Daily Physical Activity, Smoking, and Mood in High-Risk Young Adults

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THESIS

Submitted as partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Psychology
in the Graduate College of the
University of Illinois at Chicago, 2014

Chicago, Illinois

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This dissertation is dedicated to the memory of my mother, Marla A. Richmond, without whom it would never have been accomplished.

ACKNOWLEDGEMENTS

I would like to thank my advisor, Robin Mermelstein, Ph.D., for her unwavering support, guidance, and trust throughout my graduate training. I would also like to thank my committee, Gloria Balague, Ph.D., Donald Hedeker, Ph.D., Jon Kassel, Ph.D., David Marquez, Ph.D., and Sandy Slater, Ph.D., for all of their assistance in this process.

A number of individuals were extremely helpful to me during the data collection, management, and analysis, and I would like to acknowledge them as well – Kathleen Diviak, Ph.D., James Lynch, John O'Keefe, Alex Sokolovsky, Siu Chi Wong, and the entire Piece by Piece: Making Health Connections Study Team. Additionally, I would like to thank the Chancellor's Graduate Research Fellowship for helping to support me in this project. The project was also supported by grant P01CA098262 (PI: Mermelstein) from the National Cancer Institute. However, the content is solely the responsibility of the author and does not necessarily represent the official views of the National Cancer Institute or the National Institutes of Health.

Finally, I would like to thank my patient, kind, and incredibly supportive husband, Matt Nadell, for allowing me the time and energy needed to complete this project. Additional thanks to my family (Michael and Matthew Richmond) and my friends for supporting me in this endeavor.

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LIST OF ABBREVIATIONS

BMI	Body Mass Index
BS	Between-subjects
CDC	Centers for Disease Control and Prevention
EMA	Ecological Momentary Assessment
M	Mean
NegA	Negative Affect
NWPA	Non-work-related Physical Activity
PA	Physical Activity
PAR	Physical Activity Recall
PosA	Positive Affect
SD	Standard Deviation
SE	Standard Error
WHO	World Health Organization
WPA	Work-related Physical Activity
WS	Within-subjects

SUMMARY

Physical activity (PA) and smoking are inversely related across adolescent, young adult, and adult populations. In part as a result, PA has been increasingly incorporated as an adjunctive tool for smoking cessation in adults and more recently, younger individuals. Yet, despite a growing body of knowledge on the association between smoking and PA, largely in adult populations, much less is known about how these behaviors covary in *young* adults' daily lives or factors that may explicate mechanisms or contexts of influence. Thus, better understanding the links between PA and smoking as well as other cessation targets, such as urges, in younger age groups is essential. Researchers have proposed that PA might indirectly influence smoking via its impact on mood; however, this meditational pathway has received limited empirical support to date. As such, this study sought to examine an alternative framework by which PA, smoking, and mood are interrelated. Specifically, it was hypothesized that PA might moderate the association between mood and smoking, lessening the degree to which mood is associated with smoking outcomes. Participants were 190 ethnically diverse young adults (53.7% female; 91.1% current smokers) who completed an ecological momentary assessment week, during which they were randomly prompted to answer questions about their mood (i.e., positive affect - PosA and negative affect- NegA) and urges to smoke as well as event-recorded smoking episodes. They then completed a 7-day PA recall interview to obtain a detailed assessment of PA over the same week. Five PA measures were obtained: caloric energy expenditure, proportion of non-work-related PA (NWPA), proportion of work-related PA (WPA), level of moderate PA, and level of vigorous PA. Between-subjects (BS) effects were calculated as the overall average of PA and mood reports from the week. Within-subjects (WS) effects were created to represent subjects' daily deviations from their weekly mean. Mixed-effects regression models, controlling for body mass index and gender (when not a moderator), examined two questions: 1. Does PA predict smoking level and urges? 2. Does PA reduce the effect of mood on smoking outcomes? Results revealed that effects of PA on smoking varied by type of PA, whether associations were BS or WS, and gender. Results also showed that higher BS NWPA, BS moderate PA, and BS vigorous PA each reduced the link between low BS PosA and higher urges; however, the effect of vigorous PA was only present for males. Higher WS WPA enhanced the link between both low WS PosA and high WS NegA and higher urges. Finally, for females, higher BS moderate PA enhanced the association between mood and smoking level, such that higher BS NegA predicted lower smoking among more active females. Findings suggest gender and context-specific differences in associations between PA, smoking, and mood. Results are discussed in terms of the methodological, theoretical, and clinical implications for the use of PA as a tool for smoking reduction and cessation in young adults.

PUBLICATION PERMISSIONS

Some of the work included was previously published in Prevention Science, a journal of Springer, and the Journal of Clinical Child and Adolescent Psychology, a journal of Taylor & Francis (both under my maiden name – Melanie J. Richmond). As shown in appendix c, both publishers grant authors permission to reuse published material in dissertations and selected repositories. Please refer to this appendix for more information on both articles located within each permission agreement.

I. Introduction

A. **Background**

Young adults (i.e., ages 18-24) evidence significant declines in physical activity (PA; Gordon-Larsen, Nelson, & Popkin, 2004; Kwan, Cairney, Faulkner, & Pullenayegum, 2012) and increases in cigarette smoking (Hammond, 2005), both risk factors for myriad negative health outcomes (Haskell, Blair, & Hill, 2009; Haskell et al., 2007; U.S. Department of Health and Human Services, 2004). Although each behavior independently has its own negative health sequelae, extant research suggests that these health behaviors are inversely related (see Kaczynski, Manske, Mannell, & Grewal, 2008, for a review) and thus potentially even more problematic. Empirical evidence reveals that lower PA often co-occurs with higher levels of smoking (Kaczynski et al., 2008), whereas higher PA confers decreased risk for escalation in smoking throughout adolescence (Audrain-McGovern, Rodriguez, & Moss, 2003) as well as into young and early adulthood (Kujala, Kaprio, & Rose, 2007). Given the opposing nature of these behaviors, PA has more consistently been incorporated into interventions to reduce smoking and help smokers quit (see Ussher, Taylor, & Faulkner, 2012, for a review). Adolescent populations have also recently been beneficiaries of these adjunctive strategies (e.g., Horn et al., 2013; Horn et al., 2011). Despite a growing body of knowledge on the association between smoking and PA, largely in adult populations, we know little about how they covary in *young* adults' daily lives or factors that may explicate mechanisms or contexts of influence. Due to the clear implications for intervention, better understanding the association between PA and smoking is paramount.

Furthermore, clarifying PA's ties to other cessation targets, such as urges to smoke, may provide invaluable guidance for cessation efforts.

Negative Affect (NegA) reduction and positive affect (PosA) enhancement are two of the more well-established motivational processes thought to drive smoking and are backed by a plethora of data across age groups and a variety of smoking levels (e.g., Baker, Brandon, & Chassin 2004). Given the notable mood benefits of PA (e.g., Poole et al., 2011; Wichers et al., 2012), many researchers have labeled mood as the mechanism by which PA and smoking are related (e.g., Kaczynski et al., 2008). Although there is some evidence to support this claim (Tart et al., 2010), others have proposed that the mood – smoking relationship within the context of PA may be more complex (Roberts, Maddison, Simpson, Bullen, & Prapavessis, 2012). We propose an alternative, yet possibly complementary, hypothesis that PA might reduce smoking by serving as a moderating, or protective, factor acting to attenuate affect's role in smoking.

This project used innovative real-time data collection methods to examine the associations between daily PA, smoking (behavior and urges), and affect in a sample of young adults at high risk for smoking escalation. We considered mood broadly and assessed a variety of positive and negative affective constructs. More specifically, we aimed to explore how daily PA predicted daily smoking level and urges to smoke, and furthermore, how daily PA might lessen the association between mood (PosA and NegA) and smoking variables. Examining PA in young adults at high risk for continued smoking and escalation, particularly how it may interact with other related variables to predict smoking, has significant implications for our theoretical understanding of these related behaviors and improving intervention strategies.

B. <u>Importance of Young Adulthood for Smoking and Physical Activity</u>

Young adulthood is a particularly important time to study both smoking and PA. Data from 2006 revealed that young adults had the highest rates of smoking compared to any other age group at 23.9% (Centers for Disease Control and Prevention [CDC], 2007), and more recent data suggest that this rate remains relatively constant and comparable to older age groups (CDC, 2010). Additionally, research examining trajectories of youth smoking have shown that young adulthood is a period during which many experimental smokers progress in their smoking and may become regular smokers (Chassin, Presson, Pitts, & Sherman, 2000; Hammond, 2005). Despite these alarming statistics, these data also revealed that regular young adult smokers are more likely to make a quit attempt compared to older age groups (CDC, 2008). As such, developing a better understanding of factors that influence young adult smoking and quitting may have significant implications for creating effective intervention programs targeting this high-risk, yet seemingly motivated, age group.

Self-report (Gordon-Larsen et al., 2004) and objective accelerometer (Troiano et al., 2008) assessments show that PA declines across the lifespan. Furthermore, a recent longitudinal study identified that PA during the transition from adolescence to young adulthood exhibits a steeper rate of change compared to other health behaviors at this juncture (Kwan et al., 2012). Specifically, Kwan and colleagues (2012) examined annual changes in PA, smoking, and binge drinking patterns from adolescence (i.e., 12-15) through early adulthood (i.e., 25-27). Results showed that overall smoking prevalence and binge drinking rates steadily increased throughout adolescence but showed either stabilization or slight decreases as youth moved into early adulthood. In contrast, youth

PA showed a sharp decline during the same transitional time period. Although young adults generally exhibit PA declines, individual PA patterns from younger ages do not necessarily track (i.e., maintain relative position in a group) as well as other health behaviors into adulthood (Herman, Craig, Gauvin, & Katzmarzyk, 2009). In their 22-year longitudinal study, Herman and colleagues (2009) showed that young adult PA tracked moderately to later adulthood (i.e., ages 32-41), however childhood and adolescent PA showed little consistency over time. Herman and colleagues (2009) suggested that such inconsistency might provide room for intervention and behavior change. Young adulthood clearly represents a critical time for both PA and smoking, yet little work to date has simultaneously examined these behaviors during this formative period.

C. **Physical Activity and Smoking**

A burgeoning area of research has focused broadly on the association between smoking and PA. A recent review synthesizing extant data on this link asserts that PA and smoking tend to be inversely related (Kaczynski et al., 2008). However, authors also highlighted the literature's notable limitations. For example, Kaczynski et al. (2008) identified that the numerous methods of operationalizing PA and smoking make this data difficult to integrate and compare. Another limitation noted in this review was the need for more innovative research methods that can better evaluate the psychological and environmental contexts of these behaviors (Kaczynski et al., 2008). These weaknesses suggest a need for an in-depth and more methodologically sophisticated approach that can evaluate multiple definitions of PA and smoking and their functioning in daily life.

It is also apparent from extant literature that the majority of published data examining PA and smoking come from larger studies broadly assessing health behavior and often include only a crude measure of PA. For example, Iannotti, Kogan, Janssen, and Boyce (2009) compiled data from the Health Behavior in School-Aged Children survey to examine the effects of PA on multiple types of positive and negative health behavior in samples of U.S. and Canadian 6th through 10th grade youth. In this study, PA was assessed by obtaining the average number of days youth engaged in 60 minutes of PA both over the last week and on a typical basis. Their analyses revealed that higher levels of PA were positively related to all positive health variables (e.g., physical self-image and physical health status). When examining negative health behaviors, however, cigarette smoking was the only behavior inversely related to PA across all samples analyzed (i.e., both U.S. and Canada and males and females). Such studies provide important foundational evidence for the inverse and unique association between PA and smoking and its generalizability across populations.

Cross-sectional studies are important for drawing predictions in the present study, but longitudinal evidence is useful to better understand this study's rationale and longer-term impact. Specifically, research has shown that PA can uniquely predict longer-term patterns of cigarette smoking, and thus has important implications for smoking escalation. For example, one longitudinal study evaluated whether persistence of PA across multiple time points during late adolescence (i.e., ages 16, 17, and 18.5) predicted daily smoking at ages 22-27 (Kujala et al., 2007). Results among the whole sample showed that daily smoking at follow-up was more common among inactive or occasionally active adolescents when compared to persistently active youth; this was true even after controlling for baseline smoking status. These associations were also observed among twins discordant for baseline PA levels and rates of smoking at follow-up. Results from this study highlight the importance of PA in late adolescence for predicting long-term smoking outcomes. Furthermore, based on the twin pair analyses, Kujala and colleagues (2007) suggested that PA is an important part of the causal pathway for developing and maintaining non-smoking behavior that cannot be attributed solely to familial effects.

Another longitudinal study examining smoking and PA used self-report PA data to create and compare distinct trajectories of PA across the high school years (Audrain-McGovern, Rodriguez, Rodgers, Cuevas, & Sass, 2012). Researchers used estimates of PA at multiple time points, beginning early in 9th grade through the end of 12th grade, to identify five distinct PA trajectories (stable low, curvilinear, stable regular, decreased, and stable higher). In contrast with many previous studies, Audrain-McGovern et al. (2012) used a more rigorous tool to assess PA by having participants complete a 6-month PA recall to derive hours of weekly moderate to vigorous PA. Specifically, respondents listed their participation in common activities, the months in which they practiced those activities, and the estimated duration. Results showed that compared to those who maintained high levels of PA (i.e., stable higher), those in the decreased, stable low, and stable regular trajectories were at least twice as likely to smoke across all four years. Not only were the trajectory differences present early on, but the strength of these differences increased across time. A particularly important finding that emerged was that youth in both the decreasing and stable regular PA trajectories consistently met standards for healthy amounts of PA yet still exhibited heightened risk for smoking. This finding led authors to assert that not all types of PA may be protective, and additional research is needed to discern the types of PA that are most associated with tobacco use. This study is especially important to the present investigation in two important ways. First, the findings indicate that the PA and smoking link may only strengthen across adolescence, further emphasizing that young adulthood is a critical time for evaluating this association. Second, it is clear that there is a need to take a more in-depth approach to evaluating PA among youth who have experimented with smoking to better understand and delineate more specific PA contexts that may be associated with lower smoking.

D. **Physical Activity Interventions for Smoking**

Interventions targeting smoking cessation have begun to use PA more consistently, typically as an adjunctive component to treatment (e.g., Prochaska et al., 2008). However, a recent review of the most empirically rigorous randomized controlled trials in adults cast doubt on the efficacy of PA as an aid for *long-term* cessation (Ussher et al., 2012). Accordingly, more research is necessary to evaluate other factors that may differentiate for whom or under what circumstances PA functions to reduce smoking. Furthermore, the way in which these processes work in younger populations has received much less empirical attention.

Recently, Horn and colleagues published the first data using PA as an adjunctive component to smoking cessation with teens (Horn et al., 2013; Horn et al., 2011). In their trial, youth were randomized to either a brief intervention (i.e., one 10-15 minute advice session), the NOT program (i.e., one advice session plus 10 weekly group sessions), or the NOT+ FIT program (i.e., one advice session plus 10 weekly group sessions plus a fitness component). The fitness component consisted of youth receiving a pedometer and challenge log to record weekly steps and other PA. Participants also received five minutes of meeting time with facilitators following the standard NOT protocol, focusing on encouragement and instruction about PA and its benefits to smoking cessation. Particularly important for comparison to the present study is that participating youth were smoking at high rates (about 10 cigarettes per day on weekdays and almost one pack each day on weekends). Results of the trial revealed that youth in the combined NOT+FIT program maintained a higher likelihood of quitting up to their final, 6-month, follow-up compared to the NOT program alone. Gender comparisons suggested that the NOT+FIT program was particularly effective for decreasing risk of continued smoking among males (lowered risk fourfold), but these robust effects were not observed for females. An additional analysis with this sample revealed that among all youth, increasing PA (days on which 20 minutes of exercise was obtained) helped reduce smoking (Horn et al., 2013). Results of this trial highlight the importance of studying PA and smoking in young adults to better understand and improve cessation programming for younger age groups.

E. **Physical Activity and Smoking Urges**

To enhance smoking cessation interventions using PA, it is essential not only to understand the association between PA and the act of smoking but to further evaluate factors related to smoking, such as smoking urges, that may be particularly pronounced in smokers trying to quit. Urges to smoke are largely defined and measured in the literature as experiencing a strong desire to smoke. Urges are often further characterized as having intent to smoke as well as motivation to experience pleasure or reduce negative affect (Tiffany & Drobes, 1991). However, some suggest that simply assessing desire is an appropriate measure for smoking urges (Kozlowski, Pillitteri, Sweeney, Whitfield, & Graham, 1996). Although evidence indicates that experiencing urges to smoke does not always result in actual smoking behavior (Tiffany, 1990), experiencing urges can make quitting challenging. For example, the severity of urges during quit attempts have been shown to be one of the strongest predictors of relapse in adolescent (Van Zundert, Ferguson, Shiffman, & Engels, 2012) and adult samples (Doherty, Kinnunen, Militello, & Garvey, 1995). Even prior to a quit attempt, the strength of urges to smoke on a normal smoking day has been shown to be a marker for future difficulties quitting (Fidler & West, 2011). As such, urges to smoke even outside of a defined quit attempt have been deemed an important measure of addiction (Fidler & West, 2011) and variable of clinical interest.

Due to the developing use of PA in smoking cessation programs, there has been a surge of laboratory-based studies examining the effects of PA (primarily purposeful exercise) on smoking urges and cravings (see Roberts et al., 2012 and Taylor, Ussher, & Faulkner, 2007, for reviews). Based on these reviews, evidence is robust that in adult populations, a short bout of exercise is beneficial both for ameliorating desires to smoke in abstaining smokers and reducing the heaviness of smoking among those not attempting to quit (i.e., increasing time to next cigarette). However, researchers assert that more naturalistic studies are needed to better understand this phenomenon within real-world contexts.

The majority of studies examining the link between PA and smoking (as well as urges) have been conducted in adults, and some research indicates that the benefits of PA on smoking may not be as strong in younger populations (Kaczynski et al., 2008). For example, Everson and colleagues examined the effects of 10 minutes of moderate exercise on urges to smoke in abstaining late-adolescent smokers (Everson, Daley, & Ussher, 2006). They compared this to a “very low intensity” placebo control condition and found no differences between the groups on urges to smoke. Everson et al. (2006) proposed that longer and more intense exercise might be necessary to reduce smoking urges in younger populations. Similar to Audrain-McGovern et al. (2012) who suggested that not all types of PA might be similarly beneficial, Everson and colleagues (2006) emphasized the importance of more clearly examining the parameters of exercise beneficial for reducing urges to smoke in younger populations.

F. **Defining and Measuring Physical Activity by Type**

The way in which PA is operationalized varies widely in the literature. One important distinction to emphasize is the difference between PA and exercise, which are often used interchangeably. PA is defined as any bodily movements that result in energy expenditure (Caspersen, Powell, & Christenson, 1985). Thus, PA can be a variety of activities, including those related to occupational activity (e.g., lifting boxes in a warehouse, waitressing, or running around after children while babysitting), domestic/household activity (e.g., cooking or cleaning), transportation activity (e.g., walking or riding a bike to school or work), in addition to more structured or leisure-time activity (e.g., dancing, running, weight lifting, sports). Exercise is a type of PA but is defined as “planned, structured, repetitive, and purposeful” bodily movement often with the objective to improve physical fitness (Caspersen et al., 1985, pp. 128). Caspersen and colleagues (1985) emphasized the necessity of being careful in descriptions of PA within research and further stressed the importance of evaluating unique correlates of different types of PA.

