Physical Activity and Quit Motivation Moderators of Adolescent Smoking Reduction

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***Objectives*: We examined participant characteristics as moderators of adolescents' smoking cessation outcomes as a function of intervention: Not-on-Tobacco (N-O-T), N-O-T with a physical activity (PA) module (N-O-T+FIT), or Brief Intervention (BI). *Methods*: We randomly assigned youth (N = 232) recruited from public high schools to an intervention, and measured their baseline levels of PA and motivation to quit. The number of cigarettes/day for weekdays and weekends was obtained at baseline and 3-month follow-up. *Results*: Across timepoints, cigarette use declined for youth in N-O-T (p = .007) and N-O-T+FIT (ps < .02), but not BI (n.s.). For N-O-T+FIT youth, the steepest declines in weekday smoking occurred for those with high PA levels (p = .02). Weekend cigarette use decreased for N-O-T+FIT youth with moderate-high levels of intrinsic motivation to quit (ps < .04). *Conclusions*: Adolescents may benefit from interventions designed to address the barriers faced during a quit attempt, including their motivation to make a change and their engagement in other healthy behaviors such as physical activity.**

***Key words*: smoking; cessation; adolescents; physical activity; exercise; motivation**

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Approximately 16% of high school-aged youth in the United States (US) report current cigarette smoking.[1] Smoking during adolescence is a robust predictor of smoking in adulthood,[2,3] and this knowledge has prompted the development of numerous prevention and cessation interventions for youth.[4,5] For instance, *NOT on Tobacco* (N-O-T) is an evidence-based cessation program in the US that targets adolescents ages 14-19 years who smoke.[6,7] Facilitated by trained counselors in a group setting, the N-O-T program encourages self-evaluation of tobacco use through enhancement of healthy life skills (eg, stress management, constructive relationships, quality nutrition, etc.). The success of N-O-T is demonstrated through 3-month quit rates of up to 19% across adolescent samples.[8]

More recently, N-O-T investigators incorporated a structured physical activity (PA) module into the general N-O-T program (N-O-T+FIT). The FIT component includes the use of pedometers, activity logs, and fitness tips to promote increases in any type of PA.[9,10] This hybrid program has resulted in significantly higher quit rates among participants, compared to rates for those in the N-O-T only or brief intervention (BI) programs.[10] Additionally, participants who are able to increase the frequency of days in which they engage in PA for at least 30 minutes show the highest quit rates.[9] However, in this previous work, intervention efficacy is typically evaluated using point prevalence quit rates, or the proportion of individuals deemed "quitters" at a given point in time. Of course, some participants may have been unable to achieve complete cessation, yet reduced significantly the number of cigarettes smoked on daily basis. It also has been argued that conservative definitions for quitting (eg, assuming those lost to follow-up are smokers) are not appropriate for youth.[11] Thus, a more precise measurement of treatment effects may include assessing the number of cigarettes smoked daily rather than a dichotomous indicator differentiat-

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ing cigarette smoking and smoking cessation (ie, point-prevalence quit rates). Importantly, the behavioral indicator of smoking reduction has shown to predict future cessation outcomes.[12,13]

Also notable is that previous research rarely addresses individual characteristics that may influence the effectiveness of smoking cessation interventions targeting youth smokers. [5] One characteristic that may moderate the relationship between cessation intervention and outcomes is PA, as links between PA and cigarette smoking among youth are well-established.[14-16] Youth who engage in greater levels of PA are more likely to be nonsmokers,[17] and among those who are current smokers, PA is inversely related to smoking behavior.[18] Research on text message-based interventions indicates that baseline levels of PA positively predict reductions in smoking behavior over and above positive effects of the intervention.[19] Thus, in the current study, adolescents with greater PA prior to enrollment may be more receptive to the FIT components of the N-O-T+FIT condition.

