 depicts the association between the two adherence behavior domains by showing Pearson product–moment correlations between smoking program adherence and dietary plan adherence plotted as a function of time. From being uncorrelated at Visits 2 and 3, the two domains of adherence behaviors grew moderately positively correlated as treatment progressed. Those adherent to the smoking cessation program grew increasingly likely to be adherent to the dietary plan and vice versa.

Relationship between smoking cessation program and activity plan adherence behaviors. The second RRM set tested whether adherence to the smoking cessation and activity plans were related and whether the association changed as a function of time. Smoking cessation adherence was the DV in these analyses, and time-varying activity adherence and time served as IVs. The RIT model included the interaction of exercise adherence with the linear time effect, which was not significant. Consequently, the model was refitted by omitting the interaction term. Results revealed a significant main effect of time (estimate = −.11), $t(75) = -4.17$, $p < .0001$, indicating that the downward trajectory of smoking cessation program adherence remained significant after accounting for the effect of activity plan adherence. As Figure 1 shows, results did not support an association between adherence to the smoking cessation program and adherence to the activity plan (estimate = .005), $t(333) = .17$, $p = .86$.

Relationship between dietary and activity plan adherence behaviors. In the final set of RRMs, dietary plan adherence was the DV and time and time-varying exercise plan adherence were IVs. RIT and AR(1) provided the best fitting model. The interaction of activity plan adherence with the linear time effect was not significant and therefore was excluded from the model. Findings revealed a significant main effect of time (estimate = −.19), $t(75) = -6.07$, $p < .0001$, indicating that the downward trend in dietary adherence remained significant when activity plan adherence was included in the model. A significant effect of activity plan adherence was not observed. Thus, as shown in Figure 1, results did not support the hypothesized association between behavioral adherence to diet and activity.

Discussion

In the present study, we examined an intervention that required participants to make simultaneous changes in three health behavior domains: cigarette smoking, eating, and physical activity. The



results indicated that adherence to both the smoking cessation and the dietary plans declined over time and covaried, with the association growing stronger over time. In contrast, adherence to the physical activity plan did not change significantly over time, and the time course of exercise adherence was unrelated to the time trend for change in either smoking or dietary plan adherence. Thus, when concurrent changes were required across three behavior domains, adherence across the domains of smoking cessation and diet was unitary, whereas adherence to exercise was domain specific.

A large proportion of patients has difficulty following recommended lifestyle changes. Observed adherence rates vary from 10% to 85%, depending on the demands of the regimen and the criteria used to define and measure adherence (Kyngas, Duffy, & Kroll, 2000). During the 7-week period of treatment studied here, the proportion of good or excellent adherers to either the smoking cessation program or the dietary plan decreased by about 25%. After 8 weeks of treatment, 65%, 30.5%, and 25% of participants were rated as good or excellent adherers to the smoking cessation program, dietary plan, and activity plan, respectively. Our findings mirror those of Pirie et al. (1992), who found that adherence decreased over the course of a 6-week treatment promoting smoking cessation and weight control, such that 56% and 23% of participants exhibited acceptable smoking cessation and diet program adherence, respectively. Pirie et al.'s (1992) intervention also included a physical activity prescription similar to ours, but exercise adherence was not reported.

No changes in activity plan adherence were observed in the present study. In fact, activity levels did not even increase significantly from baseline as a consequence of entering the intervention. Rather than measuring behavioral adherence to a physical activity program, therefore, our physical activity measure appears to have captured continuation of an exercise habit. These findings are consistent with those of Hall et al. (1992), who failed to observe significant changes in activity when participants in a smoking cessation plus weight gain prevention program were asked to engage in aerobic exercise three or more times per week.

Whereas our intervention and Hall et al.'s (1992) failed to increase physical activity during smoking cessation, Marcus et al.'s (1999) intervention did increase exercise. Sedentary female smokers randomized by Marcus et al. to a regular, on-site, supervised vigorous physical activity program attended 67.3% of all exercise sessions, while also attending as many weekly smoking cessation sessions as controls. Whether exercise adherence remained constant or declined over time in Marcus et al.'s study was not reported. The reason for these discrepant findings is unclear, but two alternative explanations suggest themselves. First, exercise adoption while following a smoking cessation program may be more likely to occur when other behavioral goals, such as dietary change, are not being attempted simultaneously. Second, a structured, supervised vigorous-intensity program like Marcus et al.'s may be required to increase activity while quitting smoking. The moderate-intensity active lifestyle interventions used in the current study and by Pirie et al. (1992) and Hall et al. (1992) may be insufficiently intensive to significantly alter physical activity, at least when added to smoking cessation and dietary change requirements. It remains unknown whether adding a more intensive exercise intervention to the current diet and smoking plans would increase physical activity and whether it could do so without impeding adherence to the smoking and dietary plans. We found it noteworthy that when given a primary behavior change focus (smoking) and two secondary foci (eating and physical activity), participants, of their own accord, adhered better and more similarly to the smoking and eating regimens than to the physical activity plan.