Despite the documented differences between PA types, World Health Organization (WHO) PA guidelines do not discriminate between the types of PA (e.g., occupational versus leisure-time) in which individuals should engage (WHO, 2010). However, as Caspersen et al. (1985) contended, there might be some important differences in terms of the determinants and benefits of different types of activity, and several studies have corroborated this claim (e.g., Dowda, Ainsworth, Addy, Saunders, & Riner, 2003; Sternfeld, Ainsworth, & Quesenberry Jr, 1999). In fact, one older study revealed that higher levels of occupational PA were associated with higher levels of smoking and several risk factors for coronary heart disease among adult men, whereas leisure-time PA was protective against such negative outcomes (Holme, Helgeland, Hjermann, Leren, & Lund-Larsen, 1981). As described, many studies examining the effects of PA on smoking urges, for example, have used lab-based paradigms of traditionally intentional exercise (e.g., running, biking). Thus, the manner in which different categories of PA function in younger populations as well as real-world contexts is far less understood. Based on this evidence, the way in which PA is operationalized and defined (e.g., work-related versus non-work-related) may have substantial implications for smoking research.

G. **Defining and Measuring Physical Activity by Intensity**

Investigations incorporating more complex definitions of PA provide insight into the nuances of PA and why minor differences in operationalization may be so important. For example, some studies have defined PA by the intensity of the activity, such as moderate or vigorous, and whether PA meets healthy standards. Recent recommendations from the WHO suggest that young adults need to participate in at least 150 minutes of moderate PA each week, 75 minutes of vigorous PA, or an equivalent combination of the two (WHO, 2010). As a part of their Project Eating Among Teens, Larson et al. surveyed youth and found no differences between frequent and non-frequent smokers in the percentage of those who met recommendations for moderate PA (Larson, Story, Neumark-Sztainer, Hannan, & Perry, 2007). In contrast, there was a marginally significant (*p* =.05) association between smoking and PA in meeting standards for vigorous PA (defined as 20 minutes/day on 3 days a week). Another cross-sectional study used a similar categorical approach to examine how varying levels of PA differentiated smoking levels in adolescents and young adults in Cyprus (Charilaou, Karekla, Constantinou, & Price, 2009). Using reports of the frequency, intensity, and duration of typical PA patterns, researchers compared youth who did and did not meet healthy PA recommendations (defined as 30 minutes/day on 5 days a week of moderate PA or 30 minutes/day on 3 days a week of vigorous PA) on smoking (smoke vs. no smoke). Across both adolescent and young adult samples, active youth were significantly less likely to be smokers compared to their inactive peers. Charilaou et al. (2009) further analyzed how more specific PA levels (inactive, moderately active, active, and very active) differentiated similarly specific smoking levels (nonsmokers, occasional, regular-light, and regular-heavy). Their results suggested an inverse linear trend between PA and smoking, such that as PA increases, smoking decreases. As was found in previous international comparisons (Iannotti et al., 2008), researchers suggested that these findings likely generalize to youth from other countries.

Additional research has also found intensity-specific associations between PA and smoking level (non, light, heavy) in U.S. college students from both 2- and 4-year universities (VanKim, Laska, Ehlinger, Lust, & Story, 2010). VanKim and colleagues (2010) hypothesized that comparisons in PA and smoking across 2- and 4-year university students would yield differences due to socio-demographic factors that often differentiate the behavioral risk profiles of these groups. Results revealed that engaging in moderate PA did not differentiate levels of smoking. In contrast, vigorous PA reduced risk of all weekday smoking (i.e., at either a light or heavy level). The effect of vigorous PA was generally comparable on the weekends, with a slightly more robust effect observed in lessening risk of heavy smoking compared to light smoking. Contrary to predictions, this study yielded no significant differences between 2- and 4-year students in the association between PA and smoking (VanKim et al., 2010). The importance of these findings lies in the ability to generalize the PA and smoking link across demographically diverse groups of young adults. Results also highlight the complexities that exist between PA and smoking not explored by the majority of studies examining these two health behaviors.

When evaluating the association between PA and urges to smoke, similar definitional issues are important to address. Specifically, in adult populations, there has been little consistency across studies in terms of establishing an intensity of PA needed to reduce urges to smoke. The entire range of intensities, from very light yoga and isometric exercises to vigorous running and bike riding, have been shown to be beneficial, with moderate PA and vigorous PA tending to have more robust benefits (Roberts et al., 2012). A few studies have attempted to directly compare different intensity levels of PA in terms of their effects on desires to smoke. In a sample of inactive and acutely abstinent young adults, Everson and colleagues directly examined the benefits of moderate and vigorous PA on desire to smoke. Results revealed that the strength of the desire to smoke was reduced for both moderate and vigorous activity, and no differences were found between intensities (Everson, Daley, & Ussher, 2008). In contrast, a more recent study further investigated differences in moderate and vigorous activity using a walking versus running paradigm. Consistent with Everson et al. (2008), Scerbo and colleagues (Scerbo, Faulkner, Taylor, & Thomas, 2010) found no difference in the magnitude of craving during exercise, but the running group had longer-lasting benefits following the conclusion of the PA. There is no clear consensus as to the intensity of exercise that may be most beneficial in reducing urges to smoke and smoking itself, and many researchers suggest that this warrants additional empirical attention (e.g., Roberts et al., 2012; Taylor et al., 2007).

H. **Theoretical Rationale: The Role of Mood in Smoking and Physical Activity**

Many researchers suggest that mood, or depressive symptoms, explains the association between PA and smoking (e.g., Audrain-McGovern et al., 2012; Kaczynski et al., 2008). They propose that PA reduces negative mood, which in turn, reduces smoking or urges to smoke. Although this mediational pathway has been validated in some contexts (Tart et al., 2010), there might be other unexplored ways in which PA, smoking, and mood are interrelated. We propose an alternative model and assert that PA functions to reduce the association between negative mood states (i.e., low PosA and high NegA) and smoking. For example, it might be suggested that PA reduces smoking by creating an alternative tool by which to achieve affect enhancement, thereby reducing reliance on smoking to ameliorate negative moods.

Both affect-regulating and behavioral economic theories of substance use may converge to serve as a viable explanation for how PA might attenuate the link between affect and smoking. Two of the more seminal theories to explain the reinforcing effects of smoking are the self-medication (Khantzian, 1997) and stress-coping models (Wills &

Filer, 1996). The self-medication model of smoking suggests that the mood-reinforcing properties of cigarettes play a significant role in maintaining smoking behavior. Similarly, stress-coping models assert that individuals smoke as a way of coping with stress. These theories are backed by substantial empirical evidence showing that smoking youth may use cigarettes to improve moods and reduce negative affective states (e.g., Chaiton, Cohen, O'Loughlin, & Rehm, 2009). Furthermore, research reveals that individuals who report using cigarettes primarily to ameliorate NegA are less motivated to stop smoking compared to those who cite other motivations (Stevens, Colwell, Smith, Robinson, & McMillan, 2005), making self-medication an important target for cessation.

Recent laboratory and observational studies have highlighted the mood-altering properties of cigarette smoking in younger populations using real-time assessments of affect. Kassel and colleagues were the first group to employ a laboratory procedure to examine the acute effects of cigarette smoking on PosA and NegA in adolescent smokers (Kassel et al., 2007). Youth, qualified to smoke based on smoking history, were randomized to smoke either a high-yield nicotinized or a denicotinized cigarette and completed a mood assessment both before and after smoking. Nonsmokers were also used for comparison. Analyses comparing how affective changes differentiated these groups revealed that youth smoking high-yield cigarettes experienced a significant drop in NegA after smoking, whereas youth smoking the denicotinized cigarettes experienced only a marginally significant reduction in NegA. All smokers, regardless of nicotine content, experienced reductions in PosA following smoking, which authors suggested to indicate a reduction in high-arousal PosA and the induction of an overall calming effect. Nonsmokers did not exhibit any changes in PosA or NegA. Results of the study support the mood-enhancing effects of cigarette smoking among older adolescent smokers, albeit in a controlled environment, on both PosA and NegA.

Observational studies have also found important links between smoking and affect using ecological momentary assessment (EMA) techniques to evaluate real-time affective responses to smoking. Using a sample of youth participating in the EMA from the earlier waves of the present study, Hedeker, Mermelstein, Berbaum, and Campbell (2009) evaluated how PosA and NegA following smoking compared to these affective states at random times. In contrast with the PosA measure used in Kassel et al. (2007), the PosA scale in this study included both high- and low-arousal affective states (e.g., cheerful and relaxed). Hedeker and colleagues (2009) found that at the within-person level, youth reported experiencing higher PosA and lower NegA following smoking as compared to their own non-smoking, random, times. They also proved that as smoking level increased, the magnitude of the mood change following smoking dissipated, suggesting the development of tolerance. Together, these studies suggest that both in the laboratory and in a real-world context, younger populations experience mood boosts from cigarette smoking.

Behavioral economic theory broadly posits that the choice of one reinforcing behavior (e.g., smoking) depends in large part on access or availability of other alternative reinforcing behaviors (Madden, 2000). Audrain-McGovern et al. (2004) tested this theory in a high-school sample, using school involvement, academic performance, PA, and team sports participation as alternate reinforcing behaviors to cigarette smoking. In their longitudinal analyses, researchers found a negative association between initial smoking level and substitute reinforcement trend; that is, smoking youth reported experiencing declines in substitute reinforcers over time. Additionally, increases in substitute reinforcers over time were linked with a coinciding decline in smoking. Although PA was one of several substitute reinforcers examined, results suggest that its role as an alternative reinforcing behavior may help explain the inverse association between PA and smoking. Audrain-McGovern et al. (2004) also examined the role of delayed discounting, or devaluing an outcome due to the delay in reward. They found that higher levels of delay discounting were associated with higher levels of baseline smoking, suggesting that cigarettes may be a valuable reinforcer for youth who want to experience an immediate reward. An additional analysis of this sample examined the role of delayed discounting in smoking uptake and progression from ages 15 to 21 (Audrain-McGovern, Rodriguez, Epstein, Cuevas, et al., 2009). Audrain-McGovern, Rodriguez, Epstein, Cuevas and colleagues (2009) found that higher delayed discounting not only promoted smoking acquisition but was particularly elevated among adolescents who progressed to regular smoking across the transition into young adulthood. Another study by Audrain-McGovern, Rodriguez, Epstein, Rodgers and colleagues (2009) translated these findings and evaluated behavioral economic concepts in a group of young adult smokers who entered into a 7-day smoking cessation program. Results showed that an increase in substitute reinforcers across treatment was associated with a greater likelihood of quitting smoking. According to these researchers, results suggested an important delineation between substitute *behaviors* and substitute *reinforcers*, and promoted the use of PA as a good substitute reinforcer. This line of research suggests that individuals involved in PA may be less likely to smoke, and furthermore, PA may be particularly helpful in reducing the reliance on smoking to regulate negative moods.

As individuals progress in their smoking, negative moods (both low PosA and high NegA) become cues to elicit smoking urges and cigarette smoking (e.g., Conklin, 2006; Tiffany & Drobes, 1990). Basic learning models would suggest that when a cue (negative mood) acquires a second meaning, such as through an alternative behavior, counterconditioning and ultimately extinction of the original behavior could occur (Bouton, 2000). Cognitive social learning models, more specifically, might suggest that by introducing a coping skill by which individuals can rely on to boost mood, it might be possible to dampen the affect–smoking pathway and reduce the potency of negative mood states as cues for smoking (Niaura, 2000). Based on this theory and evidence, one might suspect that if young adults can experience similar affective improvements, both in terms of speed and magnitude, through alternative reinforcers, they may be less likely to turn to cigarettes or develop an urge to smoke upon experiencing a negative mood state.

I. **Physical Activity and Mood**

Considerable evidence exists to support the notion that PA has a direct effect on mood and broad measures of emotional well-being across adolescent, young adult, and adult populations (e.g., Penedo & Dahn, 2005). For example, one ten-year longitudinal study found that PA and depressed mood consistently and inversely covaried throughout multiple time points from adolescence into young adulthood (Birkeland, Torsheim, & Wold, 2009). Additional research using a three-day PA recall proved that higher levels of PA in early adolescence were associated with lower levels of depressive symptoms concurrently and predicted a decline in symptoms over three years (Raudsepp & Neissaar, 2012). Cross-sectional studies among young adult populations have revealed similar protective effects of PA on reducing risk for depressive symptoms, as well as other related indices, including hopelessness and suicidal behavior (Taliaferro, Rienzo, Pigg, Miller, & Dodd, 2010). The findings highlight the benefits of PA on depressive symptoms across multiple age groups and emphasize that even relatively minimal PA can have significant and, in some cases, long-term mental health benefits.

PA programs have also been utilized as a method of intervention to combat existing depression in adolescent populations. For example, one randomized controlled trial tested the clinical benefits of an eight-week group running program on depressive symptomatology in mild-to-moderately depressed 18 to 20 year-old females (Nabkasorn et al., 2006). The exercise regimen consisted of 50 minute sessions, five days a week for eight weeks. The first group was then followed for eight weeks of typical activity during which a second group began the same eight-week exercise regimen. Results from outcome analyses indicated that for both groups, depressive symptoms were significantly reduced, with particular improvements observed on items related to depressed affect (i.e., "I felt sad"). Because smokers tend to be higher in depressive symptoms (e.g., Ameringer & Leventhal, 2010; Chaiton et al., 2009; Kassel, Stroud, & Paronis, 2003), this sample offers a realistic comparison in terms of more global mood.

Many studies examining the mood benefits of PA use outcomes of clinical depression or symptoms of depression; however, other mood indices have also received empirical attention. For example, real-time assessments of PA and mood have identified the more proximal benefits of PA on PosA and NegA. Although evidence implicating the longer-term benefits of PA on mood is important, daily positive and negative affective states may be especially meaningful for understanding PA's association with daily smoking. For example, one study in adult females examined the associations between

PA, assessed by accelerometer, and daily diary mood reports (Poole et al., 2011). These data were the first to examine and show that objectively measured PA throughout the week was positively related to daily positive mood over the same time period. There were no associations between daily negative mood and PA. Furthermore, Poole et al. found intensity-specific associations, such that only light and moderate activity (as well as total) were associated with these affective outcomes; vigorous activity was not. Other studies evaluating daily PA and mood indicate that PA may influence both PosA and NegA. Specifically, Steptoe and colleagues also used daily diary methodology to compare mood reports on days with exercise to days without exercise in a sample of young adult men and women (Steptoe, Kimbell, & Basford, 1998). Results revealed that all young adults reported lower depressed mood on exercise days compared to days without PA. The improvements in positive mood on exercise days were only observed among females.

The more acute, momentary effects of PA have also received empirical attention. One study evaluating the immediate effects of PA on mood changes in college-aged women showed that just 10 minutes of PA can have a significant and positive impact on overall mood (Hansen, Stevens, & Coast, 2001). Another study proved that not only do PA benefits occur rapidly, but they also last long beyond the PA itself. Wichers et al. (2012) employed electronic diary methods to evaluate the effects of PA on acute changes in both PosA and NegA in adult women. They found that PosA increased significantly in the moments following increases in activity, and PosA scores remained elevated for up to three hours following the activity. As was found with daily negative mood (Poole et al., 2011), no effect was observed on acute NegA. Particularly given the notion that adolescent and young adult smokers seek out more immediate rewards (based in the delay discounting research –Audrain-McGovern, Rodriguez, Epstein, Cuevas, et al., 2009; Audrain-McGovern, Rodriguez, Epstein, Rodgers, et al., 2009; Audrain-McGovern et al., 2004), the speed at which PA can have an impact enhances its utility as a tool for lessening smoking. Results from these studies provide important evidence for the rapid and sustained mood benefits of PA.

Although the majority of research highlights the benefits of PA on emotional functioning, there is evidence to indicate some PA may instead have a negative impact on mood. The majority of laboratory-based studies in adult populations of abstinent smokers have found affect-enhancing effects (e.g., Roberts et al., 2012, Taylor et al., 2007); however, some have shown PA to be uncomfortable and associated with more psychological distress (Everson et al., 2006). Furthermore, some researchers suggest that individual variability in affective response to PA, particularly at more intense levels, is determined in large part by an individual’s preference and tolerance for certain somatosensory cues (Ekkekakis, Hall, & Petruzzello, 2005). Lending support to this assertion, an earlier study compared NegA and PosA responses to exercise in generally active and non-active individuals and found that active individuals experienced affective improvements, whereas inactive individuals showed worsening affect (Petruzzello, Jones, & Tate, 1997). A recent review further emphasized the heterogeneity in affective response to PA (Ekkekakis, Parfitt, & Petruzzello, 2011). For example, Ekkekakis and colleagues (2011) noted that when individuals select to engage in higher intensity PA, they may show improved affective outcomes compared to when those higher intensity levels are imposed. Because smokers tend to be more sedentary (Kaczynski et al., 2008), whether (and how much) PA improves mood in smokers requires further investigation.

In addition to the intensity of the activity, other contextual aspects of PA may be important to consider. For example, research has shown that different types of PA may be tied to different mood effects (McKercher et al., 2009). In a sample of young adults, McKercher et al. (2009) examined both self-report and pedometer data and its associations with a diagnosis of depression. Results showed that in women, more activity (assessed via pedometer) was associated with improved depression outcomes. However, they found important differences when evaluating the self-report data in terms of the types of activity performed. Although those who engaged in more leisure-time activity were protected against depression, those engaged in higher levels of work-related PA had worse depressive outcomes compared to sedentary individuals. This study provides additional evidence for the necessity of differentiating types of PA when examining its relation to both affect and smoking.

J. **Gender**

Gender differences are prominent across the prevalence rates of cigarette smoking (CDC, 2010), PA behavior (Gordon-Larsen et al., 2004; Troiano et al., 2009), and mood (e.g., Almeida & Kessler, 1998). Additionally, as can be clearly observed across many studies, extensive research in the domain of PA and mood uses predominantly female samples (e.g., Hansen et al., 2001; Nabkasorn et al., 2006). Empirical data support the claim that PA at a variety of intensity levels is associated with broad mental health outcomes; however, gender comparisons do suggest that effects may differ depending upon both the type of activity explored and the specific mental health outcome evaluated (Asztalos, De Bourdeaudhuij, & Cardon, 2010). Furthermore, as described, there is initial evidence to suggest that PA programs for smoking cessation in teens may be more effective for males than females (Horn et al., 2011). As a result, examining how these complex associations vary across gender is necessary.

K. **Benefits of Real-time Data Collection**

Electronic diary methods, such as EMA, have gained appeal as sensitive and effective ways of obtaining real-time reports of affective states (Shiffman, Stone, & Hufford, 2008). EMA provides numerous methodological benefits to global reporting, in that it is sensitive enough to detect both individual variation and between-person differences. Its use also circumvents many of the reporting biases existing in global measures (Shiffman et al., 2008). Real-time technology has been utilized independently to study the relationships between mood and smoking (e.g., Hedeker et al., 2009) as well as between PA and mood (e.g., Wichers et al., 2012). Incorporating sophisticated EMA methods with a recent retrospective recall will not only enhance our knowledge of how these behaviors co-exist in daily life but will also limit methodological error that comes with longer-term recall periods and shared method variance.

L. **The Current Study**

The current study combined a 7-day physical activity recall (PAR; Sallis et al., 1985) to assess PA and EMA to assess smoking level, urges to smoke, and mood in a sample of young adults enriched for previous smoking behavior. These methods yielded outcomes of daily and weekly PA, smoking level, urges to smoke, and affect (PosA and NegA). This study had several aims:

Aim 1: To examine how multiple constructs of PA predicted smoking level and urges to smoke. The following types of PA were examined: an estimate of daily caloric energy expenditure; the proportion of non-work-related PA (NWPA) to total PA; the proportion of work-related PA (WPA) to total PA; hours of moderate NWPA; and hours of vigorous NWPA.

Aim 2: To evaluate whether PA might lessen the association between mood and smoking variables.

Aim 3: To examine how gender may moderate these effects.

M. **Hypotheses**

Hypotheses are listed by aim below. For each predictor variable of interest (PA, NegA, PosA), we calculated an individual's weekly average of these variables to assess between-subjects (BS) effects as well as how an individual's daily level deviates from his/her own weekly mean to assess within-subjects (WS) effects. Across hypotheses, results are predicted to be consistent across BS and WS effects but are described generally below.