Youth's response to cessation treatment also may be explained by their motivations to quit smoking, including those that are intrinsically (ie, motivations that derive from internal factors such as for personal enjoyment or interest) or extrinsically (ie, motivations that derive from external factors such as reward gain or punishment avoidance) focused. Among adult smokers, success with quitting cigarettes is higher among those who more strongly (vs less strongly) endorse intrinsic types of motivations, such as health-related reasons.[20] Quitting success rates are also higher among those with motivations that are intrinsically, versus extrinsically (eg, social pressure), focused.[21,22] Among youth smokers, however, little work has investigated such motivations to quit even though cessation interventions that specifically target their motivations tend to be more successful than others.[23] A previous evaluation of the N-O-T and N-O-T Plus (ie, access to supplemental online resources and a cessation counselor via telephone) conditions revealed that individual motivation items predicted cessation.[24] In this study, regardless of condition, participants most likely to quit were those who reported not enjoying smoking. Although prior studies have not found that motivations moderate the effectiveness of different treatments, we expected that individuals with more intrinsic motivating factors (eg, those striving to be healthier or physically fit) might be especially responsive to the N-O-T+FIT condition given its emphasis on exercise and health.

Importantly, prior studies reporting on the efficacy of cessation programs for adolescents, including N-O-T, have focused on point-prevalence quit rates. Though cessation is the ultimate goal of such programs, reductions in smoking behavior can reflect a meaningful change, one that may be necessary for future smoking cessation. Consequently, the goal of this secondary data analysis was to examine the impact of PA engagement and motivations to quit smoking on youth smoking cessation interventions for reducing smoking behaviors (ie, the number of cigarettes smoked per day). These baseline characteristics were thought to be logical moderators to evaluate based on prior literature. Specifically, we expected that adolescents who are more physically active at baseline[19] or who have more intrinsic motives for quitting[20-22] would be more successful in the N-O-T+FIT condition compared to those lower on these dimensions or to those in other conditions. High school students, aged 14-19, who reported current cigarette smoking were enrolled into one of 3 conditions: N-O-T, N-O-T+FIT, or brief intervention (ie, BI). Participants' smoking rates were measured separately for weekday and weekend periods given the high variability in adolescent cigarette use between these time periods.[25,26] Smoking rates were evaluated at baseline and at a 3-month follow-up visit, and as function of youth's baseline levels of PA and motivations to quit.

METHODS

Participants

During 2006-2009, 99 of 123 available public high schools in West Virginia met the criteria for inclusion. A total of 40 schools initially agreed to participate, though 21 dropped out prior to the start of the study. Dropout rates across study conditions were comparable (see[9,10] for additional recruitment details). The final total of 19 participating high schools was assigned randomly to one of 3 study conditions: N-O-T (N = 6 schools), N-O-T+FIT (N = 7 schools), or BI (N = 6 schools). Importantly, the randomization process resulted in well-matched groups (for review, see[9]). Within these schools, students aged 14 –19 years reporting current use of cigarettes were eligible. Although recruitment efforts emphasized daily smokers, given the variability in how teens perceive smoking status, we maintained a flexible inclusion criterion of "at least 1 day of smoking in the previous 30 days" (as in[27]). All participants provided assent and obtained parental consent.

Procedures

Full procedural details for each condition are described in our previous publications of these same data.[9,10] Briefly, an American Lung Association (ALA) master trainer instructed intervention facilitators (ie, teachers, counselors, or other staff employed within the schools). Training for facilitators (total of N = 25) covered teen smoking and nicotine dependence, participant recruitment, basic research design/procedures, and research ethics. Facilitators initiated recruitment in their respective schools and provided interested students with the institutional-approved parental consent and youth assent forms for signatures. Participants in all 3 conditions received 10-15 minutes of advice about smoking consequences and withdrawal ef-

fects, as well as a brochure with tips for quitting. Those in the N-O-T and N-O-T+FIT conditions also received 10 weekly sessions with the ALA-trained facilitator to cover topics such as stress management, dealing with family/peer pressure, and promotion of a healthy lifestyle. Whereas this last topic included increasing PA for both conditions, the PA components comprising N-O-T+FIT were theory- and research-based, and also tailored based on participants' sex.[9] For example, youth in the N-O-T+FIT condition were given goals, tips, and information for self-monitoring, as well as a pedometer for daily use and a challenge log to record their PA engagement. At each weekly session, these youth also received additional instruction and reinforcement from facilitators. Across all 3 study conditions researchers collected participants' baseline data before the onset of intervention (+/- 2 weeks), and again at a follow-up evaluation 3 months after the baseline assessment (+/- 3 weeks).