The present study found greater overlap between smoking and dietary adherence than between exercise adherence and either smoking or dietary adherence. The lack of association between dietary and exercise adherence is especially intriguing because both were secondary treatment emphases, compared with the primacy given to smoking cessation. Moreover, participants seem to have registered the lesser clinical emphasis placed on adhering to the dietary and exercise plans, as reflected by their lower attained adherence levels for diet and activity compared with smoking.

The findings suggest that in the current study eating and smoking adherence may have shared functional or topographic features that were unshared by exercise adherence (Rosen, 2000). Behavioral economic theory posits that some concurrently available reinforcers can interact with each other as substitutes: As consumption of one decreases (because of increased cost or decreased availability), consumption of the other increases (Bickel & Vuchinich, 2000). It has previously been suggested that palatable treat foods are substitutable for cigarettes, perhaps contributing to overeating and weight gain after smoking cessation (Carroll, Carmona, & May, 1991; Spring, Pagoto, McChargue, Hedeker, & Cook, 2003; Spring, Wurtman, Gleason, Wurtman, & Kessler, 1991). To the extent that study participants were able to substitute prescribed low-calorie treat foods for cigarettes, behaving adherently with the meal plan should have supported adherence to the smoking treatment plan, which is consistent with what we observed. Perhaps participants found physical activity less readily substitutable for smoking.

Whereas smoking and dietary adherence requires inhibiting enjoyable but unhealthful old appetitive habits (i.e., smoking and eating high-fat foods), exercise adherence requires initiating new, more active behavior that, although healthful, may not at its outset be inherently enjoyable to an inactive person (Salmon, Owen, Crawford, Bauman, & Sallis, 2003). When faced with the need to make changes across three health behaviors, participants may have found it easier to adhere to the two change requirements that demanded topographically parallel behavior change (i.e., decreasing two unhealthful behaviors, rather than decreasing one unhealthful behavior and increasing one healthful behavior). Perhaps symmetrical behavior change goals were easier than asymmetric goals for participants to represent cognitively (Franz, Zelaznik, Swinnen, & Walter, 2001; Levy & Pashler, 2001). Alternatively, participants may have found it less burdensome and taxing of self-control resources to suppress old habitual behavior (smoking, high-fat eating) than to initiate new effortful behavior (becoming more active; Baumeister, Heatherton, & Tice, 1994).

Some limitations of the present study should be considered. Constraints imposed by the parent study meant that adherence could not be examined beyond the 8th week of the intervention. Consequently, no conclusions can be drawn about longer term adherence to health behavior recommendations. Our largely self-reported, retrospective measures of adherence probably incorporated bias and may have overestimated actual adherence behavior (Rand, 2000). Adherence is most commonly measured via self-report, however (Dunbar-Jacob, Burke, & Puczynski, 1995), because many aspects of adherence behavior cannot be directly observed or biologically verified. Even though we considered counselors' observations in order to corroborate participants' self-reports, correction may have been less accurate for eating and activity adherence than for smoking adherence because the latter was more directly observable as cessation group attendance and homework completion. Still, if concordance between adherence measures reflected predominantly shared method variance, overlap would have been expected to be greatest for measures of dietary and exercise adherence, because these were the ratings most exclusively dependent on self-report. On the contrary, however, measures of eating and activity adherence did not cohere.

The relatively small sample size potentially limits the reliability of the study findings. However, the effects were sufficiently robust to be detected with a modest-sized sample. Because participants were adult female smokers who self-selected to participate in the multicomponent intervention, it is unknown whether the findings would generalize to male smokers or to others less motivated to make multiple behavior changes. Nor is it known whether the results would generalize to an intervention that addressed smoking cessation, eating, and exercise in a different manner, for example via nicotine replacement, energy restriction, or strength training.

Much remains to be learned about the circumstances under which individuals can make multiple, simultaneous behavior changes. In the current study, neither stable person characteristics (e.g., nicotine dependence, BMI) nor attributes that change over time (e.g., smoking status) were able to account for variation in behavioral adherence. Nevertheless, there remains a need to examine individual (e.g., self-efficacy, readiness, mood), interpersonal (e.g., social support), and environmental (e.g., location of exercise) process variables that may influence adherence (Abrams et al., 1998; Bock et al., 1998; Brawley & Culos-Reed, 2000; Perkins et al., 2001).

The current study demonstrated that the adherence trajectories of individuals trying simultaneously to change smoking, eating, and activity behaviors showed both overlap and domain specificity. Despite the temptation to categorize patients as good or bad adherers, the current findings and others (e.g., Pirie et al., 1992) indicate that adherence across different behavior domains is more variable than a dichotomous classification would suggest (Vitolins, Rand, Rapp, Ribisl, & Sevick, 2000). Better understanding of functional relationships among different health behaviors is needed to design interventions that synergize adherence and support healthful change across multiple behaviors.

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