1. **Physical Activity and Smoking**

Consistent with extant literature (e.g., Kaczynski et al., 2008; Roberts et al., 2012), we predicted a negative association between PA and smoking as well as urges to smoke, such that higher PA would be associated with lower smoking level and lower urges to smoke. However, consistent with research in adults identifying negative health outcomes related to WPA (Holme et al., 1981), we predicted that WPA would show the opposite effect and be the only PA construct associated with increased smoking and urges to smoke. Further, given differences in intensity-specific associations between PA and smoking (e.g., VanKim et al., 2010) as well as urges to smoke (Scerbo et al., 2010), we predicted that the relationship between PA and smoking (both cigarettes smoked and urges) would be stronger when examining vigorous PA compared to moderate PA.

2. **Physical Activity, Mood, and Smoking**

Based in the behavioral economic (e.g., Audrain-McGovern et al., 2004) and affect regulating theories of smoking (e.g., Khantzian, 1997), as well as evidence documenting the mood benefits of PA (e.g., Hansen et al., 2001; Poole et al., 2011; Steptoe et al., 1998; Wichers et al., 2012), we predicted that PA would moderate the association between affect and smoking. Specifically, we predicted that the association between mood (both NegA and PosA) and smoking as well as urges to smoke would be reduced among those higher in PA compared to lower in PA. This should be true across PA constructs examined with the exception of WPA. Specifically, based on evidence from McKercher et al. (2009), showing a positive association between WPA and depression, we predicted that WPA should enhance the association between mood and smoking outcomes.

3. **Gender**

Based on recent evidence indicating that PA may be more effective at enhancing teen smoking cessation in males (Horn et al., 2011), we predicted that the association between PA and smoking would be stronger in males than females. Given that no one has examined the interaction between daily PA and mood on smoking outcomes, our analyses of gender differences in the interactive effects were predominantly exploratory.

II. Methods

A. <u>Overview of Design, Participant Recruitment, and Description</u>

Data for this study come from the 5-year assessment wave of a large longitudinal study investigating the social and emotional context of adolescent smoking patterns. The cornerstone of the longitudinal study was the establishment of a cohort of adolescents comprised primarily of youth who had ever smoked.

Participants were initially recruited from 16 Chicago-area high schools. The sample was derived in a multi-stage process. All 9^{th} and 10^{th} graders at the schools (N = 12,970) completed a brief screening survey of smoking behavior. Invitations were mailed to eligible students and their parents. Students were eligible to participate in the longitudinal study if they fell into one of four levels of smoking experience: 1) never smokers; 2) former experimenters (smoked at least one cigarette in the past, have not smoked in the last 90 days, and have smoked fewer than 100 cigarettes in their lifetime); 3) current experimenters (smoked in the past 90 days, but smoked less than 100 cigarettes in lifetime); and 4) regular smokers (smoked in the past 30 days and have smoked more than 100 cigarettes in their lifetime).

We mailed recruitment packets to 3,654 eligible students and their parents. These recruitment targets included all youth in the "current experimenter" and "regular smoker" categories plus random samples from the "never smoker" and "former experimenter" categories. Youth were enrolled into the longitudinal study after written parental consent and student assent was obtained. It is important to note that all youth and parents had to agree to potentially participate in all components of the main, larger program project study including multiple longitudinal questionnaire assessments, an ecological momentary assessment study, a family observation study, and a psychophysiological laboratory assessment study. Of the 3,654 students invited, 1,344 agreed to participate (36.8%). Of these, 1,263 (94.0%) completed the baseline measurement wave. Our baseline sample of 1,263 youth included 213 never smokers, 304 "former experimenters," 594 "current experimenters," and 152 "regular smokers." Additional study components were added to the program project for the 5th year of data collection, including a study to assess for genetic markers related to smoking. All original participants were invited to participate in the questionnaire and genetic portions of the study and an additional subset were selectively recruited into the ecological momentary assessment and psychophysiological laboratory assessment studies.

B. **Participants**

Participants for the present study consisted of a subset of young adults who completed the 5-year EMA study (*N* = 190; 62.3%). They were 21.32 years old on average (Range = 19.8-23.2), around half were female (53.7% female), 91.9% reported smoking on at least one day in the past month, and the racial/ethnic composition was as follows: 62.1% White, 12.6% Black, 16.3% Hispanic, 4.7% Asian or Pacific Islander, and 4.2% Other or Unknown. In terms of educational status, 38.9% were not enrolled in school, 1.1% were attending high school or working toward a GED, 2.6% were enrolled in a vocational or technical school, 22.2% were enrolled in a 2-year college, 33.3% were enrolled in a 4-year college, 1.6% were enrolled in graduate school, and 0.5% were unknown. Regarding paid employment status, 25.3% were not working, 47.9% worked part-time, 26.3% worked full-time, and 0.5% were unknown.

Participants were selected into this sample from the original cohort based on established criteria to create a group at high risk for continued smoking and escalation. More specifically, a subset of young adults was selected from those who participated in the EMA study between the baseline and 24-month assessments and recorded at least one smoking prompt on the EMA device over all four waves. Additional recruited participants were selected from those in the larger project using proportions equivalent to the smoking level distribution of the original EMA participants (i.e., 35% infrequent smokers, 65% escalating smokers). The final sample for the EMA at the 5-year wave included 305 individuals; however, the PAR was added to the EMA protocol part-way into the 5-year measurement wave and thus only 203 participants completed the interview at this time. Of the 203 participants, two participants were not included in this sample because their electronic diary data was lost due to technical problems, two participants were excluded from the study because they were pregnant at the time of the interview and reported that this interfered with their PA, one person was not included because s/he did not provide a report of her weight, and eight participants were not included in analyses due to problems related to error in the administration of the PAR interview.

There were no significant differences between the current sample and the total EMA sample in terms of several relevant study variables, including number of days smoked in the last month (Included: M = 19.23 (SD = 11.70); Excluded: M = 17.73 (SD =12.67), $t(226) = -1.03$, $p = .305$) or monthly daily smoking rate (Included: M = 5.84 (SD = 5.41); Excluded: M = 6.03 (SD = 6.36), $t(303) = 0.29$, $p = .772$). There were also no significant differences in questionnaire-reported PA measures, including number of days in the past week they participated in 30 minutes of moderate activity (Included: M = 3.77

(*SD* = 2.53); Excluded: *M* = 3.87 (*SD* = 2.69), *t*(302) = 0.31, *p* = .758) or number of days in the past week they participated in 20 minutes of vigorous PA (Included: *M* = 3.56 (*SD* = 2.14); Excluded: *M* = 3.36 (*SD* = 2.22), *t*(302) = -0.79, *p* = .429). Additionally, participants included did not differ from excluded participants by age, *t* (303) = -0.82, *p* =.411, gender, χ^2 (1, *N* =305) = .23, *p* =.629, race/ethnicity, χ^2 (4, *N* = 305) = 5.03, *p* = .284, current educational status, χ^2 (5, *N*= 304) = 2.72, *p* =.744, or current employment status, χ^2 (3, *N*= 304) = 1.42, *p* =.702.

C. Procedures

Three methods of data collection were used for the present study: 1) Self-report questionnaire to assess demographic variables, BMI, as well as smoking and PA variables for descriptive analyses; 2) EMA to evaluate smoking, smoking urges, and mood; and 3) PAR to evaluate PA. Procedures during all phases of the study received approval from the Institutional Review Board at the University of Illinois at Chicago.

1. Self-report Questionnaires

Questionnaires were mailed to participants before their EMA training visit and completed packets were either brought to training visits or completed in-person at the time of the training.

2. Ecological Momentary Assessment

All participants received training on the use of the EMA device at the beginning of the data collection week and carried the device for seven consecutive days.

Throughout the week, the EMA device randomly prompted participants 5-7 times throughout the day to answer questions about their mood, feelings about smoking, behavior, and situation just before the prompt. Only mood data and reports of urges to smoke were used from the random prompt interviews in this study. Participants were also trained in and event-recorded "smoke" interviews following cigarette smoking; only data reflecting the number of smoked cigarettes recorded were used from smoke interviews. Additionally, after participants completed several smoking interviews on a given day, all subsequent smoking events were "noted" on the device but did not result in an interview to reduce burden. Only four participants within this subsample completed these "smoke noted" events, for a total of 40 "smoke noted" events throughout the week. Finally, participants were also trained in and event-recorded "can't smoke" interviews during times when they wanted to smoke but could not, but data from these interviews were not included in this study. The handheld computers dated and time-stamped each entry. At the end of the data collection week, participants were debriefed about their week.

3. **Physical Activity Recall**

Participants were informed on the EMA training day that they would be asked about their PA when they returned for debriefing at the end of the week. They were further informed that they did not need to alter their PA in any way, and the notification was simply to aid in recall accuracy at the end of the week. When participants returned for debriefing, trained staff completed the PAR interview to assess activity throughout the days corresponding to the seven days in which he/she carried the diary. All interviewers were trained on a standardized protocol adapted from Sallis et al. (1985). During this interview, participants were asked to provide the name, approximate time, and duration of each activity. Participants were also asked to provide their own assessment of intensity using walking as a guide for moderate activity, running as a measure of very hard activity, and "anything in between" as guide for hard activity. They were also asked to recall whether they were with others during this activity; however, this data was not used in the present study. Finally, participants were also asked to recall the time that they got into and out of bed daily. Interviewers were trained to ask various questions to help promote recall, such as "how did you get to work that day?"

After data was entered and verified, all activities were coded into the categories of NWPA and WPA. NWPA was considered structured, purposeful, or other recreational/leisure time activity (e.g., sports, running, weight-lifting, dancing) or activities that could be considered transportation (e.g., walking or biking). WPA was considered any activity described by the participant as work (e.g., waitressing, janitorial work), household activities (e.g., cleaning, cooking, moving furniture), or caretaking activities (e.g., taking care of children as parents or babysitters). For two participants, activity names were not indicated throughout the interview and thus could not be coded. These two participants were removed from all work- and non-work-related PA analyses.

D. **Measures**

1. **Demographic information**

Demographic information was assessed via questionnaire and included age, gender, race (White, African American, American Indian/Alaska Native, Asian, or Native Hawaiian/Other Pacific Islander), ethnicity (Hispanic/Latino or not), current educational status, and current employment status.

2. **Smoking Variables**

a. **Smoking Level**

Smoking level was assessed using EMA reports of daily smoke interviews. During each participant-initiated interview, participants were asked to report on the amount smoked just before the interview, and the options were "less than one cigarette," "one cigarette," or "more than one cigarette." The amount was recoded, such that less than one cigarette and one cigarette were each counted as one cigarette and more than one cigarette was counted as two. The number of cigarettes was then summed for each day and any additional "smoke noted" interviews (described previously) were added to their respective days as one cigarette each. Days without smoke interviews that had corresponding random prompt data were considered to have had zero smoking episodes. This variable was highly skewed and thus was transformed into three different groups representing various levels of cigarette use on a given day. Days with zero cigarettes were coded as "0," days with one cigarette were coded as "1," and days with more than one cigarette were coded as "2."

b. **Smoking Urges**

Urges to smoke were assessed by one item on each random prompt EMA interview asking participants to rate their "urge for a cigarette" just before the signal on a 10-point Likert-type scale, from 1 (not at all) through 10 (very much). A daily urge score was calculated to represent the mean of responses throughout the day.

c. **Self-reported smoking**

Self-reports of smoking were assessed via questionnaire and used in the present study for the purposes of describing the sample. Participants were asked to record the number of days on which they smoked cigarettes in the last month as well as the number of cigarettes smoked each day on days smoked.

3. **Physical Activity Variables**

As described, an adapted version of the 7-Day PAR was used to assess PA. The 7-day PAR is a semi-structured interview used to estimate an individual's time spent in PA over the last seven days. The PAR is a widely used tool in epidemiologic, clinical, and behavior change research. It has been shown to have good reliability (Richardson, Ainsworth, Jacobs, & Leon, 2001) as well as good concurrent validity compared to daily recall (Dishman & Steinhardt, 1988) and objective PA assessments, such as accelerometers (Washburn, Jacobsen, Sonko, Hill, & Donnelly, 2003).

For the majority of participants (*n* = 165; 86.8%), six days of data were obtained from the week (i.e., Days 2 through 7) for the current analysis. This is because Day 1 on the PAR was intended to coincide with the electronic diary training day, which took place at various times throughout the day. Some participants had fewer days of data either because they carried the diary for only six full days instead of seven or data was not collected on certain days of the week. There were also a small number of episodes of interview error (*n* = 11) during which Day 1 on the PAR did not properly correspond to the EMA training day. For these instances, the PAR was corrected to appropriately correspond to the EMA day; however, this resulted in some lost data (e.g., if Day 1 on the PAR was appropriately recoded to Day 3). Together, this resulted in eight participants with only four days of data (4.2%) and 17 participants with five days of data (8.9%).

a. **Caloric Energy Expenditure**

An estimate of total daily energy expenditure was calculated based on specifications outlined in Sallis et al. (1985). First, metabolic energy equivalents (METs) were assigned to each intensity level of activity. Moderate PA was equal to 4 METs, hard PA was equal to 6 METs, and very hard PA was equal to 10 METs. Light

PA, which corresponded to 1.5 METs, was first calculated by subtracting the total hours of PA each day and the total hours in bed daily from 24 (total hours in a day). Finally, time in bed was equal to one MET. Each MET equivalent was multiplied by the total hours of participation in the respective intensity activity level on a given day to yield an energy expenditure value (in kcal/kg). The total energy expenditure value (in kcal/kg) for each day was summed and then multiplied by the participants' self-reported body weight (first converted to kilograms). This calculation yielded an estimate of daily caloric energy expenditure. For preliminary and primary analyses, this value was divided by 1000.

b. **Non-work-related Physical Activity**

NWPA was computed by summing the total hours of NWPA in a day and dividing this value by the total hours of PA in that day. Thus, this variable reflects the proportion of NWPA an individual engaged in within the day. Although this variable was highly bimodal (i.e., either 0 or 1), it remained continuous to maintain the integrity of the operationalization as a proportion.

c. **Work-related Physical Activity**

WPA was computed by summing the total hours of WPA in a day and dividing this value by the total hours of PA in that day. Therefore, this reflects the proportion of WPA an individual engaged in within a day. As with NWPA, WPA was also highly bimodal but also remained continuous.

d. **Moderate Physical Activity**

Moderate PA was defined as any activity determined by participants as being similar to how he/she feels while walking at a normal pace during activities. Only those activities coded as non-work related were included. Given the skewed nature of this variable, hours of moderate PA each day were grouped into three levels: no activity (coded as “0”), less than one hour of activity (coded as “1”), and one hour or more of activity (coded as “2”). Among females, the breakdown of total moderate activities across all days included within the study (n = 368) was the following: 78.8% walking, 1.6% sports, 1.9% strength and toning activities, and 17.7% included other cardiovascular exercise (e.g., swimming and dancing) or general recreational activities. Among males, the breakdown of total moderate activities (n = 248) was the following: 75.0% walking, 5.6% sports, 9.3% strength and toning activities, and 10.1% included other cardiovascular exercise (e.g., biking) or general recreational activities.

e. **Vigorous Physical Activity**

Vigorous PA was defined as any activity determined by participants to be “hard” or “very hard” and that was also classified as non-work-related. This variable was also highly skewed and thus days were dichotomized according to whether or not any vigorous PA took place on that day (i.e., no vigorous activity days were coded as “0” and vigorous activity days were coded as “1”). Among females, the breakdown of total vigorous activities across all days included within the study (n =143) was the following: 30.1% running, 19.6% biking, 16.1% strength and toning, 4.9% sports, and 29.3% included other cardiovascular exercise (e.g., dancing and swimming) or general recreational activities. Among males, the breakdown of total vigorous activities (n =142) was the following: 38.7% strength and toning, 29.6% sports, 14.1% running, 4.2% biking, and 13.4% included other cardiovascular exercise (e.g., swimming) or general recreational activities.

f. **Self-reported Physical Activity**

Self-reported PA for the purpose of sample description was assessed via questionnaire and asked participants to report the number of days in the last week on which they participated in 30 minutes of activity without sweating or breathing hard (i.e., moderate PA) as well as the number of days in the last week on which they participated in 20 minutes of activity that caused them to sweat or breathe hard (i.e., vigorous PA).

4. **Mood**

Participants were asked on each random prompt EMA interview to rate their mood just before the signal, for example, "before the signal, I felt happy." Participants responded to several mood adjectives using a 10-point Likert-type scale, ranging from 1 (not at all) to 10 (very). Using results from factor analyses on the earlier EMA sample (N = 461), the following adjectives formed a strong "Positive Affect" (PosA) scale: happy, relaxed, cheerful, accepted, and confident. The "Negative Affect" (NegA) scale was formed by angry, frustrated, irritable, sad, and stressed. A daily affect score for PosA and NegA was calculated to represent the mean of responses throughout the day for each mood variable. Standardized alpha at the subject level for PosA was 0.899 and for NegA was 0.962 at the 5-year wave.

5. **Body Mass Index**

Body mass index (BMI) was assessed using participant self-reports of weight and height from questionnaire data. BMI was calculated as [weight (in pounds) divided by height (in inches)^2] x 703.

III. Results

A. **Analytic Approach**

Data were analyzed using two types of models depending on the measurement scale of the outcome evaluated. Specifically, when examining smoking level (measured on an ordinal scale), mixed-effects ordinal logistic regression analyses with a random intercept were conducted using the GLIMMIX procedure with the descending command in SAS 9.2. When smoking urges was the outcome variable of interest, mixed-effects regression models for continuous outcomes with a random intercept were conducted using the MIXED procedure in SAS 9.2.

Multiple steps were used to prepare each variable for analysis. For the following formulas, let i represent each individual (i = 1, 2, 3,…N, where the maximum of N is 190 subjects) and j refer to each day (j = 1, 2, 3,…n_i, where maximum of n_i is 6). First, a weekly mean of NegA and PosA for each subject was calculated from daily average NegA and average PosA values (i.e., $m\text{NegA}_i$; $m\text{PosA}_i$). Each subject's daily NegA and PosA was then subtracted from the calculated weekly mean to derive a measure of the daily NegA or PosA deviation from each subject's own average (i.e., $\text{NegA}_{ij} - m\text{NegA}_i$; $\text{PosA}_{ij} - m\text{PosA}_i$). The weekly average served as the BS effect and the daily deviation from the average served as the WS effect. The same procedure was used for each construct of PA and mood to yield the weekly average as well as daily deviations.

Two main sets of models were evaluated for each PA construct and then for each smoking outcome. The first set of models evaluated the effect of PA on smoking outcomes (both smoking level and urges). The second set of models examined the interaction between PA and mood (separately for NegA and PosA) on smoking outcomes. The BS PA and mood variables were first mean-centered at the BS level and then interaction terms were created to reduce multicolinearity and enhance the interpretability of the model. The WS variables were naturally mean-centered in their creation. Significant interactions were probed and plotted using techniques outlined by Aiken and West (1991) at one standard deviation above and below the mean. Each main model was also evaluated for gender differences, and significant interactions were probed using techniques outlined by Holmbeck (2002). If gender interactions were not significant, they were removed from the analysis and not presented. Finally, all analyses included BMI and gender (when not included as a moderator) as control variables.

For all analyses, the WS effect refers to how the daily deviation of that variable from the weekly average predicts the outcome. In text, this will be referred to as "daily" for simplicity (e.g., daily PA, daily NegA). In turn, the BS effect represents the overall weekly average of the variable of interest on the outcome. This will be referred to as "overall" (e.g., overall PA, overall NegA).