Attrition

Out of a total of 232 youth who participated at baseline, ~50% were lost to attrition by the follow-up assessment (ie, 3-months post-baseline). Similar rates of attrition have been reported previously (see[5] for review). These baseline and follow-up samples (N = 232 vs 114) were compared on characteristics using independent samples t-tests (baseline weekday and weekend smoking rates; age) and a chi-square analysis (sex). No significant differences were observed between youth participating at both pre- and post-assessment waves and youth lost due to attribution for any characteristic (ps >.05). Two participants' self-reported weekday and weekend smoking behavior were missing, and another youth reported smoking zero cigarettes at baseline. Thus, the final analytic sample was comprised of 114 adolescents: average age of 16.44 (SD = 1.36), 87.0% Caucasian, 57.9% women, and 31.6% of senior class rank. Youth were divided relatively equally across intervention group, with N = 29 (25.9%) for BI, N = 54 (47.4%) for N-O-T, and N = 31 (26.7%) for N-O-T+FIT. These youth had relatively similar smoking rates for weekday and weekend at both baseline (Weekday: M = 10.69, SD = 7.65; Weekend: M = 15.59, SD = 10.76) and 3-months post baseline (Weekday: M = 9.32, SD = 8.06; Weekend: M = 13.43, SD = 10.30). Importantly, attrition rates did not differ significantly among intervention conditions.

Measures

Smoking behavior.

Adolescent smoking behavior between weekday and weekend periods may vary,[25,26] and thus, is not best represented by a single global measure of daily cigarette use. Accordingly, respondents were asked 2 free-response questions: (1) "*How many cigarettes do you smoke A DAY on a typical WEEKDAY (such as Monday or Tuesday)?*" and (2) "*How many cigarettes do you smoke A DAY on a typical WEEKEND day (such as Saturday)?*" These questions were used at both baseline and 3-month follow-up time-points. Note that 11 participants provided an improbable number of cigarettes smoked in a given day: N = 1 baseline weekday, N = 2 baseline weekend, N = 2 follow-up weekday, and N = 6 follow-up weekend. Given that 40 cigarettes appeared to be a pivotal point in the distributions (ie, at baseline weekend, 16 people reported 40 per day, 1 reported 54 and 1 reported 60), and is within +3 SD for baseline weekend rates, we recoded these extreme outliers to 40.

Physical activity (PA). PA was originally assessed within the intervention conditions through 3 questions that addressed "moderate," "vigorous," and "moderate + vigorous" activity.[9] Horn et al[9] found that change in vigorous exercise was differentially related to change in smoking behavior for youth in the N-O-T and N-O-T+FIT programs. Thus, we utilized participants' baseline reports of their engagement in vigorous activity:

> *"On how many of the past 7 days did you exercise or participate in physical activity for at least 20 minutes that made you sweat and breathe hard (such as basketball, soccer, running, swimming laps, fast bicycling, fast dancing, or similar aerobic activities)?"*

Youth were categorized into low (0-2 days, 52.5%) and high (3+ days, 47.5%) levels of exercise.

Motivation factors to quit smoking. Items administered to assess motivation to quit were modeled after those used in previous work with adult[22] and adolescent[24] smokers, given that a well-validated measure for adolescents is not available. Youth were instructed to select their top 3 motivations for quitting smoking, which were categorized as *intrinsic* ("I want to be healthier," "It makes me and my clothes stink," "It looks stupid to smoke," "I want to be more athletic," "I want to be fit," and "I want to beat tobacco addiction") and *extrinsic* ("My parents want me to quit," "My boyfriend/girlfriend wants me to quit," "I don't want to spend money on smoking," and "I was caught smoking at school") factors. Some participants selected either fewer than 3 or more than 3 motivating factors; thus, scores were created representing the proportion of extrinsic and intrinsic motivations for quitting out of the total number of motivations selected. Youth were categorized into groups based on whether they had proportionally low (bottom third), moderate (middle third), or high (highest third) extrinsic and intrinsic motivations, respectively.