B. **Descriptive Analyses**

Descriptive statistics for PA, mood, smoking, and BMI variables for the total sample across all days (across people for BMI), and also stratified by gender, are shown in Table I. Table I also displays results from a series of mixed-effects regression analyses with random intercepts in SAS 9.2 comparing gender differences in study variables. As can be seen, males had greater caloric energy expenditure and females exhibited greater levels of moderate PA; no other gender differences emerged. An independent samples t-test examined gender differences in the between-subjects variable of BMI and also revealed no differences.

TABLE I

DESCRIPTIVE STATISTICS OF SELECTED STUDY VARIABLES STRATIFIED BY GENDER

	Females			Males			Total		
	N(n)	*M*	*SD*	*N(n)*	*M*	*SD*	*N(n)*	*M*	*SD*
<u>PA</u>									
Caloric Energy Expenditure	102(599)	2578.59	785.80	88(508)	3366.92	1296.68	190(1107)	2940.36**	1122.08
Non-Work Proportion	102(579)	0.47	0.48	88(490)	0.46	0.49	188(1069)	0.47	0.48
Work Proportion	102(579)	0.29	0.44	88(490)	0.31	0.45	188(1069)	0.30	0.44
Moderate PA	102(579)	0.68	0.83	88(490)	0.54	0.79	188(1069)	0.61*	0.81
Vigorous PA	102(579)	0.18	0.38	88(490)	0.24	0.43	188(1069)	0.21	0.41
<u>Mood</u>									
NegA	102(599)	3.17	1.86	88(508)	3.14	1.77	190(1107)	3.16	1.82
PosA	102(599)	7.11	1.48	88(508)	7.01	1.57	190(1107)	7.06	1.52
<u>Smoking</u>									
Urges	102(599)	4.07	2.78	88(508)	4.53	2.70	190(1107)	4.28	2.75
BMI	102	25.00	4.51	88	25.02	3.98	190	25.01	4.26

Notes. For all gender comparisons across days, *p*-values represent the significance of mixed-effects regression models: ** $p<.001$, * $p< .05$. For the BMI comparison, an independent samples t-test showed that females and males did not differ on BMI; NegA = negative affect; PosA = positive affect; BMI = body mass index. All PA and mood data represent values across all days for the entire sample before averaging to obtain between-subject weekly means; N = number of people; n = number of observations (i.e., days).

Table II shows the frequencies and result of a mixed-effects ordinal logistic regression analysis with a random intercept and descending command in SAS 9.2 examining gender differences in daily smoking level. This model revealed no significant differences between males and females in their daily levels of cigarette smoking.

TABLE II

CIGARETTE SMOKING LEVEL OUTCOME STRATIFIED BY GENDER

	N	**0 Cigarette Day**	**1 Cigarette Day**	**> 1 Cigarette Day**
Females	102	337	100	162
Males	88	273	95	140
Total	190	610	195	302

Note. Mixed-effects ordinal logistic regression model for gender difference across days of cigarettes: *Gender Estimate = 0.2052*, *p* = 0.592.

Tables III and IV show the frequencies of activity level across days by gender and results of mixed-effects regression models (ordinal and binary logistic, respectively) with random intercepts and descending commands in SAS 9.2 conducted to evaluate gender differences. As shown in Table III, females were engaging in significantly more moderate activity compared to males. Table IV indicates that that males were engaging in significantly (marginally) more vigorous PA compared to females.

C. <u>**Preliminary Analyses**</u>

Prior to conducting main analyses, we sought to better understand: 1) how mood (WS and BS) predicted smoking and urges to smoke and 2) how PA (WS and BS)

TABLE III

MODERATE PHYSICAL ACTIVITY LEVEL BY DAYS STRATIFIED BY GENDER

	N	**No Moderate Activity (0)**	**Medium Moderate Activity (1)**	**High Moderate Activity (2)**
Females	100	325	116	138
Males	88	315	85	90
Total	188	640	201	228

Note. Mixed-effects ordinal logistic regression model for gender difference across days of moderate PA: *Gender Estimate* = -0.5052, p = .027. No moderate activity is equal to zero hours on a day. Medium moderate activity is equal to physical activity greater than zero hours but less than one hour on a day. High moderate activity is equal to one hour or more of physical activity on a day.

TABLE IV

VIGOROUS PHYSICAL ACTIVITY LEVEL BY DAYS STRATIFIED BY GENDER

	N	**No Vigorous Activity (0)**	**Any Vigorous Activity (1)**
Females	100	475	104
Males	88	371	119
Total	188	846	223

Note. Mixed-effects binary logistic regression model for gender difference across days of vigorous PA: *Gender Estimate* = 0.5714, p =.091. No vigorous activity is equal to 0 hours of vigorous physical activity on a day. Any vigorous activity is equal to greater than zero hours of vigorous physical activity on a day.

predicted mood. Consistent with the analytic approach previously described for the main analyses, continuous outcomes were modeled using mixed-effects regression analyses for continuous outcomes with a random intercept using the MIXED procedure in SAS 9.2. Ordinal outcomes were modeled using mixed-effects ordinal logistic regression analyses with a random intercept using the GLIMMIX procedure with the descending command in SAS 9.2. Gender differences were explored using techniques outlined by Holmbeck (2002). Similar to the main analyses, BMI and gender (when not included as a moderator) were used as control variables.

1. **Smoking and Mood**

a. **Smoking Level Outcome**

Results revealed that NegA was not associated with smoking level for either the WS or BS effect (see Table V). There were no significant interactions between NegA and gender on smoking level.

For PosA, there was a significant positive effect of BS PosA on smoking level, but the WS PosA effect was not significant. The BS effect, however, was qualified by a marginally significant interaction between BS PosA and gender. Follow-up analyses indicated that for females, there was a significant positive effect of BS PosA on smoking level, Estimate = 0.4448, $p = .035$, such that overall higher levels of PosA were associated with higher levels of smoking. For males, however, the BS PosA effect was not significant, Estimate = -0.0506, $p = .808$.

b. **Smoking Urge Outcome**

For NegA, results showed a positive association between both WS and BS NegA and urges to smoke (see Table VI). That is, higher levels of daily and overall NegA were associated with greater daily and greater overall urges to smoke. Gender did not moderate either the WS or BS effect. For PosA, analyses revealed a significant effect of WS PosA, however, this was qualified by a significant interaction between WS PosA and gender. Follow-up analyses revealed a significant negative association between WS PosA and urges for females, Estimate = -0.3055, $p < .001$, such that lower daily PosA was associated with higher daily urges to smoke. This effect was not significant for males, Estimate = -0.0766, $p = .245$. There was no significant effect of BS PosA or BS PosA and gender interaction on urges to smoke.

TABLE V

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODELS OF AFFECT PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept 2	187	-2.3911	1.1499	-2.08	.039
Intercept 1	187	-1.0070	1.1469	-0.88	.381
Gender	914	0.2103	0.3824	0.55	.582
BMI	914	0.0216	0.0446	0.48	.629
Negative Affect (WS)	914	-0.0612	0.0843	-0.73	.468
Negative Affect (BS)	914	0.0669	0.1205	0.56	.579
Positive Affect Model					
Intercept 2	186	-2.7043	1.1589	-2.33	.021
Intercept 1	186	-1.3127	1.1553	-1.14	.257
Gender	913	0.2221	0.3798	0.58	.559
BMI	913	0.0330	0.0448	0.74	.461
Positive Affect (WS)	913	0.1398	0.1267	1.10	.270
Positive Affect (BS)	913	0.4448	0.2101	2.12	.035
Positive Affect (WS) x Gender	913	0.1142	0.1859	0.61	.539
Positive Affect (BS) x Gender	913	-0.4954	0.2939	-1.69	.092

Note. Gender coded as 0= female, 1= male; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 190; *n* (observations) = 1107.

TABLE VI

MIXED-EFFECTS REGRESSION MODELS OF AFFECT PREDICTING URGES TO SMOKE

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept	187	3.5987	1.0116	3.56	.001
Gender	915	0.4907	0.3354	1.46	.144
BMI	915	0.0182	0.0394	0.46	.644
Negative Affect (WS)	915	0.3787	0.0410	9.24	<.001
Negative Affect (BS)	915	0.6014	0.1059	5.68	<.001
Positive Affect Model					
Intercept	186	3.5575	1.0936	3.25	.001
Gender	914	0.4427	0.3594	1.23	.218
BMI	914	0.0209	0.0426	0.49	.625
Positive Affect (WS)	914	-0.3055	0.0632	-4.83	<.001
Positive Affect (BS)	914	-0.3093	0.1976	-1.57	.118
Positive Affect (WS) x Gender	914	0.2289	0.0912	2.51	.012
Positive Affect (BS) x Gender	914	0.0707	0.2793	0.25	.800

Note. Gender coded as 0= female, 1= male; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; N = 190, n *(observations)* = 1107.

c. **Summary of Smoking and Mood**

Results revealed that higher daily and overall NegA were each associated with greater urges to smoke across the sample, but NegA was not associated with smoking level. Significant effects of PosA on smoking were only present for females. That is, higher overall PosA predicted higher levels of smoking for females, while lower daily PosA predicted higher urges to smoke.

2. **Physical Activity and Mood**

a. **Caloric Energy Expenditure**

Analyses showed that there was no significant effect of BS caloric energy expenditure on NegA, but the WS effect was marginally significant (see Table VII). However, the WS effect was qualified by a marginally significant interaction between WS caloric energy expenditure and gender. Follow-up analyses revealed that for females, there was a marginally significant negative effect of WS caloric energy expenditure, Estimate = -0.1680, $p = .092$, such that higher daily caloric energy expenditure was associated with lower daily NegA. In contrast, for males, the effect of WS caloric energy expenditure was not significant, Estimate = 0.0281, $p = .645$.

For PosA, there was a marginally significant main effect of WS caloric energy expenditure, but the effect of BS caloric energy expenditure was not significant. The WS effect was further qualified by a significant interaction between WS caloric energy expenditure and gender. Follow-up analyses revealed that for females, there was a marginally significant positive effect of WS caloric energy expenditure, Estimate = 0.1681, $p = .069$, such that higher daily caloric energy expenditure was associated with higher daily PosA. In contrast, for males, there was a marginally significant negative

TABLE VII

MIXED-EFFECTS REGRESSION MODELS OF CALORIC ENERGY EXPENDITURE PREDICTING AFFECT

	df	*Estimate*	*SE*	*t-value*	*p*
Predicting Negative Affect					
Intercept	186	3.1170	0.8863	3.52	.001
Gender	914	-0.1721	0.2622	-0.66	.512
BMI	914	0.0044	0.0329	0.13	.894
Calories (WS)	914	-0.1680	0.0997	-1.68	.092
Calories (BS)	914	0.1491	0.2627	0.57	.571
Calories (WS) x Gender	914	0.1961	0.1169	1.68	.094
Calories (BS) x Gender	914	0.0558	0.2835	0.20	.844
Predicting Positive Affect					
Intercept	186	8.2893	0.7136	11.62	<.001
Gender	914	-0.1072	0.2111	-0.51	.612
BMI	914	-0.0455	0.0265	-1.72	.086
Calories (WS)	914	0.1681	0.0923	1.82	.069
Calories (BS)	914	0.1071	0.2115	0.51	.613
Calories (WS) x Gender	914	-0.2635	0.1082	-2.44	.015
Calories (BS) x Gender	914	-0.1865	0.2282	-0.82	.414

Note. Gender coded as 0= female, 1= male; Calories = caloric energy expenditure; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 190; *n (observations)* = 1107.

effect of WS caloric energy expenditure, Estimate = -0.0954, p = .091, such that higher daily caloric energy expenditure was associated with lower daily PosA.

b. **Non-work-related Physical Activity**

There was a significant negative effect of WS NWPA on NegA, such that engaging in a greater proportion of daily NWPA was associated with lower daily NegA (see Table VIII). The BS NWPA effect on NegA was not significant. In addition, there were no significant effects of either WS or BS NWPA on PosA. No gender interactions were present across analyses.

c. **Work-related Physical Activity**

Results revealed a marginally significant positive effect of WS WPA on NegA (see Table IX), such that engaging in a greater proportion of daily WPA was associated with higher levels of daily NegA. The BS WPA effect on NegA was not significant. There was also a significant negative effect of WS WPA on PosA, indicating that engaging in a greater proportion of daily WPA was associated with lower daily PosA. The BS WPA effect on PosA was not significant. There were no interactions between WPA and gender to predict NegA or PosA.

d. **Moderate Physical Activity**

There was a marginally significant negative effect of WS moderate PA on NegA (see Table X), indicating that higher levels of daily moderate PA were associated with lower levels of daily NegA. The BS effect was not significant. There were no effects of moderate PA on PosA or gender interactions with PA variables for either NegA or PosA.

TABLE VIII

MIXED-EFFECTS REGRESSION MODELS OF NON-WORK PHYSICAL ACTIVITY PREDICTING AFFECT

	df	*Estimate*	*SE*	*t-value*	*p*
Predicting Negative Affect					
Intercept	185	2.5561	0.6858	3.73	<.001
Gender	879	-0.0033	0.2291	-0.01	.989
BMI	879	0.0235	0.0267	0.88	.381
NWPA (WS)	879	-0.1766	0.0817	-2.16	.031
NWPA (BS)	879	-0.3840	0.3546	-1.08	.279
Predicting Positive Affect					
Intercept	185	8.2518	0.5558	14.85	<.001
Gender	879	-0.1373	0.1858	-0.74	.460
BMI	879	-0.0441	0.0217	-2.04	.042
NWPA (WS)	879	0.0872	0.0758	1.15	.251
NWPA (BS)	879	0.0012	0.2876	0.00	.997

Note. Gender coded as 0= female, 1= male; NWPA = non-work-related physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188, *n (observations)* = 1069.

TABLE IX

MIXED-EFFECTS REGRESSION MODELS OF WORK PHYSICAL ACTIVITY PREDICTING AFFECT

	df	*Estimate*	*SE*	*t-value*	*p*
Predicting Negative Affect					
Intercept	185	2.5694	0.6871	3.74	<.001
Gender	879	0.0022	0.2295	0.01	.992
BMI	879	0.0228	0.0268	0.85	.395
WPA (WS)	879	0.1944	0.0995	1.95	.051
WPA (BS)	879	0.2432	0.3487	0.70	.486
Predicting Positive Affect					
Intercept	185	8.2517	0.5557	14.85	<.001
Gender	879	-0.1373	0.1857	-0.74	.460
BMI	879	-0.0441	0.0217	-2.04	.042
WPA (WS)	879	-0.1868	0.0922	-2.03	.043
WPA (BS)	879	0.0007	0.2822	0.00	.998

Note. Gender coded as 0= female, 1= male; WPA = work-related physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

TABLE X

MIXED-EFFECTS REGRESSION MODELS OF MODERATE PHYSICAL ACTIVITY PREDICTING AFFECT

	df	*Estimate*	*SE*	*t-value*	*p*
Predicting Negative Affect					
Intercept	185	2.5703	0.6842	3.76	<.001
Gender	879	-0.0418	0.2313	-0.18	.857
BMI	879	0.0236	0.0267	0.88	.377
MPA (WS)	879	-0.0758	0.0452	-1.68	.094
MPA (BS)	879	-0.3178	0.2361	-1.35	.179
Predicting Positive Affect					
Intercept	185	8.2531	0.5554	14.86	<.001
Gender	879	-0.1328	0.1878	-0.71	.480
BMI	879	-0.0443	0.0217	-2.04	.041
MPA (WS)	879	0.0058	0.0419	0.14	.891
MPA (BS)	879	0.0311	0.1918	0.16	.871

Note. Gender coded as 0= female, 1= male; MPA = moderate physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

e. **Vigorous Physical Activity**

Results for NegA indicated that there were no main effects of either WS or BS vigorous PA; however, there was a marginally significant interaction between WS vigorous PA and gender (see Table XI). Follow-up analyses indicated that the effect of WS vigorous PA on NegA was not statistically significant for either gender, but effects were in the opposite direction (i.e., the positive direction for females, Estimate = 0.1871, *p* = .189, and the negative direction for males, Estimate = -0.1661, *p* = .201). When gender interaction terms were removed, no significant main effects of vigorous PA were observed. There were no significant effects of either WS or BS vigorous PA on PosA or gender interactions.

f. **Summary of Physical Activity and Mood**

Overall, daily moderate PA (marginally) and daily NWPA were

TABLE XI

MIXED-EFFECTS REGRESSION MODELS OF VIGOROUS PHYSICAL ACTIVITY PREDICTING AFFECT

	df	*Estimate*	*SE*	*t-value*	*p*
Predicting Negative Affect					
Intercept	184	2.5699	0.6936	3.71	<.001
Gender	878	0.0238	0.2308	0.10	.918
BMI	878	0.0224	0.0271	0.83	.409
VPA (WS)	878	0.1871	0.1424	1.31	.189
VPA (BS)	878	-0.3258	0.6060	-0.54	.591
VPA (WS) x Gender	878	-0.3532	0.1927	-1.83	.067
VPA (BS) x Gender	878	-0.0111	0.8894	-0.01	.990
Predicting Positive Affect					
Intercept	185	8.2637	0.5544	14.91	<.001
Gender	879	-0.1552	0.1864	-0.83	.405
BMI	879	-0.0443	0.0216	-2.05	.041
VPA (WS)	879	-0.0014	0.0890	-0.02	.987
VPA (BS)	879	0.3144	0.3539	0.89	.375

Note. Gender coded as 0= female, 1= male; VPA = vigorous physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; N = 188; *n (observations)* = 1069.

associated with lower daily NegA. Furthermore, daily WPA predicted higher daily NegA (marginally) and lower daily PosA. Finally, gender differences emerged for caloric energy expenditure, such that for females, higher daily caloric energy expenditure was marginally associated with higher PosA and lower NegA; for males, higher daily caloric energy expenditure was marginally associated with lower PosA but did not predict NegA. Vigorous PA did not predict either mood variable.

D. Primary Analyses

1. Caloric Energy Expenditure

a. Smoking Level

For the first model, results revealed a significant positive effect of

BS caloric energy expenditure on smoking level, but the effect of WS caloric energy expenditure was not significant (see Table XII). However, the BS effect was qualified by a significant interaction between BS caloric energy expenditure and gender. Follow-up analyses showed that for females, there was a significant positive association between BS caloric energy expenditure and smoking level, Estimate = 1.2846, p = .003, but the effect was not significant for males, Estimate = 0.3606, p = .186. That is, for females, but not males, higher overall caloric energy expenditure was associated with greater levels of smoking. For the second set of models, there were no significant interactions between caloric energy expenditure and either measure of affect on smoking level (see Table XIII). Additionally, there were no significant three-way interactions between caloric energy expenditure, affect, and gender to predict smoking level.

TABLE XII

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODEL OF CALORIC ENERGY EXPENDITURE PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Intercept 2	187	0.3040	1.4394	0.21	.833
Intercept 1	187	1.6932	1.4407	1.18	.241
Gender	912	-0.4092	0.4287	-0.95	.340
BMI	912	-0.0676	0.0535	-1.26	.207
Calories (WS)	912	-0.3357	0.2454	-1.37	.172
Calories (BS)	912	1.2846	0.4325	2.97	.003
Calories (WS) x Gender	912	0.1422	0.2832	0.50	.616
Calories (BS) x Gender	912	-0.9240	0.4621	-2.00	.046

Note. Gender coded as 0= female, 1= male; Calories = caloric energy expenditure; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; N = 190; *n (observations)* = 1107.

TABLE XIII

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODELS OF CALORIC ENERGY EXPENDITURE AND AFFECT PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept 2	186	-0.7270	1.4042	-0.52	.605
Intercept 1	186	0.6643	1.4039	0.47	.637
Gender	911	-0.2115	0.4266	-0.50	.620
BMI	911	-0.0379	0.0530	-0.72	.475
Calories (WS)	911	-0.2327	0.1239	-1.88	.061
Calories (BS)	911	0.5241	0.2575	2.04	.042
Negative Affect (WS)	911	-0.0521	0.0854	-0.61	.542
Negative Affect (BS)	911	0.0298	0.1203	0.25	.804
Calories (WS) x Negative Affect (WS)	911	-0.0854	0.1217	-0.70	.483
Calories (BS) x Negative Affect (BS)	911	0.1021	0.0998	1.02	.307
Positive Affect Model					
Intercept 2	185	-0.9013	1.4154	-0.64	.525
Intercept 1	185	0.4950	1.4151	0.35	.727
Gender	912	-0.2479	0.4252	-0.58	.560
BMI	912	-0.0307	0.0535	-0.57	.566
Calories (WS)	912	-0.2294	0.1240	-1.85	.065
Calories (BS)	912	0.5867	0.2523	2.33	.020
Positive Affect (WS)	912	0.1828	0.0932	1.96	.050
Positive Affect (BS)	912	0.2457	0.1521	1.62	.107
Calories (WS) x Positive Affect (WS)	912	0.0697	0.1439	0.48	.628
Calories (BS) x Positive Affect (BS)	912	-0.1328	0.1114	-1.19	.234

Note. Gender coded as 0= female, 1= male; Calories = caloric energy expenditure; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; N = 190; *n (observations)* = 1107.

b. **Smoking Urges**

For the first model, results revealed a significant positive effect of BS caloric energy expenditure on urges, but the WS effect was not significant (see Table XIV). However, the BS effect was qualified by a significant interaction with gender. Specifically, follow-up results showed a significant positive effect of BS caloric energy expenditure on urges for females, Estimate = 0.9945, *p* = .016, but the effect was not significant for males, Estimate = 0.0343, *p* = .897. Thus, for females, greater overall caloric energy expenditure was associated with greater urges to smoke.

TABLE XIV

MIXED-EFFECTS REGRESSION MODEL OF CALORIC ENERGY EXPENDITURE PREDICTING URGES TO SMOKE

	df	*Estimate*	*SE*	*t-value*	*p*
Intercept	186	4.9635	1.3826	3.59	<.001
Gender	914	0.1007	0.4090	0.25	.806
BMI	914	-0.0217	0.0514	-0.42	.672
Calories (WS)	914	-0.0609	0.1296	-0.47	.638
Calories (BS)	914	0.9945	0.4099	2.43	.016
Calories (WS) x Gender	914	0.0376	0.1518	0.25	.805
Calories (BS) x Gender	914	-0.9602	0.4423	-2.17	.030

Note. Gender coded as 0= female, 1= male; Calories = caloric energy expenditure; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 190; *n (observations)* = 1107.

The second set of models revealed no significant interactions between caloric energy expenditure and either measure of affect on smoking urges (see Table XV). Additionally, there were no significant three-way interactions between caloric energy expenditure, affect, and gender to predict smoking urges.

TABLE XV

MIXED-EFFECTS REGRESSION MODELS OF CALORIC ENERGY EXPENDITURE AND AFFECT PREDICTING URGES TO SMOKE

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept	185	4.0834	1.2502	3.27	.001
Gender	913	0.3698	0.3784	0.98	.329
BMI	913	0.0010	0.0473	0.02	.984
Calories (WS)	913	-0.0232	0.0646	-0.36	.718
Calories (BS)	913	0.1503	0.2305	0.65	.515
Negative Affect (WS)	913	0.3773	0.0412	9.17	<.001
Negative Affect (BS)	913	0.5931	0.1064	5.57	<.001
Calories (WS) x Negative Affect (WS)	913	0.0206	0.0706	0.29	.770
Calories (BS) x Negative Affect (BS)	913	0.0221	0.0892	0.25	.805
Positive Affect Model					
Intercept	185	4.2479	1.3435	3.16	.002
Gender	913	0.2293	0.4027	0.57	.569
BMI	913	-0.0035	0.0508	-0.07	.945
Calories (WS)	913	-0.0369	0.0670	-0.55	.582
Calories (BS)	913	0.2518	0.2407	1.05	.296
Positive Affect (WS)	913	-0.1951	0.0458	-4.26	<.001
Positive Affect (BS)	913	-0.2416	0.1433	-1.69	.092
Calories (WS) x Positive Affect (WS)	913	-0.0285	0.0852	-0.33	.738
Calories (BS) x Positive Affect (BS)	913	-0.1136	0.1073	-1.06	.290

Note. Gender coded as 0= female, 1= male; Calories = caloric energy expenditure; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 190; *n (observations)* = 1107.

c. **Summary of Caloric Energy Expenditure**

In sum, results for caloric energy expenditure diverged from predictions. Specifically, for females, higher overall caloric energy expenditure was associated with higher levels of both smoking and urges to smoke, however, no other significant associations were present between caloric energy expenditure and smoking. Furthermore, caloric energy expenditure did not interact with affect to predict either smoking outcome.

2. **Non-work-related Physical Activity**

a. **Smoking Level**

For the first set of models, results revealed significant negative effects of both WS NWPA and BS NWPA on smoking level (see Table XVI). The WS effect, however, was qualified by an interaction between WS NWPA and gender. Follow-up analyses of the gender interaction showed a significant negative effect of WS NWPA on smoking level for females, Estimate = -0.7584, p = .007, such that engaging in a greater proportion of daily NWPA was associated with lower smoking. For males, this effect was in the opposite direction, and there was a significant positive effect of daily NWPA on smoking level, Estimate = 0.7597, p = .013. That is, for males, engaging in a greater proportion of daily NWPA was associated with increased smoking. The BS effect indicated that for all individuals, engaging in a greater proportion of overall NWPA was associated with overall lower smoking levels.

The second set of models showed a marginally significant three-way interaction between BS NWPA, BS NegA, and gender (see Table XVII). Follow-up analyses revealed that the interaction between BS NWPA and BS NegA was near statistically

TABLE XVI

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODEL OF NON-WORK PHYSICAL ACTIVITY PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Intercept 2	183	-2.6691	1.1387	-2.34	.020
Intercept 1	183	-1.2351	1.1349	-1.09	.278
Gender	878	0.1384	0.3814	0.36	.717
BMI	878	0.0286	0.0441	0.65	.518
NWPA (WS)	878	-0.7584	0.2790	-2.72	.007
NWPA (BS)	878	-2.0845	0.8621	-2.42	.016
NWPA (WS) x Gender	878	1.5181	0.4146	3.66	<.001
NWPA (BS) x Gender	878	0.9001	1.1923	0.75	.451

Note. Gender coded as 0= female, 1= male; NWPA = non-work-related physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; N = 188; *n (observations)* = 1069.

TABLE XVII

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODELS OF NON-WORK PHYSICAL ACTIVITY AND AFFECT PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept 2	181	-2.7000	1.1294	-2.39	.018
Intercept 1	181	-1.2633	1.1255	-1.12	.263
Gender	872	0.2011	0.3775	0.53	.594
BMI	872	0.0275	0.0437	0.63	.529
NWPA (WS)	872	-0.7999	0.2831	-2.83	.005
NWPA (BS)	872	-2.4412	0.8722	-2.80	.005
Negative Affect (WS)	872	-0.1512	0.1276	-1.19	.236
Negative Affect (BS)	872	-0.2694	0.1666	-1.62	.106
NWPA (WS) x Gender	872	1.5619	0.4176	3.74	<.001
NWPA (BS) x Gender	872	1.2875	1.1918	1.08	.280
Negative Affect (WS) x Gender	872	0.1793	0.1755	1.02	.307
Negative Affect (BS) x Gender	872	0.5682	0.2474	2.30	.022
NWPA (WS) x Negative Affect (WS)	872	-0.1969	0.4037	-0.49	.626
NWPA (BS) x Negative Affect (BS)	872	-0.9700	0.6334	-1.53	.126
NWPA (WS) x Negative Affect (WS) x Gender	872	0.0275	0.5603	0.05	.961
NWPA (BS) x Negative Affect (BS) x Gender	872	1.4265	0.8322	1.71	.087
Positive Affect Model					
Intercept 2	183	-2.9638	1.1392	-2.60	.010
Intercept 1	183	-1.5434	1.1349	-1.36	.176
Gender	876	0.1660	0.3758	0.44	.659
BMI	876	0.0404	0.0440	0.92	.359
NWPA (WS)	876	-0.0901	0.2047	-0.44	.660
NWPA (BS)	876	-1.6077	0.5894	-2.73	.007
Positive Affect (WS)	876	0.2020	0.0940	2.15	.032
Positive Affect (BS)	876	0.2451	0.1475	1.66	.097
NWPA (WS) x Positive Affect (WS)	876	0.1309	0.3094	0.42	.672
NWPA (BS) x Positive Affect (BS)	876	-0.0708	0.4302	-0.16	.869

Note. Gender coded as 0= female, 1= male; NWPA = non-work-related physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

significant for females, Estimate = -0.9700, *p* = .126, but was far from significant in males, Estimate = 0.4570, *p* =.395. Given that neither interaction was significant, effects were not further examined. When three-way interactions and their additional components (i.e., all relevant two-way interactions) were removed, no significant two-way interactions between NWPA and NegA emerged. Additionally, there were no significant two-way interactions between NWPA and PosA or three-way interaction effects between NWPA, PosA, and gender to predict smoking level.

b. **Smoking Urges**

Results for the first model indicated that there was no significant effect of WS NWPA on daily urges to smoke; however, there was a significant negative effect of BS NWPA on urges (see Table XVIII). Effects were consistent across males and females, as there were no significant interactions with gender. This means that for all individuals, engaging in greater proportion of overall NWPA was associated with lower overall urges to smoke.

TABLE XVIII

MIXED-EFFECTS REGRESSION MODEL OF NON-WORK PHYSICAL ACTIVITY PREDICTING URGES TO SMOKE

	df	*Estimate*	*SE*	*t-value*	*p*
Intercept	185	3.1004	1.0818	2.87	.005
Gender	879	0.4967	0.3612	1.38	.170
BMI	879	0.0369	0.0422	0.87	.382
NWPA (WS)	879	0.0155	0.1048	0.15	.883
NWPA (BS)	879	-1.2615	0.5587	-2.26	.024

Note. Gender coded as 0= female, 1= male; NWPA = non-work-related physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

For the second set of models, analyses did not show any significant two-way interaction effects between NegA and NWPA on urges to smoke (see Table XIX). There were also no significant three-way interaction effects between NegA, NWPA, and gender on urges to smoke.

Results evaluating PosA, however, identified a marginally significant interaction between BS NWPA and BS PosA. Because this was a hypothesized interaction, it was examined further. Follow-up analyses showed that at low levels of BS NWPA, there was a significant negative association between BS PosA and urges to smoke, Estimate = -0.4906, p = .014. In contrast, among those higher in BS NWPA, there was no significant association between BS PosA and smoking urges, Estimate = -0.0333, p = .860. That is, among individuals lower in their proportion of overall NWPA, lower overall PosA was associated with higher overall urges to smoke; however, this association was no longer present among individuals higher in overall NWPA (see Figure 1). The two-way interaction between WS NWPA and WS PosA was not significant. Furthermore, there were no significant three-way interaction effects between NWPA, either dimension of affect, and gender, on urges to smoke.

c. <u>**Summary of Non-work Related Physical Activity**</u>

In sum, results for NWPA partially corroborated hypotheses by showing that engaging in a greater proportion of overall NWPA predicted lower smoking levels and urges to smoke. Partially consistent with predictions, a higher proportion of daily NWPA predicted lower smoking levels but not urges. However, the protective effect of daily NWPA on smoking level was true for females only and worked in the opposite direction for males. Contrasting predictions, NWPA did not alter the association

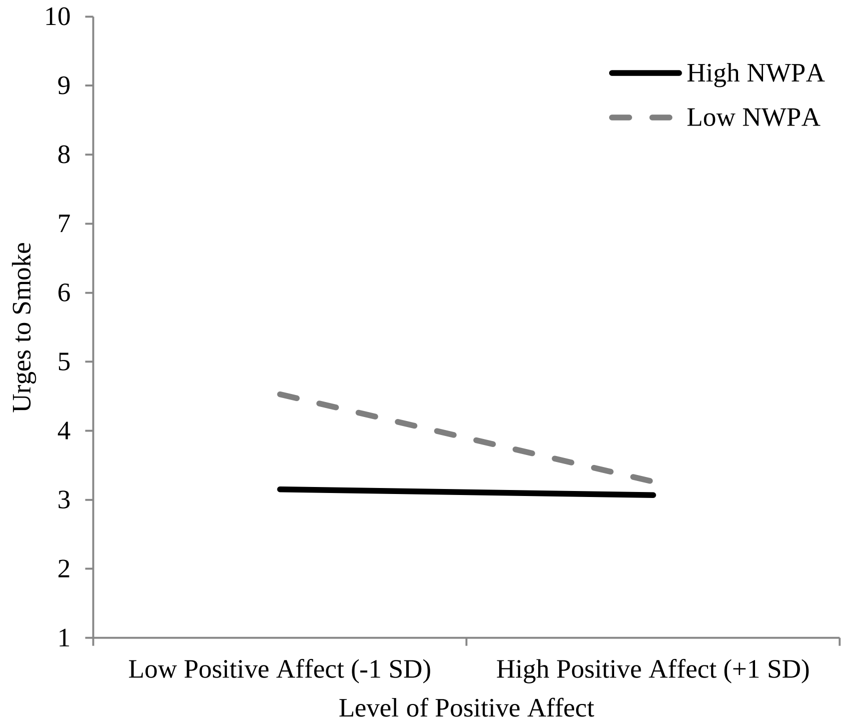
TABLE XIX

MIXED-EFFECTS REGRESSION MODELS OF NON-WORK PHYSICAL ACTIVITY AND AFFECT PREDICTING URGES TO SMOKE

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept	183	3.4815	1.0079	3.45	.001
Gender	877	0.5030	0.3359	1.50	.135
BMI	877	0.0210	0.0393	0.53	.594
NWPA (WS)	877	0.0810	0.1002	0.81	.419
NWPA (BS)	877	-1.0614	0.5222	-2.03	.042
Negative Affect (WS)	877	0.3775	0.0414	9.13	<.001
Negative Affect (BS)	877	0.5658	0.1096	5.16	<.001
NWPA (WS) x Negative Affect (WS)	877	-0.1867	0.1335	-1.40	.162
NWPA (BS) x Negative Affect (BS)	877	-0.2108	0.3639	-0.58	.563
Positive Affect Model					
Intercept	184	3.5029	1.0799	3.24	.001
Gender	876	0.4545	0.3564	1.28	.203
BMI	876	0.0215	0.0421	0.51	.609
NWPA (WS)	876	0.0264	0.1038	0.25	.799
NWPA (BS)	876	-1.2102	0.5512	-2.20	.028
Positive Affect (WS)	876	-0.2002	0.0460	-4.35	<.001
Positive Affect (BS)	876	-0.2620	0.1400	-1.87	.062
NWPA (WS) x Positive Affect (WS)	876	0.2309	0.1578	1.46	.144
NWPA (BS) x Positive Affect (BS)	876	0.7052	0.4144	1.70	.089

Note. Gender coded as 0= female, 1= male; NWPA = non-work-related physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

Figure 1. Simple slopes of overall positive affect on urges to smoke as a function of the overall proportion of NWPA (non-work-related physical activity).



Note. N = 188; *n (observations)* = 1069.

between NegA or PosA and smoking level or NegA and urges to smoke. However, consistent with predictions, the protective effects of NWPA on urges were observed in that the association between low PosA and greater urges to smoke was no longer present among those engaging in more overall NWPA.

3. **Work-related Physical Activity**

a. **Smoking Level**

For the first set of models, results revealed a significant positive effect of BS WPA on smoking level, indicating that engaging in a greater proportion of overall WPA was associated with greater overall smoking level (see Table XX). The WS effect of WPA was not significant. These effects did not vary as a function of gender, as gender interactions were not significant.

TABLE XX

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODEL OF WORK PHYSICAL ACTIVITY PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Intercept 2	186	-2.5812	1.1209	-2.30	.022
Intercept 1	186	-1.1683	1.1173	-1.05	.297
Gender	877	0.1285	0.3763	0.34	.733
BMI	877	0.0261	0.0434	0.60	.547
WPA (WS)	877	0.0681	0.2394	0.28	.776
WPA (BS)	877	1.5397	0.5727	2.69	.007

Note. Gender coded as 0= female, 1= male; WPA = work-related physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

For the second set of models, there were no significant interactions between WPA and either measure of affect on smoking level (see Table XXI). Additionally, there were no significant three-way interactions between WPA, affect, and gender to predict smoking level.

b. **Smoking Urges**

Results for the first model showed that there was no main effect of either WS WPA or BS WPA on smoking urges (see Table XXII). Further, there were no significant interactions with gender.

The second set of models revealed a significant interaction between WS WPA and WS NegA in predicting urges to smoke (see Table XXIII). Follow-up analyses showed a significant positive effect of NegA on smoking urges for all individuals, indicating that greater daily NegA was associated with greater urges to smoke. However, this effect was significantly stronger on days with a greater proportion of WPA, Estimate = 0.5233, p <.001, compared to days with a lower proportion of WPA, Estimate = 0.2015, p = .002 (see Figure 2). In contrast, the interaction between BS NegA and BS WPA was not significant.

When examining PosA, results were similar in revealing a significant interaction between WS PosA and WS WPA in predicting smoking urges. Follow-up analyses indicated that on days with a greater proportion of WPA, there was a negative association between WS PosA and urges, Estimate = -0.3267, p <.001. That is, lower daily PosA was associated with stronger urges to smoke on higher WPA days. In contrast, on days with a lower proportion of WPA, the effect of PosA on urges to smoke was not significant, Estimate = -0.0558, p =.432 (see Figure 3). The interaction between BS PosA and BS

TABLE XXI

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODELS OF WORK PHYSICAL ACTIVITY AND AFFECT PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept 2	184	-2.5816	1.1226	-2.30	.023
Intercept 1	184	-1.1674	1.1189	-1.04	.298
Gender	875	0.1251	0.3767	0.33	.740
BMI	875	0.0264	0.0435	0.61	.544
WPA (WS)	875	0.0833	0.2403	0.35	.729
WPA (BS)	875	1.5471	0.5741	2.69	.007
Negative Affect (WS)	875	-0.0374	0.0865	-0.43	.666
Negative Affect (BS)	875	0.0278	0.1199	0.23	.816
WPA (WS) x Negative Affect (WS)	875	-0.2521	0.2996	-0.84	.400
WPA (BS) x Negative Affect (BS)	875	-0.0807	0.3506	-0.23	.818
Positive Affect Model					
Intercept 2	183	-2.8853	1.1351	-2.54	.012
Intercept 1	183	-1.4625	1.1309	-1.29	.198
Gender	876	0.1703	0.3764	0.45	.651
BMI	876	0.0373	0.0439	0.85	.396
WPA (WS)	876	0.0968	0.2415	0.40	.689
WPA (BS)	876	1.5828	0.5715	2.77	.006
Positive Affect (WS)	876	0.1964	0.0945	2.08	.038
Positive Affect (BS)	876	0.2340	0.1476	1.59	.113
WPA (WS) x Positive Affect (WS)	876	0.3672	0.3251	1.13	.259
WPA (BS) x Positive Affect (BS)	876	0.3364	0.3987	0.84	.399

Note. Gender coded as 0= female, 1= male; WPA = work-related physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; N = 188; *n (observations)* = 1069.

TABLE XXII

MIXED-EFFECTS REGRESSION MODEL OF WORK PHYSICAL ACTIVITY PREDICTING URGES TO SMOKE

	df	*Estimate*	*SE*	*t-value*	*p*
Intercept	185	3.1645	1.0933	2.89	.004
Gender	879	0.5199	0.3650	1.42	.155
BMI	879	0.0338	0.0426	0.79	.428
WPA (WS)	879	0.0568	0.1277	0.44	.657
WPA (BS)	879	0.5152	0.5545	0.93	.353

Note. Gender coded as 0= female, 1= male; WPA = work-related physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; N = 188; n *(observations)* = 1069.