Data Analysis

Schools were randomized to different treatment conditions. With such a design, multilevel modeling approaches are ideal, as they allow for the testing of hypotheses at the school level while accounting for potential clustering effects. Because of the small number of schools in each treatment

Table 1
Correlations and Descriptive Statistics for Key Study Variables

	1	2	3	4	5	6	7	8	9
1. Exercise	-	.06	-.01	-.04	-.02	-.12	-.08	-.01	.29***
2. Intrinsic Motivation		-	.68***	-.06	.05	-.02	.06	-.06	.12
3. Extrinsic Motivation			-	-.08	-.11	-.13	-.09	.02	-.09
4. Weekday Smoking_BL				-	.79***	.43***	.36***	.06	.08
5.Weekend Smoking_BL					-	.45***	.51***	.001	.04
6.Weekday Smoking_3mo						-	.82***	.08	.11
7.Weekend Smoking_3mo							-	.12	.03
8. Age								-	.19**
9. Men									-
Mean	2.69	.58	.30	10.00	14.39	9.21	13.24	16.52	-
SD	2.37	.31	.26	8.17	10.82	8.00	10.24	1.33	-

***** p < .001, ** p < .01**

Note.
Proportion scores used for intrinsic (total intrinsic motivations /total motivations) and extrinsic (total extrinsic motivations/total motivations) motivations. BL = baseline assessment; 3mo = 3-month follow-up assessment.

condition (N-O-T = 6, N-O-T+FIT = 7, BI = 6), however, our study was not sufficiently powered to utilize a MLM approach. Similar to previous research that has used this dataset, analyses were run at the level of the individual participant.[9,10] However, steps were taken to test for potential school effects. In previous studies, analyses examined differences between schools on multiple variables including adolescent age, nicotine dependence, and age at first cigarette.[10] These analyses revealed that schools were overwhelmingly equivalent across key potential confounding factors. Additionally, intraclass correlation coefficients (ICC) were analyzed to assess potential clustering in adolescent self-reported smoking (weekends and weekdays, baseline and 6 months). ICC's ranged from .03 to .11, thereby indicating small to moderately small levels of clustering at the school level. Although previous research has determined that even small amounts of clustering can influence outcomes, these small ICC's combined with findings from previous studies that schools did not differ on important variables increases confidence that potential school-level clustering effects within the current study were most likely minimal.

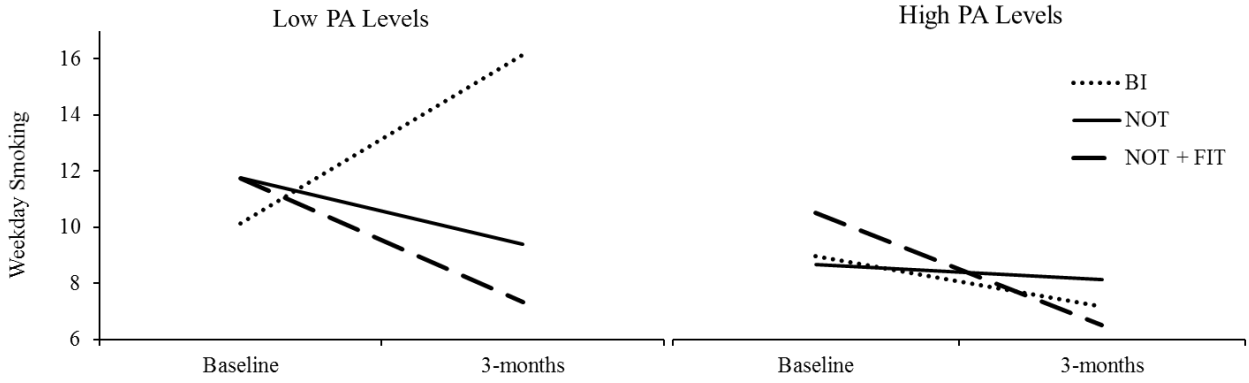
To examine differences among intervention groups on weekday and weekend smoking rates, mixed analysis of variance tests were conducted: 2 (baseline, follow-up) X 3 (N-O-T, N-O-T + FIT, BI). To explore whether patterns of change in youth

Table 2
Mean±SD Weekday and Weekend Smoking Rates (Cigarettes/Day) by Intervention Group

	Weekday		Weekend		t-ratio	
	Baseline	**Follow-up**	**Baseline**	**Follow-up**	**Weekday**	**Weekend**
BI	10.28±8.0 (N = 29)	12.52±10.1 (N = 29)	14.62±8.4 (N = 29)	17.76±12.0 (N = 29)		
NOT	10.42±5.8 (N = 54)	8.96±7.5 (N = 54)	15.02±10.6 (N = 54)	12.42±9.2 (N = 54)	1.36	2.80**
NOT + FIT	11.54±8.8 (N = 31)	6.98±5.7 (N = 31)	17.32±12.8 (N = 31)	10.95±9.3 (N = 31)	3.30**	2.50*