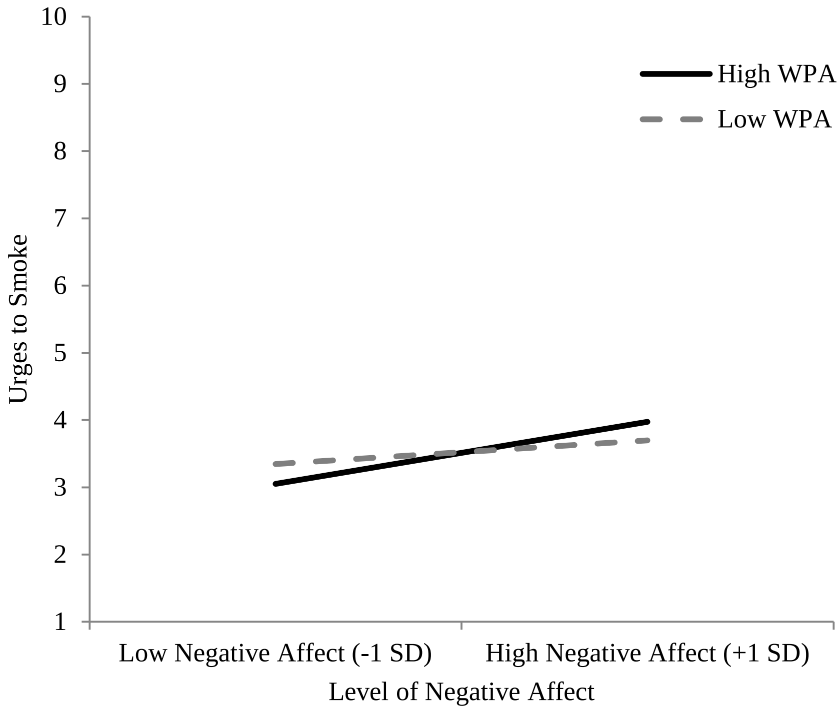
TABLE XXIII

MIXED-EFFECTS REGRESSION MODELS OF WORK PHYSICAL ACTIVITY AND AFFECT PREDICTING URGES TO SMOKE

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept	183	3.5162	1.0170	3.46	.001
Gender	877	0.5231	0.3392	1.54	.123
BMI	877	0.0191	0.0397	0.48	.630
WPA (WS)	877	-0.0168	0.1213	-0.14	.890
WPA (BS)	877	0.3453	0.5159	0.67	.504
Negative Affect (WS)	877	0.3624	0.0413	8.78	<.001
Negative Affect (BS)	877	0.5848	0.1080	5.42	<.001
WPA (WS) x Negative Affect (WS)	877	0.5415	0.1521	3.56	<.001
WPA (BS) x Negative Affect (BS)	877	0.1613	0.3204	0.50	.615
Positive Affect Model					
Intercept	183	3.4498	1.0967	3.15	.002
Gender	877	0.4636	0.3636	1.27	.203
BMI	877	0.0232	0.0427	0.54	.588
WPA (WS)	877	0.0441	0.1264	0.35	.727
WPA (BS)	877	0.4763	0.5501	0.87	.387
Positive Affect (WS)	877	-0.1912	0.0461	-4.15	<.001
Positive Affect (BS)	877	-0.2431	0.1424	-1.71	.088
WPA (WS) x Positive Affect (WS)	877	-0.4557	0.1700	-2.68	.008
WPA (BS) x Positive Affect (BS)	877	-0.3789	0.3948	-0.96	.338

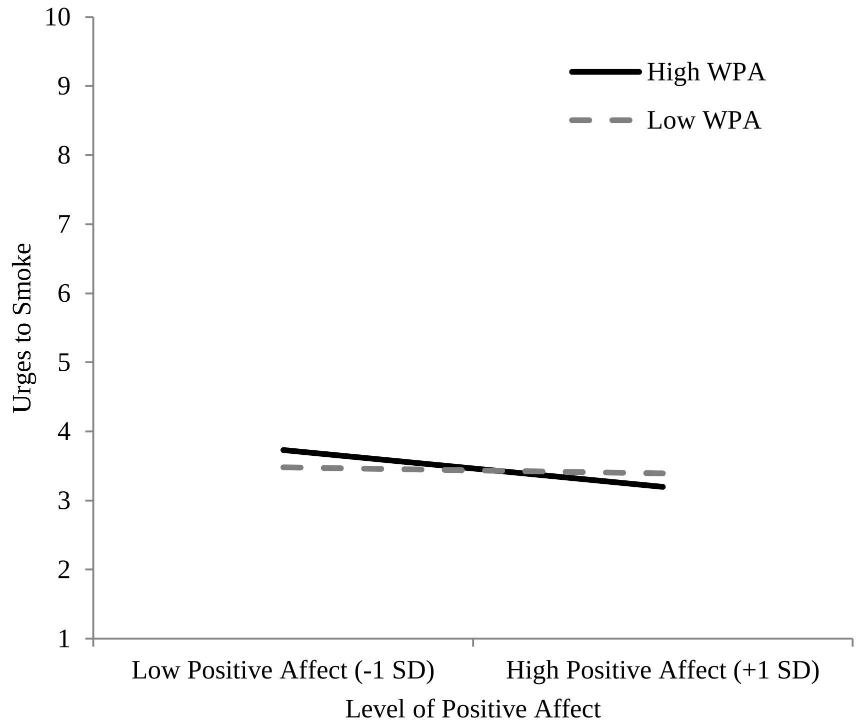
Note. Gender coded as 0= female, 1= male; WPA = work-related physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; N = 188; *n (observations)* = 1069.

Figure 2. Simple slopes of daily negative affect on urges to smoke as a function of the daily proportion of WPA (work-related physical activity).



Note. N = 188; *n (observations)* = 1069.

Figure 3. Simple slopes of daily positive affect on urges to smoke as a function of the daily proportion of WPA (work-related physical activity).



Note. N = 188; *n (observations)* = 1069.

WPA was not significant. There were no significant three-way interactions between WPA, affect, and gender.

c. **Summary of Work-related Physical Activity**

In sum, results for WPA partially confirmed hypotheses by showing that overall, but not daily, WPA predicted greater smoking levels; WPA did not influence urges. The affect hypothesis did not hold true for smoking level but was present for both NegA and PosA in predicting smoking urges. Specifically, engaging in a greater proportion of daily WPA strengthened both NegA's and PosA's associations with smoking urges.

4. **Moderate Physical Activity**

a. **Smoking Level**

Results for the first set of models showed a significant negative effect of BS moderate PA on smoking level, but the WS effect was not significant (see Table XXIV). The main effects, however, were both qualified by significant interactions with gender. Specifically, follow-up analyses showed that the WS effect was not significant for females but trending in the negative direction, Estimate = -0.2225, p = .133. For males, there was a significant positive effect of WS moderate PA on smoking level, Estimate = 0.3494, p =.046, such that higher levels of daily moderate PA were associated with greater daily smoking. For the BS effect, follow-up analyses showed a significant negative effect of BS moderate PA on smoking level for females, Estimate = -1.3753, p = .018, such that higher overall moderate PA was associated with lower levels of smoking. The BS effect was not significant for males, Estimate = 0.3789, p = .492.

TABLE XXIV

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODEL OF MODERATE PHYSICAL ACTIVITY PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Intercept 2	185	-2.7025	1.1412	-2.37	.019
Intercept 1	185	-1.2807	1.1375	-1.13	.262
Gender	876	0.1114	0.3841	0.29	.772
BMI	876	0.0332	0.0443	0.75	.453
MPA (WS)	876	-0.2225	0.1481	-1.50	.133
MPA (BS)	876	-1.3753	0.5816	-2.36	.018
MPA (WS) x Gender	876	0.5719	0.2295	2.49	.013
MPA (BS) x Gender	876	1.7541	0.8028	2.19	.029

Note. Gender coded as 0= female, 1= male; MPA = moderate physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect*;* *N* = 188; *n (observations)* = 1069.

Results for the second set of moderate PA models showed a significant three-way interaction between BS moderate PA, BS NegA, and gender (see Table XXV). Follow-up analyses revealed that the two-way interaction between BS moderate PA and NegA was significant for females, Estimate = -0.8988, p = .040, but not for males, Estimate = 0.2626, p = .485. Thus, the two-way interaction was further probed for females only. These analyses showed that among females higher in overall moderate PA, there was a significant negative association between NegA and smoking level, Estimate = -0.6692, p = .018. That is, higher levels of NegA were associated with lower smoking among those higher in overall moderate PA. Among those lower in moderate PA, there was no effect of NegA on smoking level, Estimate = 0.2149, p = .398 (see Figure 4).

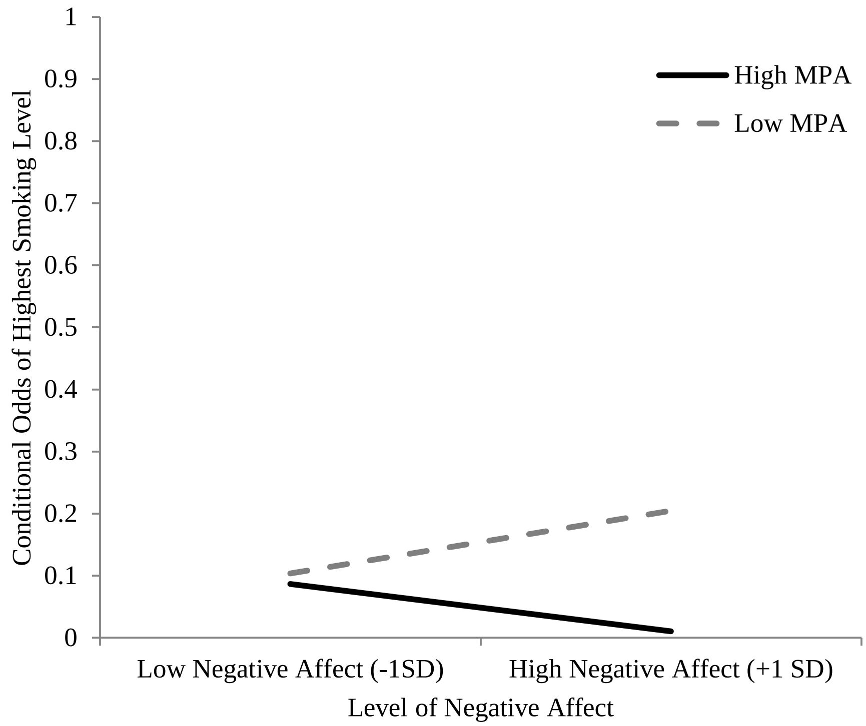
TABLE XXV

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODELS OF MODERATE PHYSICAL ACTIVITY AND AFFECT PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept 2	180	-2.7181	1.1354	-2.39	.018
Intercept 1	180	-1.2939	1.1315	-1.14	.254
Gender	873	0.2116	0.3790	0.56	.577
BMI	873	0.0312	0.0441	0.71	.479
MPA (WS)	873	-0.2413	0.1488	-1.62	.105
MPA (BS)	873	-1.6085	0.5918	-2.72	.007
Negative Affect (WS)	873	-0.1392	0.1262	-1.10	.271
Negative Affect (BS)	873	-0.2272	0.1611	-1.41	.159
MPA (WS) x Gender	873	0.5964	0.2306	2.59	.010
MPA (BS) x Gender	873	2.1042	0.8052	2.61	.009
Negative Affect (WS) x Gender	873	0.1534	0.1741	0.88	.378
Negative Affect (BS) x Gender	873	0.5696	0.2499	2.28	.023
MPA (WS) x Negative Affect (WS)	873	-0.1649	0.2229	-0.74	.456
MPA (BS) x Negative Affect (BS)	873	-0.8988	0.4360	-2.06	.040
MPA (WS) x Negative Affect (WS) x Gender	873	0.0890	0.3342	0.27	.790
MPA (BS) x Negative Affect (BS) x Gender	873	1.1609	0.5748	2.02	.044
Positive Affect Model					
Intercept 2	184	-2.9165	1.1642	-2.51	.013
Intercept 1	184	-1.4957	1.1601	-1.29	.199
Gender	875	0.1277	0.3865	0.33	.741
BMI	875	0.0391	0.0451	0.87	.386
MPA (WS)	875	0.0130	0.1134	0.11	.909
MPA (BS)	875	-0.4797	0.4013	-1.20	.232
Positive Affect (WS)	875	0.1977	0.0942	2.10	.036
Positive Affect (BS)	875	0.2532	0.1516	1.67	.095
MPA (WS) x Positive Affect (WS)	875	0.0716	0.1768	0.40	.686
MPA (BS) x Positive Affect (BS)	875	-0.0752	0.2559	-0.29	.769

Note. Gender coded as 0= female, 1= male; MPA = moderate physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

Figure 4. Simple slopes of overall negative affect on the conditional odds of highest smoking level as a function of overall MPA (moderate physical activity) for females.



Note. N = 188; *n (observations)* = 1069.

There were no significant interactions between PosA and moderate PA on smoking level. Further, no three-way interactions between PosA, moderate PA, and gender were found.

b. **Smoking Urges**

Results revealed a significant negative main effect of BS moderate PA on smoking urges, and the WS main effect of moderate PA was not significant (see Table XXVI). Both effects were qualified by marginally significant interactions with gender. Follow-up analyses showed that for females, there was a significant negative effect of BS moderate PA on urges, Estimate = -1.1901, p = .025, such that higher overall moderate PA was associated with lower overall urges to smoke. For males, this effect was not significant, Estimate = 0.1157, p = .826. Additionally, for WS moderate PA, the effect was not significant for either gender but in the negative direction for females, Estimate = -0.0740, p = .317, and in the positive direction for males, Estimate = 0.1418¸ p =.128.

For the second set of models, results revealed no significant two-way interactions between moderate PA and NegA on urges to smoke (see Table XXVII). For PosA, however, there was a marginally significant interaction between BS moderate PA and BS PosA. Follow-up analyses showed that among those lower in overall moderate PA, there was a significant negative association between BS PosA and urges, Estimate = -0.4874, p = .013. That is, among individuals lower in PA, lower levels of overall PosA were associated with higher urges to smoke. Among those higher in overall PA, however, the association between BS PosA and urges was not significant, Estimate = -0.0661, p =.705

TABLE XXVI

MIXED-EFFECTS REGRESSION MODEL OF MODERATE PHYSICAL ACTIVITY PREDICTING URGES TO SMOKE

	df	*Estimate*	*SE*	*t-value*	*p*
Intercept	184	3.0859	1.0820	2.85	.005
Gender	878	0.4491	0.3652	1.23	.219
BMI	878	0.0403	0.0423	0.95	.341
MPA (WS)	878	-0.0740	0.0739	-1.00	.317
MPA (BS)	878	-1.1901	0.5301	-2.25	.025
MPA (WS) x Gender	878	0.2158	0.1188	1.82	.070
MPA (BS) x Gender	878	1.3057	0.7467	1.75	.081

Note. Gender coded as 0= female, 1= male; MPA = moderate physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

TABLE XXVII

MIXED-EFFECTS REGRESSION MODELS OF MODERATE PHYSICAL ACTIVITY AND AFFECT PREDICTING URGES TO SMOKE

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept	183	3.5819	1.0208	3.51	.001
Gender	877	0.4609	0.3418	1.35	.178
BMI	877	0.0178	0.0399	0.45	.655
MPA (WS)	877	0.0394	0.0554	0.71	.477
MPA (BS)	877	-0.3518	0.3504	-1.00	.316
Negative Affect (WS)	877	0.3827	0.0413	9.27	<.001
Negative Affect (BS)	877	0.5737	0.1102	5.20	<.001
MPA (WS) x Negative Affect (WS)	877	0.0653	0.0778	0.84	.402
MPA (BS) x Negative Affect (BS)	877	-0.1524	0.2456	-0.62	.535
Positive Affect Model					
Intercept	182	3.6366	1.0886	3.34	.001
Gender	878	0.4276	0.3629	1.18	.239
BMI	878	0.0166	0.0425	0.39	.697
MPA (WS)	878	0.0134	0.0573	0.23	.815
MPA (BS)	878	-0.4694	0.3711	-1.26	.206
Positive Affect (WS)	878	-0.1940	0.0463	-4.19	<.001
Positive Affect (BS)	878	-0.2768	0.1417	-1.95	.051
MPA (WS) x Positive Affect (WS)	878	-0.1295	0.0861	-1.50	.133
MPA (BS) x Positive Affect (BS)	878	0.4290	0.2438	1.76	.079

Note. Gender coded as 0= female, 1= male; MPA = moderate physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

(see Figure 5). There were no significant three-way interactions between moderate PA, affect, and gender on smoking urges.

c. Summary of Moderate Physical Activity

In sum, results for moderate PA were again partially consistent with predictions but also diverged in some ways as well. For females, overall moderate PA was associated with lower overall smoking level and urges to smoke; the effects for daily moderate PA were in the same direction but not significant. In contrast, for males, overall PA was not related to smoking levels or urges, but higher levels of daily moderate PA were significantly associated with greater daily smoking levels and trended in that direction for urges. The affect hypotheses diverged from predictions for smoking level for females by showing that higher levels of overall moderate PA enhanced the relation between NegA and smoking. However, consistent with predictions, higher overall moderate PA did reduce the link between low PosA and higher urges to smoke.

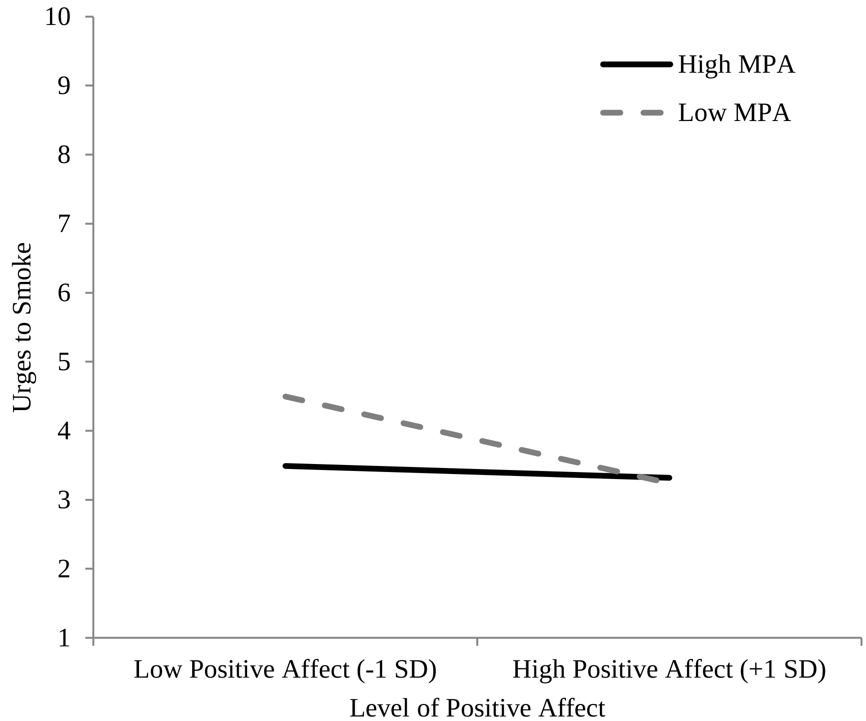
5. Vigorous Physical Activity[1]

a. Smoking Level

There was a significant negative main effect of WS vigorous PA on smoking level, but the BS main effect was not significant (see Table XXVIII). Both main effects, however, were qualified by significant interactions between vigorous PA and gender. For the WS effect, follow-up analyses showed a significant negative effect for females, Estimate = -0.9339, p = .015, indicating that higher daily vigorous PA was associated with lower daily smoking level. For males, the WS vigorous PA effect was not significant, Estimate = 0.4118, p = .197. Regarding the BS effect, the effect of vigorous

[1] For vigorous PA analyses, the *SD* for the between-subjects average PA was slightly higher than the mean, and thus lower levels represent the value when average vigorous PA is equal to 0.

Figure 5. Simple slopes of overall positive affect on urges to smoke as a function of overall MPA (moderate physical activity).



Note. N = 188; *n (observations)* = 1069.

TABLE XXVIII

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODEL OF VIGOROUS PHYSICAL ACTIVITY PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Intercept 2	185	-2.8889	1.1446	-2.52	.012
Intercept 1	185	-1.4633	1.1405	-1.28	.201
Gender	876	0.2101	0.3817	0.55	.582
BMI	876	0.0381	0.0444	0.86	.391
VPA (WS)	876	-0.9339	0.3812	-2.45	.015
VPA (BS)	876	0.4908	1.0025	0.49	.625
VPA (WS) x Gender	876	1.3449	0.4980	2.70	.007
VPA (BS) x Gender	876	-3.0214	1.4938	-2.02	.043

Note. Gender coded as 0= female, 1= male; VPA = vigorous physical activity; BMI = body mass Index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

PA on smoking level was significant and negative for males, Estimate = -2.5174, p =.022, indicating that higher overall vigorous PA was associated with lower overall smoking level. This BS effect was not significant for females, Estimate = 0.4908, p = .625.

For the second set of models, there were no significant interactions between vigorous PA and affect on smoking level (see Table XXIX). Furthermore, there were no significant three-way interaction effects between vigorous PA, affect, and gender, on smoking level.

b. **Smoking Urges**

The first set of models indicated that there was no main effect of either WS or BS vigorous PA on urges to smoke (see Table XXX). There was, however, a significant interaction between BS vigorous PA and gender. Follow-up analyses

TABLE XXIX

MIXED-EFFECTS ORDINAL LOGISTIC REGRESSION MODELS OF VIGOROUS PHYSICAL ACTIVITY AND AFFECT PREDICTING SMOKING LEVEL

	df	*Estimate*	*SE*	*t-value*	*p*
Negative Affect Model					
Intercept 2	184	-2.4592	1.1413	-2.15	.033
Intercept 1	184	-1.0446	1.1379	-0.92	.360
Gender	875	0.1989	0.3843	0.52	.605
BMI	875	0.0199	0.0442	0.45	.653
VPA (WS)	875	-0.1554	0.2413	-0.64	.520
VPA (BS)	875	-0.8977	0.7391	-1.21	.225
Negative Affect (WS)	875	-0.0491	0.0856	-0.57	.567
Negative Affect (BS)	875	0.0267	0.1220	0.22	.827
VPA (WS) x Negative Affect (WS)	875	-0.2600	0.3428	-0.76	.448
VPA (BS) x Negative Affect (BS)	875	-0.1017	0.4849	-0.21	.834
Positive Affect Model					
Intercept 2	183	-2.8189	1.1545	-2.44	.016
Intercept 1	183	-1.3967	1.1505	-1.21	.226
Gender	876	0.2380	0.3840	0.62	.536
BMI	876	0.0332	0.0447	0.74	.458
VPA (WS)	876	-0.1581	0.2425	-0.65	.514
VPA (BS)	876	-0.9807	0.7392	-1.33	.185
Positive Affect (WS)	876	0.2143	0.0952	2.25	.025
Positive Affect (BS)	876	0.2489	0.1507	1.65	.099
VPA (WS) x Positive Affect (WS)	876	0.3988	0.3821	1.04	.270
VPA (BS) x Positive Affect (BS)	876	0.0851	0.5479	0.16	.877

Note. Gender coded as 0= female, 1= male; VPA = vigorous physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; N = 188; *n (observations)* = 1069.

TABLE XXX

MIXED-EFFECTS REGRESSION MODEL OF VIGOROUS PHYSICAL ACTIVITY PREDICTING SMOKING URGES

	df	*Estimate*	*SE*	*t-value*	*p*
Intercept	184	2.7469	1.0767	2.55	.012
Gender	878	0.6138	0.3580	1.71	.087
BMI	878	0.0508	0.0421	1.21	.228
VPA (WS)	878	0.0604	0.1826	0.33	.741
VPA (BS)	878	0.3809	0.9408	0.40	.686
VPA (WS) x Gender	878	0.0655	0.2471	0.26	.791
VPA (BS) x Gender	878	-3.6168	1.3804	-2.62	.009

Note. Gender coded as 0= female, 1= male; VPA = vigorous physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; *N* = 188; *n (observations)* = 1069.

revealed that for males, there was a significant negative effect of overall vigorous PA on smoking urges, Estimate = -3.2359, *p* =.001, such that higher overall vigorous PA was associated with lower urges to smoke. This effect was not significant for females, Estimate = 0.3908, *p* = .686.

The second set of models showed a marginally significant three-way interaction between BS vigorous PA, BS NegA, and gender (see Table XXXI). Follow-up analyses revealed that the interaction between BS vigorous PA and BS NegA was near statistically significant for females, Estimate = 0.8917, *p* = .111, but was far from significant in males, Estimate = -0.4709, *p* =.436. Given that neither interaction was significant, effects were not further examined. When higher-order three-way interactions and their additional components (i.e., all relevant two-way interactions) were dropped, neither interaction

TABLE XXXI

MIXED-EFFECTS REGRESSION MODELS OF VIGOROUS PHYSICAL ACTIVITY AND AFFECT PREDICTING SMOKING URGES

	df	*Estimate*	*SE*	*t- value*	*p*
Negative Affect Model					
Intercept	180	3.0363	0.9911	3.06	.003
Gender	874	0.5671	0.3291	1.72	.085
BMI	874	0.0404	0.0388	1.04	.298
VPA (WS)	874	-0.0295	0.1758	-0.17	.867
VPA (BS)	874	0.6951	0.8678	0.80	.423
Negative Affect (WS)	874	0.4347	0.0566	7.68	<.001
Negative Affect (BS)	874	0.6371	0.1419	4.49	<.001
VPA (WS) x Gender	874	0.2089	0.2371	0.88	.378
VPA (BS) x Gender	874	-3.7328	1.2712	-2.94	.003
Negative Affect (WS) x Gender	874	-0.1127	0.0832	-1.35	.176
Negative Affect (BS) x Gender	874	-0.0598	0.2106	-0.28	.777
VPA (WS) x Negative Affect (WS)	874	0.0978	0.2497	0.39	.695
VPA (BS) x Negative Affect (BS)	874	0.8917	0.5589	1.60	.111
VPA (WS) x Negative Affect (WS) x Gender	874	-0.0861	0.3228	-0.27	.790
VPA (BS) x Negative Affect (BS) x Gender	874	-1.3626	0.8234	-1.65	.098
Positive Affect Model					
Intercept	180	3.1487	1.0683	2.95	.004
Gender	874	0.5245	0.3518	1.49	.136
BMI	874	0.0363	0.0417	0.87	.385
VPA (WS)	874	0.0206	0.1804	0.11	.909
VPA (BS)	874	0.6233	0.9393	0.66	.507
Positive Affect (WS)	874	-0.3046	0.0643	-4.74	<.001
Positive Affect (BS)	874	-0.2508	0.1947	-1.29	.198
VPA (WS) x Gender	874	0.1155	0.2440	0.47	.636
VPA (BS) x Gender	874	-3.6193	1.3675	-2.65	.008
Positive Affect (WS) x Gender	874	0.2050	0.0938	2.19	.029
Positive Affect (BS) x Gender	874	-0.0351	0.2739	-0.13	.898
VPA (WS) x Positive Affect (WS)	874	-0.0023	0.2878	-0.01	.994
VPA (BS) x Positive Affect (BS)	874	-0.7378	0.6921	-1.07	.287
VPA (WS) x Positive Affect (WS) x Gender	874	-0.0980	0.3795	-0.26	.796
VPA (BS) x Positive Affect (BS) x Gender	874	2.3382	1.0280	2.27	.023

Note. Gender coded as 0= female, 1= male; VPA = vigorous physical activity; BMI = body mass index; BS = between-subjects effect; WS = within-subjects effect; N = 188; n *(observations)* = 1069.

between WS vigorous PA and WS NegA nor BS vigorous PA and BS NegA was significant.

Furthermore, the three-way interaction between BS vigorous PA, BS PosA and gender was significant. Follow-up analyses showed that the interaction between BS vigorous PA and BS PosA was not significant for females, Estimate = -0.7378, p =.287, but was significant for males, Estimate = 1.6004, p =.036. Further probing of the interaction for males showed that among individuals lower in overall vigorous PA, there was a significant negative association between BS PosA and urges, Estimate = -0.6095, p = .025. That is, among less active males, lower overall PosA was associated with higher overall urges to smoke. Among those higher in overall vigorous PA, there was no association between BS PosA and urges, Estimate = 0.1349, p = .591 (see Figure 6).

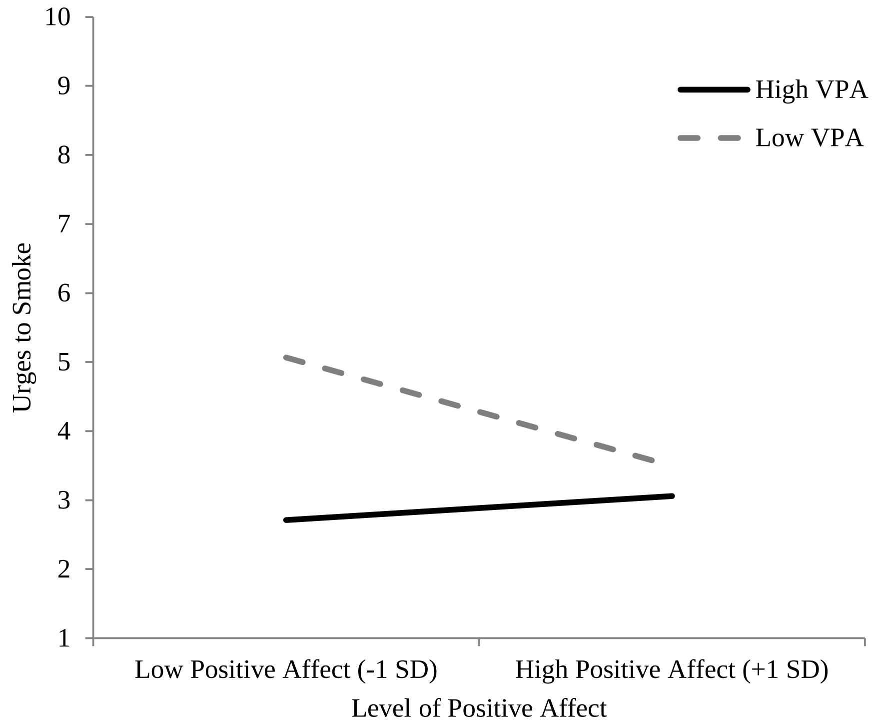
c. **Summary of Vigorous Physical Activity**

In sum, results for vigorous PA partially confirmed hypotheses by documenting that for females, higher daily, but not overall, vigorous PA was associated with lower levels of daily smoking. Neither daily nor overall vigorous PA predicted urges for females. For males, overall greater vigorous PA was associated with lower overall smoking level and urges, but daily levels were not significantly predictive of smoking outcomes. Furthermore, affect hypotheses were not confirmed for smoking level but were partially corroborated for urges. Specifically, for males, engaging in a greater amount of overall vigorous PA reduced the link between low PosA and higher smoking urges.

6. **Comparison of Moderate and Vigorous Physical Activity**

Results across intensity level were not consistent with hypotheses that

Figure 6. Simple slopes of overall positive affect on urges to smoke as a function of overall VPA (vigorous physical activity) for males.



Note. N = 188; *n (observations)* = 1069.

vigorous PA would have a uniformly stronger effect on smoking outcomes. Rather, results showed important gender differences across intensity levels. Specifically, for females, overall moderate activity was associated with lower smoking level and urges. At the daily level, the moderate PA effects trended in the negative direction to both smoking outcomes for females but were not statistically significant. Overall vigorous PA was not protective for females on either smoking outcome, but daily vigorous PA was associated with lower daily smoking level. For males, overall vigorous PA was associated with lower smoking levels and urges. In contrast, overall moderate PA was not associated with smoking outcomes for males, and daily moderate PA actually predicted higher levels of smoking.

Furthermore, gender and intensity-specific differences were also observed for affect hypotheses. Specifically, overall moderate activity enhanced NegA's link to smoking level for females; such an effect was not observed for vigorous activity for either males or females. Regarding urges, the interaction between overall moderate PA and PosA was marginally significant and showed a protective effect across the sample. This same interactive effect was statistically significant for vigorous PA but the protective effect was only present for males.

IV. Discussion

A. **Overview**

The current study examined the association between PA – obtained through a retrospective diary recall – and real-time reports of cigarette smoking and urges to smoke in a sample of young adults enriched for past smoking behavior. Despite burgeoning research linking PA to improved smoking outcomes, far less is known about whether and how these seemingly opposing behaviors co-exist in younger populations (Kaczynski et al., 2008). Furthermore, teen cessation programs are beginning to incorporate PA as an adjunctive component to treatment (Horn et al., 2013; Horn et al., 2011). Better understanding the links between PA and smoking as well as other cessation targets, such as urges, is extremely important in younger populations (e.g., young adults) who may demonstrate unique patterns of smoking, risk for progression (Chassin et al., 2000; Hammond, 2005), and desires to quit (CDC, 2008). Finally, many researchers have speculated and some have shown evidence to indicate that PA is indirectly related to smoking via its impact on mood (e.g., Kaczynski et al., 2008; Tart et al., 2010). Yet, this mediating effect has received inconsistent support to date (e.g., Roberts et al., 2012), and this study sought to assess an alternate pathway by which PA, mood, and smoking are interrelated. To this end, this study examined two main questions. First, how do varying types of PA predict cigarette smoking and urges to smoke? Second, does PA reduce the degree to which positive and negative affective states are tied to smoking behavior and urges? This study extended previous research in several ways, including its use of innovative real-time methods to evaluate PA, smoking, and mood at both within (WS)-

and between-subject (BS) levels, examining multiple constructs of PA, and assessing these associations among a unique sample of young adult smokers.

B. **Smoking and Mood**

Despite considerable empirical evidence linking negative affect (NegA) and cigarette smoking (e.g., Ameringer & Leventhal, 2010; Chaiton et al., 2009; Kassel et al., 2003), results from the present analyses diverged from this well-established finding. That is, NegA, assessed over the measurement week through random momentary reports, was not associated with smoking level across days or participants. Overall positive affect (PosA) was associated with higher smoking level for females. Results for urges converged with extant literature documenting the inherent role of NegA in smoking urges (e.g., Tiffany & Drobes, 1991) by showing that higher levels of both BS and WS NegA predicted stronger urges to smoke across the sample. For PosA, however, only low WS PosA predicted stronger urges to smoke in females.

The discrepancy from literature on the link between NegA and smoking is surprising. However, a recent review by Ameringer & Leventhal (2010) illustrated that findings have been mixed on the specific association between NegA and cigarettes per day. One explanation for the divergence could be that smoking level was measured ordinally. Recent analyses from earlier measurement waves of the current study used a piece-wise modeling approach to compare affective states in youth smoking no cigarettes, one cigarette, or multiple cigarettes across the EMA week (Pugach, Hedeker, Richmond, Sokolovsky, & Mermelstein, in press). Results revealed that adolescent non-smokers and increasingly higher-level smokers reported lower overall NegA (and lower NegA variability) compared to one-cigarette smokers; this effect was similar, albeit not statistically significant in all cases, for PosA. It is possible that in the present analyses as well, the ordinal measurement of cigarettes might preclude our ability to detect mood differences as a function of smoking level. It should also be noted that smokers in the current study were only smoking on average around 19 days in the past month. The majority of studies examining the association between NegA and smoking do so among daily and generally higher-level smokers, which may also play a role in this divergence.

Although the direction of the PosA effect on smoking level appears contrary to expectations, the data's inability to establish temporal precedence might be a viable explanation. Despite the premise of a prospective association from mood to subsequent cigarette smoking, the positive association observed for females might reflect the mood boost they receive from smoking at higher levels. When considered within this context, this may be consistent with the largely overlooked but important role of PosA enhancement in smoking and substance use (e.g., Ameringer & Leventhal, 2010; Baker et al., 2004; Wills, Sandy, Shinar, & Yaeger, 1999). The temporal ordering issues may impact the smoking level outcome more so than urges, because smoking events were recorded separately from mood, whereas mood and urges were assessed simultaneously.

Gender differences in the association between distinct affective states (i.e., both NegA and PosA) and smoking have received much less empirical attention compared to singular assessments of NegA or constructs of global mood and depressive symptoms. Yet, some evidence suggests that PosA enhancement may be a more important motivational process in smoking for females as compared to males (Nakajima & al'Absi, 2012), and the present results may validate that claim. However, one study that similarly utilized EMA to examine the association between various mood states, smoking, and smoking urges found that happiness, one component of PosA, was positively associated with contemporaneous urges and increased risk for future smoking within the hour for females but not males (Delfino, Jamner, & Whalen, 2001). The present results might corroborate these findings to some extent by suggesting that smoking in females is more sensitive to fluctuations in PosA than males, but the direction of these associations warrants further exploration.

C. **Physical Activity and Mood**

Preliminary results linking PA with mood exhibited some consistency with extant literature. In particular, daily increases in moderate PA and the proportion of non-work-related physical activity (NWPA) were each associated with lower daily NegA, corroborating evidence for the benefits of engaging in any daily PA on daily NegA (e.g., Steptoe et al., 1998). Additionally, there was no association between vigorous PA and mood, converging with results found by Poole et al. (2011) showing that light, moderate, and total activity, but not vigorous PA, were associated with improved mood. Daily work-related physical activity (WPA) was disadvantageous to both PosA and NegA, extending the little research to date showing that greater WPA is associated with elevated depression (McKercher et al., 2009). Finally, higher WS caloric energy expenditure was marginally associated with higher PosA and lower NegA for females. In contrast, for males, higher WS caloric energy expenditure was marginally associated with lower PosA. This gender difference is likely explained by the fact that caloric energy expenditure included all types of PA, including WPA and NWPA, as well as moderate and vigorous PA. Given the differential effects of these constructs on mood, their combination might dampen affective benefits, or detriments, independently observed.

Several important themes emerge from the results. First, all significant effects were only present at the WS level. This is especially meaningful given that the majority of studies examining the association between PA and mood have evaluated outcomes across as opposed to within individuals (e.g., Penedo & Dahn, 2005). Second, vigorous PA was the only PA measure not predictive of mood, perhaps in part due to individual differences in affective responses to higher-intensity PA (e.g., Ekkekakis et al., 2005; Ekkekakis et al., 2011; Petruzzello et al., 1997). It should be noted, however, that the association between WS vigorous PA and NegA trended in a negative direction for males, such that higher levels of daily vigorous PA were associated with lower levels of NegA. This trend suggests that we might observe this effect with larger samples. Third, higher levels of WPA were associated with both higher daily NegA and lower PosA, emphasizing the significance of context in the mental health benefits of PA (e.g., Asztalos et al., 2010; Asztalos et al., 2009). Finally, with the exception of WPA, and marginally with caloric energy expenditure, all effects were predictive of NegA but not PosA. Although PA has long been linked to overall better mood outcomes, such as lower depressive symptoms (e.g., Birkeland et al., 2009; Nabkasorn et al., 2006; Penedo & Dahn, 2005; Raudsepp & Neissaar, 2012), fewer studies have differentially examined PosA and NegA. Still further, even among studies that have examined both PosA and NegA (e.g., Poole et al., 2011; Steptoe et al., 1998), the evidence has been mixed, highlighting a need for further empirical clarification and replication.