**** p < .01, * p < .05**

Figure 1
Change in Weekday Smoking Behavior Based on Intervention Group and PA Levels



weekday and weekend smoking rates varied as a function of baseline characteristics, mixed analysis of covariance tests were conducted. Moderators included baseline levels of PA and smoking motivation (ie, intrinsic and extrinsic proportion scores). Significant main and interaction effects were disaggregated using pairwise post-hoc tests with Bonferonni adjustments.

RESULTS

Table 1 provides or descriptive statistics and correlations of demographic characteristics and key study variables. Youth-reported weekday and weekend smoking frequencies were significantly correlated at both baseline and 3-month follow-up periods.

Smoking Behavior Change across Time by Intervention Group

A significant Time X Group interaction was present for both weekday (F (2, 111) = 5.24, p = .007, η^2 = .09) and weekend (F (2,113) = 6.80, p = .002, η^2 = .11) smoking behavior (Table 2). For the BI group, smoking behavior did not change significantly for weekday or weekend periods. For participants in the N-O-T intervention group, cigarettes smoked per day decreased significantly across time points for weekend, but not weekday periods. Participants in the N-O-T+FIT intervention group decreased their cigarette use significantly for both weekday and weekend smoking behavior.

Investigating Moderators of the Intervention Group Effect

Physical activity (PA). The Time X PA X Group interaction was statistically significant for weekday smoking (F (2, 104) = 4.68, p = .011, η^2 = .08), but not weekend smoking (F (2,102) = 1.76, p = .178). Figure 1 displays changes in participants' weekday smoking behavior at low and high levels of baseline PA engagement. Youth in the BI group displayed a marginal increase in weekday smoking

Table 3
Mean±SD Weekday Smoking Rates (Cigarettes/Day) by Intervention Group and PA Level

	Low Physical Activity		High Physical Activity		t-ratio	
	Baseline	Follow-up	Baseline	Follow-up	Low	High
BI	10.14±9.8 (N = 14)	16.14±12.4 (N = 14)	9.50±6.1 (N = 10)	7.40±5.0 (N = 10)	2.05+	1.04
NOT	11.77±7.3 (N = 26)	9.41±6.5 (N = 26)	9.16±6.1 (N = 28)	8.53±8.4 (N = 28)	1.95+	.36
NOT + FIT	11.75±9.8 (N = 16)	7.34±7.3 (N = 16)	11.33±8.1 (N = 15)	6.60±3.5 (N = 15)	2.03+	2.71*

*** p < .05**
+ p < .10

Table 4
Mean±SD Weekend Smoking Rates (Cigarettes/Day) by Intervention Group and Intrinsic Motivation Level

	Low Intrinsic		Moderate Intrinsic		High Intrinsic		t-ratio		
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up	Low	Moderate	High
BI	12..00±7.0 (N = 4)	11.75±7.0 (N = 4)	16.67±8.8 (N = 6)	22.67±12.4 (N = 6)	18.33±11.7 (N = 6)	23.50±13.5 (N = 6)	.40	1.60	1.12
NOT	19.35±12.5 (N = 8)	13.87±9.9 (N = 8)	13.83±10.7 (N = 12)	10.6±7.27 (N = 12)	18.23±11.2 (N = 13)	17.50±10.7 (N = 13)	1.73	1.12	.30
NOT + FIT	8.0±2.6 (N = 3)	23.33±15.3 (N = 3)	17.25±5.5 (N = 4)	7.25±2.8 (N = 4)	22.60±13.2 (N = 10)	10.90±3.9 (N = 10)	1.51	3.73*	2.90*

*** p < .05**

if they engaged in low levels of PA at baseline, but displayed no change if they were in the high PA group at baseline. N-O-T participants who engaged in low levels of PA at baseline marginally decreased their weekday smoking behaviors, whereas youth engaged in high levels of PA at baseline showed no change in weekday smoking behavior. Finally, participants in the N-O-T+FIT group who engaged in low levels of PA at baseline marginally decreased their weekday smoking, but those who exercised at high levels at baseline significantly decreased their weekday smoking behavior over the 3 months of the study.

Motivations to quit smoking. Intrinsic motivation did not moderate the effects of intervention group on change in weekday smoking ($F(2,104) = .91$, $p = .549$, $\eta^2 = .026$); however, there was a statistically significant Time X Intrinsic motivation X Group for weekend smoking ($F(2, 102) = 2.62$, $p = .004$, $\eta^2 = .29$). Youth in the BI and N-O-T groups displayed no change in smoking regardless of how intrinsically motivated they were to quit. Participants in the N-O-T+FIT intervention group who reported a moderate or high proportion of intrinsic motivations for quitting smoking at baseline revealed significant decreases in their weekend smoking behavior, whereas youth who reported proportionally fewer intrinsic motivations had no change in their weekend smoking behavior. Extrinsic motivation was neither related to smoking over time nor did it interact with intervention group to predict change in weekday or weekend smoking behavior.

DISCUSSION

Our previous work demonstrated the effectiveness of the N-O-T and N-O-T+FIT interventions for smoking cessation among youth in terms of quit rates.[9,10] Unknown, however, is whether youth attributes prior to enrollment in these programs differentially affects intervention response, specifically in terms of reductions in smoking behavior. The current secondary analysis of data was performed to examine the characteristics of PA and motivations to quit smoking as moderators of intervention effectiveness by assessing the number of cigarettes smoked per day during the week and on the weekend during adolescence. Overall, baseline levels of PA and intrinsic motivations for quitting smoking significantly moderated the impact of N-O-T+FIT on changes in smoking behavior over 3 months.

We previously demonstrated that, whereas N-O-T+FIT increased significantly the likelihood of cessation relative to N-O-T, no differences in PA were observed as a function of intervention type.[9,10] These previous analyses did not account for youth's baseline levels of PA, however. In the current analysis, steeper declines in weekday smoking behavior among N-O-T+FIT youth occurred for those who were more physically active at baseline (as in[19]). This finding may be explained by the ease of N-O-T+FIT for more physically active youth. That is, the N-O-T+FIT components may have been more easily adopted by youth already engaging in PA behaviors. Engagement in PA has been shown to reduce the desire to smoke, as well as the severity of withdrawal symptoms experienced during nicotine/tobacco abstinence.[28,29] For those youth with lower levels of PA prior to enrollment, the N-O-T+FIT program did not affect cigarette use, perhaps because these youth found the FIT requirements of this program to be too involved for their current lifestyle. Alternatively, the challenge of changing both PA and smoking behavior simultaneously may have diffused participants' efforts across these activities.

Significant decreases in weekend smoking behavior were also observed for students in N-O-T+FIT with moderate or high levels of intrinsic motivation to quit smoking. Note that half of the intrinsic motivation items directly pertain to PA: desire to be "healthier," "more athletic," and "fit." Thus, for youth who had moderate to high levels of intrinsic motivation to quit smoking, perhaps the FIT component not only facilitated cessation suc-

cess among those wanting to quit for health- or fitness-related reasons, but also increased the level of investment these youth dedicated toward the FIT component of the intervention. Notable is that these reasons for adolescent smokers' interest in quitting have been reported in many studies; [24,25,30] however, our study is one of the first to incorporate PA behaviors and beliefs about one's physical health/exercise levels in a smoking intervention. Thus, future research should capitalize on this potentially powerful leverage point when examining smoking reduction or cessation rates with additional adolescent samples. Indeed, given that risk behaviors often cluster together, including smoking and sedentary behavior,[31,32] some have argued the need for interventions to target multiple behaviors.[33]

Notable is that the aforementioned effects differed by the time period used – weekday versus weekend – for measurement of cigarette use. Adolescent and young adult smokers have been shown to smoke significantly more cigarettes on weekends than on weekdays, [25,34] a pattern that we also observed. Collapsed across conditions, the average number of cigarettes per day was 14.5 (SD = 10.8) for weekend and 9.9 (SD = 8.2) for weekday at baseline ($t(226) = 10.60$, $p < .001$). Similarly, at the 3-month time point, average daily cigarette use was 13.2 (SD = 10.3) for weekend and 9.2 (SD = 8.0) for weekday smoking ($t(116) = 7.31$, $p = .037$). Increased cigarette use during weekends may be driven by factors such as socialization with peers and consumption of alcohol and other drugs.[34,35] At least one report suggests that the "weekend effect" is more prominent for women, perhaps because they are more likely than men to smoke socially.[34] We did not examine sex as a moderator due to lack of statistical power, though findings indicate that the effects of N-O-T+FIT were impacted by PA for weekday smoking rates and by intrinsic motivation for weekend smoking rates. Together, this work demonstrates the importance of considering heterogeneity in youth's smoking patterns and their underlying reasons when evaluating the impact of interventions.

Study findings need to be interpreted in light of several potential limitations. Our study relied on self-report measures, which are known to be vulnerable to social desirability bias. Thus, youth may have over-reported favorable behaviors (eg, exercise) and/or under-reported unfavorable behaviors (eg, cigarette use).[36] Additionally, we were unable to verify participants' self-reported smoking behavior, despite collection of expired air carbon monoxide (CO) samples at each assessment. The CO level at which smokers should be distinguished from non-smokers has been debated, and includes the commonly recommended cutoff values of 3 ppm[37,38] and 8 ppm.[39] In our sample, the number of youth identified as a smoker at baseline would be 63.8% or 14.3% using the cutoffs of 3 ppm and 8 ppm, respectively. Additionally, this biochemical measure has a half-life of ~2-4 hours, which confirms only recent exposure to smoke.[39] Consequently, youth who were relatively light smokers may have been identified as a non-smoker based on a given cutoff for CO level. In our sample, the majority of youth reported smoking no more than 10 cigarettes per day on weekdays (29% for 1-5 cigarettes and 40% for 6-10 cigarettes) and weekends (21% for 1-5 cigarettes and 24% for 6-10 cigarettes). Finally, CO level is not sensitive to minute changes in smoking behavior, and thus, may not capture significant but small changes in the number of cigarettes smoked per day from baseline to the 3-month follow-up.[39]

Another potential limitation is the relatively short period of time between waves of data collection (ie, 3 months); these study results may not remain stable over a longer follow-up time period. Also notable is that our previous work demonstrated statistically significant differences in treatment outcomes for men versus women.[10] In this analysis, men had higher PA levels at baseline in comparison to women. Our sample was underpowered to examine sex as a potential moderator, though the examination of motivations for quitting in relation to sex is warranted. Women have been observed to endorse health- or appearance-related reasons more often, whereas men are more likely to endorse athletic performance-related reasons.[40,41] Study findings also may be limited by the relatively low sample sizes per group (eg, moderation subsample N*s* = 3-54 participants), and thus, replication is needed with a larger sample size. Finally, despite the fact that schools were randomized to treatment conditions, we were unable to use multilevel modeling analyses because of the low number of participating schools. Although we took multiple steps to account for potential school differences and assessed potential clustering of our smoking variables through ICC's, future research should include a larger sample to incorporate these statistical approaches. Other potential limitations have been discussed thoroughly in our previous reports on these data,[9,10] including methods for measuring PA and the homogeneous sample (eg, largely Caucasian youth from rural areas).

In conclusion, these results might suggest that exercise-focused smoking cessation intervention programs adapt their components to address more directly the potential variation in motivational and behavioral barriers youth face when attempting to make positive changes to their smoking behaviors. Alternatively, results might support the idea of a personalized medicine/treatment approach. Specifically, adolescents may benefit from prescreening assessments on key characteristics for placement into interventions best-suited to their individual profile.[42] For instance, youth with low levels of intrinsic motivation to quit smoking or who engage in little to no PA may not be well-positioned to reap the benefits of a cessation program which primarily encourages self-directed PA. Such

youth may instead benefit from programs that focus more purposely on interactions and support for quitting, such as the N-O-T program. At the least, our findings stress the need for smoking programs targeting youth to consider factors such as PA and quit motivations that may interact with features of the intervention (eg, whether the intervention includes self-direct PA engagement components), which may potentially affect how adolescent smokers perceive the intervention. A greater understanding of these processes will lead to more refined and effectual interventions that will serve the greatest number of smoking youth. Ultimately, well-developed personalized interventions could be integrated into clinical practice.

Human Subjects Statement

All work described herein was approved by the West Virginia University Institutional Review Board (Protocol # 1310103187).

Conflict of Interest Statement

All authors of this article declare they have no conflicts of interest.

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