The null association observed between some types of PA and mood does not definitively falsify the notion that some individuals benefit from PA. For example, past research has suggested that males experience improved emotional responses to vigorous

PA, whereas females show affective improvements more so from moderate PA (Asztalos et al., 2010). Although few significant gender differences emerged in the current study, some analyses showed trends in opposing directions (e.g., vigorous PA), suggesting that differences may exist but are not detectable in this smaller sample. Evidence is also building to suggest that the mental health benefits of PA are not ubiquitous (e.g., Ekkekakis et al., 2005; Ekkekakis et al., 2011; Petruzzello et al., 1997). Thus, further evaluation of these associations in a piece-wise or curvilinear approach, or among further delineated subgroups, would be beneficial.

D. **Physical Activity and Smoking**

The primary aim of the current study was to examine the association between multiple measures of PA and smoking level as well as smoking urges. Results examining the association between PA and smoking varied by type of PA, whether the association was a between- or within-subjects one, and gender. As such, the largely generic hypothesis that PA (except for WPA) would be protective across all contexts, albeit stronger for males, was corroborated only for some individuals in some situations.

1. **Caloric Energy Expenditure**

Results for caloric energy expenditure revealed that higher BS caloric energy expenditure was associated with higher smoking levels and urges to smoke for females. Effects were not significant at the WS level or for males. Although contrary to predictions, results for caloric energy expenditure might be explained by closely evaluating the components of this construct. In contrast to other measures of PA in the present study, caloric energy expenditure takes into account several factors beyond PA alone, including the hours of sleep obtained each night and weight. For example, when comparing individuals of the same weight, sleeping less yielded higher daily caloric energy expenditure within the context of similar PA behavior based on the PAR formula (Sallis et al., 1985). In line with that rationale, recent analyses examining the association between sleep and smoking in adults showed that the risk of smoking was higher among those who slept less than 6 hours each night as compared to those who slept 7 to 8 hours (Schoenborn & Adams, 2008). This effect was strongest in young adults compared to older age groups. An individual's sleep behavior may thus be undermining benefits otherwise observed by PA within this context.

Weight is another potential confound of the caloric energy expenditure variable. Despite controlling for BMI, an individual's weight (only one component of BMI) largely affects daily caloric energy expenditure, as heavier individuals burn more calories than lighter individuals within the context of the same activity. However, being overweight may also be a unique risk factor for frequent smoking among females, in particular (Park, 2009), which might partially explain the gender difference observed. Finally, caloric energy expenditure subsumed all types of PA, including NWPA and WPA, as well as all intensity levels, moderate and vigorous, which each independently exhibited unique, and in some cases, opposing effects on smoking outcomes. Because we have more detailed findings from sub-categories, it seems unnecessary to draw any definitive conclusions from the caloric energy expenditure data.

2. **Non-work-related Physical Activity**

Engaging in a greater proportion of overall NWPA was associated with lower levels of smoking and urges at the BS level for females and males. At the WS level, however, greater NWPA was associated with lower levels of smoking for females but higher levels for males. There was no WS effect of NWPA on urges. Results largely corroborate extant literature on the beneficial effects of NWPA (e.g., leisure-time PA and intentional exercise) on smoking and urges to smoke (e.g., Kaczynski et al., 2008; Roberts et al., 2012) and extend it by documenting effects in real life as well as considering NWPA within the context of WPA. The WS effect on smoking level, however, diverged with predictions for males, suggesting possible gender differences in the association between NWPA, broadly, and smoking. A closer evaluation of the intensity-specific effects might provide further explanation.

3. **Moderate and Vigorous Physical Activity**

In contrast with hypotheses that vigorous PA would have stronger effects on smoking outcomes compared to moderate PA, and effects of PA would overall be stronger for males than females, results revealed much more nuanced gender and intensity-specific effects. More specifically, higher BS moderate PA was associated with lower levels of smoking and urges to smoke for females. Although WS, daily moderate PA was in the same direction to both smoking level and urges for females, effects were not significant. For males, BS moderate PA was not predictive of smoking level or urges, but higher WS moderate PA was associated with greater smoking levels and trended in that direction for urges as well. Regarding vigorous PA, greater BS vigorous PA predicted lower smoking levels and urges for males; no significant WS effects were observed for males. For females, higher daily vigorous PA was associated with lower levels of smoking but did not predict urges.

In the review by Kaczynski et al. (2008), researchers found only a subset of studies that evaluated gender differences in the association of PA and smoking— those that did showed mixed findings. Based on their synthesis, researchers asserted that some evidence might exist to support the presence of a stronger inverse association between PA and smoking in females. However, actual intervention data in younger samples, such as the NOT+FIT trial, would suggest the contrary, as they found stronger effects of the PA program for males compared to females (Horn et al., 2011). The present study took an additional step from previous explorations by examining effects at both WS and BS levels and across intensity, which might help explicate the history of mixed findings. As described, several studies among adolescent and young adult samples examining the differential effects of moderate and vigorous PA on smoking level have revealed stronger effects of vigorous PA compared to moderate PA (e.g., Larson et al., 2007; VanKim et al., 2010). Research on smoking urges has further shown that although both moderate and vigorous PA similarly reduce urges to smoke acutely, vigorous PA tends to exhibit longer-lasting benefits (Scerbo et al., 2010). Despite evidence pointing toward vigorous PA as more powerful for smoking reduction, results from the present study indicated that the specific function of vigorous PA as a tool for smoking reduction and cessation might not be universal.

The gender differences in the effects of moderate and vigorous PA on smoking outcomes might be explained by several factors, including assumptions regarding the intent behind the PA reported by participants as well as previously established gender differences in PA behavior and preferences. Specifically, as described, PA is broad and encompasses any movement that results in energy expenditure, including intentional exercise, leisure-time activities, transportation, and work-related activity (Caspersen et al., 1985). One notable limitation of the current study is that it cannot more precisely differentiate non-work-related activities. However, deductions can be made based on the categories of activity reported and knowledge from previous PA research.

By the nature of the interview, walking was nearly always considered a moderate activity, and the majority of moderate activities reported by both genders were characterized as walking (78.8% for females and 75.0% for males). Previous research reveals that young adult females are much more likely to walk than males (for transportation, recreation, or more intentional exercise; Leslie, Fotheringam, Owen, & Bauman, 2001), and that women are more likely to walk as a form of intentional exercise (Hovell et al., 1989). Furthermore, it is through walking that some females meet recommended standards for weekly moderate to vigorous PA (O'Dougherty, Arikawa, Kaufman, Kurzer, & Schmitz, 2010), suggesting that walking may serve a different purpose for females than males. Within the intensity level of moderate activity, other more seemingly intentional forms of exercise or recreation were much lower in frequency, calling the heterogeneous nature of this construct into question. In contrast, for vigorous PA, activities reported included strength and toning, sports, running, and other cardio/recreation. Thus, vigorous activities in the present study appear highly likely to be forms of intentional exercise or recreational activities for both genders.

Together, this suggests that although moderate PA likely constitutes both intentional exercise and perhaps less recreational forms of PA, females may be more likely than males to use moderate PA for health, fitness, or recreational benefits, enhancing its protective nature. For males, there might be more variability in the intention behind moderate activity, which might help explain the null effect between smoking level and overall moderate PA for males but positive association with daily moderate PA. For example, one recent study examining links between PA and anxiety in young adults used smoking as a covariate in their models and as an ancillary finding, discovered that daily smokers were more than twice as likely to walk frequently (O'Loughlin et al., 2013). Researchers proposed that young adults may be more likely to walk in order to smoke because smoking is no longer allowed inside many locations across the country, including public transit. This is true for the greater Chicago-land area, the location from which the majority of these data were collected (Illinois Department of Public Health, 2008). Although O'Loughlin et al. (2013) did not examine gender differences in this effect, it is possible that males in the present study were engaging in increased activity on a given day in an effort to smoke more frequently.

Vigorous PA, regardless of gender, appears to consist of more intentional forms of PA for exercise or recreation. Although differences were observed in the specific nature of vigorous PA effects (i.e., daily versus overall), it was protective for both males and females, and thus consistent with extant evidence on the benefits of vigorous PA for reduced smoking (Larson et al., 2007; VanKim et al., 2010). Regarding the unique benefit observed for daily vigorous PA and smoking level in females, described gender differences in activity behavior may explain the finding. That is, if females are less likely than males to engage in vigorous PA (corroborated in descriptive analyses), effects related to daily differences may be more potent.

4. **<u>Work-related Physical Activity</u>**

Higher overall WPA was associated with higher smoking at the BS level for both females and males. WS, daily WPA effects were not significant in predicting smoking level, and WPA did not predict urges either between- or within-subjects. Results for WPA were largely consistent with predictions that engaging in a greater proportion of WPA would be associated with greater smoking levels. Although there is a paucity of literature dedicated to this topic, results converge with past findings showing links between higher occupational PA and increased smoking in older adult samples (Holme et al., 1981). It is notable to mention that a recent review by Kirk and Rhodes (2011) synthesized literature examining occupational correlates of leisure-time PA in adult samples. Their analyses showed that although evidence is somewhat mixed, individuals engaging in more WPA were also likely to engage in more leisure-time PA. Our results suggest, however, that if the amount of co-occurring NWPA is not significant enough to counterbalance the WPA, these individuals may be at increased risk for negative health behavior, smoking more specifically.

5. Commentary on Associations between Physical Activity, Smoking, and Urges

Overall, two points are important to address regarding the results between PA, smoking level, and smoking urges. First, all non-work-related PA constructs (i.e., NWPA, moderate PA, and vigorous PA) showed relatively similar BS effects to both smoking level and smoking urges, corroborating past research broadly identifying PA benefits to both the behavior of smoking (e.g., Kaczynski et al., 2008) and urges to smoke (e.g., Roberts et al., 2012). This is notable for research on urges, in particular, given that the majority of studies examining the association between PA and urges in adolescent and young adult populations (as well as most age groups) have done so within the context of acute abstinence and a laboratory setting (e.g., Everson et al., 2006; Everson et al., 2008). Although acute abstinence may be more analogous to a quit attempt, we know that urges on a normal smoking day are associated with future quitting success (Fidler & West, 2011), rendering a typical day an important context of investigation. Second, similarities between smoking level and urges were not apparent for WS effects. Specifically, across PA variables, no significant WS PA effects were observed on smoking urges, although several analyses revealed trends in the expected direction. It is possible that the way in which urge was measured as a daily average might impede the ability to detect more proximal effects. It would be prudent to examine these associations with larger samples, as results suggest that effects might emerge with additional power.

E. Mood and Physical Activity Interactions

A secondary goal of the current study was to examine the association between PA, smoking, and mood both at the daily, WS, level, and across individuals over the course of a week. It was hypothesized that PA would moderate the association between mood and smoking, such that high PA levels would reduce the link between these interrelated constructs.

1. Smoking Level and Mood

Regarding smoking level, one interaction emerged between NegA and moderate PA for females. However, the direction of this effect diverged from predictions. Specifically, among females engaging in overall higher levels of moderate PA, low levels of NegA were associated with higher levels of smoking. Among those engaging in low levels of moderate PA, there was no association between NegA and smoking. Based on preliminary analyses, moderate PA was marginally associated with improved daily NegA, but it did not differentiate individuals in terms of their overall affect. It is possible that females engaging in high levels of moderate PA were experiencing daily mood boosts, perhaps counteracting withdrawal symptomatology, but not overall affective improvements, leading them to continue to rely on cigarettes to enhance baseline affect.

Although unique in content, a recent study utilized a similar theoretical and analytical framework to examine how moderate and vigorous PA reduced the association between anxiety sensitivity and binge eating behavior in adults. Their results revealed that although moderate PA functioned as hypothesized to reduce the association, vigorous PA enhanced the effect (DeBoer et al., 2012). Researchers proposed that this unexpected effect might have emerged due to the potential of vigorous PA to reinforce maladaptive coping behavior (e.g., using PA to counteract weight gain resulting from binge eating). Present results might suggest a similar phenomenon, albeit with moderate PA. Specifically, research has cited an association between weight control motives and cigarette smoking in adolescent and young adult females (French & Jeffery, 1995). Weight control motives are also common to PA; yet, research suggests that holding such extrinsic motivations for exercise is associated with lower self-esteem (Furnham, Badmin, & Sneade, 2002; Strelan, Mehaffey, & Tiggemann, 2003) and has been shown to reduce the psychological benefits of PA in younger samples (Gillison, Standage, & Skevington, 2006). Thus, if females, in particular, are engaging in both PA and smoking for weight control purposes, they may not be reaping the benefits of PA typically observed and may be *more* susceptible to smoke as an affective coping tool.

2. **Smoking Urges and Mood**

a. **Non-work-related Physical Activity Variables**

When evaluating smoking urges, several hypothesized interactions between non-work-related PA constructs and mood, most notably PosA, emerged. Specifically, the interaction effects between NWPA and moderate PA with PosA on smoking urges were marginally significant at the BS level, and trending in that direction at the WS level for the sample as a whole. Follow-up analyses for the BS interactions converged with predictions that higher levels of PA eliminated the inverse association between PosA and urges observed at lower levels of PA. Results for vigorous PA showed a similar protective effect but were unique in that the interaction between BS vigorous PA and PosA was only significant for males, and vigorous PA was the only PA construct that moderated the association between PosA and urges at the traditional statistical error rate.

In line with the combination of an alternative self-medication or alternative/substitute reinforcer conceptualization (e.g., Audrain-McGovern, Rodriguez, Epstein, Cuevas, et al., 2009; Audrain-McGovern, Rodriguez, Epstein, Rodgers, et al., 2009; Audrain-McGovern et al., 2004) and learning models (e.g., Bouton, 2000; Niaura, 2000), results might suggest that PA is serving to replace or substitute benefits from cigarettes, which over time, may yield a counterconditioning effect strong enough to reduce the association between low PosA and urges. The male-specific effect for vigorous PA might help to explain recent evidence from the NOT+FIT trial showing that the adjunctive PA intervention yielded stronger effects on cessation for males (Horn et al., 2011). Future research in this domain might consider utilizing this approach to justify gender differences in cessation outcomes. However, it should be noted that vigorous PA, moderate PA, and total NWPA were not associated with PosA enhancement in this sample. Although a linear association between PA and mood might not exist, particularly with vigorous PA, the lack of evidence for the PosA benefits of PA in the current sample suggests the need to explore alternative explanations for our findings.

One alternative explanation for the interactive effect could be that individuals have expectancies for PA to regulate affect, whether or not they are actually experiencing benefits, potentially circumventing urges in response to bad moods. Based on past smoking-specific research in youth, affect expectancies for smoking can have significant long-term effects on behavioral outcomes (e.g., Heinz, Kassel, Berbaum, & Mermelstein 2010). Future research might consider evaluating how expectations to use PA in an effort to boost mood might potentiate its effect as a cessation tool. Another explanation for present findings is that perhaps at the daily level, we are not observing proximal improvements in PosA that might be occurring. As revealed in the study by Wichers et al. (2012), mood boosts can last up to three hours following PA before dissipating. A subsequent bad mood following those three hours might weaken previous boosts achieved when examining mean daily levels. The current research design was not built to detect such time-sensitive effects. Thus, a closer examination of the temporal sequence of PosA and PA associations throughout the day is likely necessary, albeit not possible within the current study.

Although present results were only marginally significant for some constructs, they provide foundational evidence for a model linking weekly PA, smoking, and mood in a way that no known previous research has examined. Results further indicated that a similar effect might be occurring on a day-to-day basis for NWPA and moderate PA; however, the daily variation might not be strong enough in magnitude to observe effects in the current study. Although some researchers propose a mediational pathway linking PA to smoking through its impact on mood/affect, our results largely did not corroborate such a framework. In particular, across all PA, mood, and smoking constructs evaluated, not one combination yielded the requisite three significant relations to attempt a mediational analysis (Baron & Kenny, 1986). This might be due to the inability of the current study to establish temporal precedence across variables. However, one might further suggest that these constructs likely do not exist in such a clean, time-ordered pathway in real-life either, and associations may be much more dynamic.

An important finding across all interaction models predicting urges is that NWPA, moderate PA and vigorous PA all did not alter the association between NegA and urges to smoke. Recent research has suggested, however, that the strength of the association between NegA and urges might be too robust. Specifically, a recent study evaluated the differential contribution of PosA and NegA to smoking urges in an abstaining college-aged sample and showed that NegA was a much stronger predictor of co-occurring urges than PosA, and any effect of state PosA dissipated when accounting for the effect of NegA (Leventhal et al., 2013). It is thus possible that NegA and urges might be too closely and ubiquitously interrelated such that reducing this association might require other forms of intervention, perhaps pharmacological approaches.

Furthermore, a notable limitation of this study, as described, is our inability to differentiate specific types of NWPA reported by participants, and studies have asserted that unique categories of NWPA may be differentially related to mental health outcomes. For example, in a study examining types of PA and their influence on mental health outcomes, researchers found a positive association between active transport (i.e., biking) to and from work and stress for males in blue-collar jobs but not females (Asztalos et al., 2009). They suggested that the use of active transport as a means to get to work might render it a stress-inducing situation, limiting its affective benefits. Asztalos and colleagues (2009) emphasized that although some types of PA may be beneficial for physical health (i.e., cardiovascular benefits), those aimed to target psychological health are likely more context- and subgroup-dependent. Future research should be more thoughtful with these distinctions to better parse out the types of PA that may be particularly beneficial for affect-urge counterconditioning, and ultimately, smoking reduction and cessation.

b. Work-related Physical Activity

Results for WPA showed that at the daily level, higher WPA enhanced the association between affect and urges to smoke. Specifically, among days in which individuals engaged in higher levels of WPA, higher NegA and lower PosA were each associated with stronger urges to smoke. In contrast with NWPA, WPA was not directly associated with smoking urges but was the only PA construct that significantly influenced the link between affect and urges among the whole sample and influenced this association for both PosA and NegA. Given the lack of previous research in this domain, explanations can only be speculated. For example, the absence of a direct effect may indicate that the influence of WPA on urges might be further influenced by the context surrounding the PA. For example, certain types of labor-intensive jobs might be both more demanding (i.e., both physically and mentally) and fatiguing, which might potentiate the effect of WPA on urges. The moderating effect observed might also be explained by similar contextual factors, as fatigue from WPA might render individuals more likely to rely on automatic learned processes of mood and urge associations (Tiffany, 1990). The daily effect, not shown with other PA constructs, might also reflect the fact that the standard workweek is five days, potentially enhancing the ability to detect effects related to day-to-day fluctuations in WPA by providing a natural pattern of variability.

Despite the dearth of evidence linking WPA specifically to smoking, other research has evaluated work more generally and its association with substance use. For example, studies have found positive associations between specific work stressors (e.g., hours worked; low skill variety) in young adults and greater alcohol use (Butler, Dodge, & Faurote, 2010; Wiesner, Windle, & Freeman, 2005). More specifically, Butler et al. (2010) found a significant, positive association between numbers of hours worked and alcohol consumed at the within-person, daily level. Such stressors may be especially common among physically demanding, monotonous jobs, such as waitressing, janitorial work, or housecleaning. In contrast to alcohol use, however, it is socially acceptable to smoke during the course of a workday, which might lead to even more urges and subsequent use in this population in response to NegA, such as feelings of stress.

c. **Commentary on Physical Activity and Mood Interactions**

In contrast with PA and mood interactions predicting urges, for which nearly all PA constructs were influential in the mood-urge association, only one PA and mood interaction emerged to influence smoking level. Specifically for smoking level, no interactive effects were observed across caloric energy expenditure, NWPA, vigorous PA, or WPA. Further, the interactive effect that did emerge revealed findings in the opposite direction as hypothesized. Despite the fact that smoking urges and behavior are associated (e.g., Doherty et al., 1995; Van Zundert et al., 2012), and affective states are linked to both (e.g., Ameringer & Leventhal, 2010; Conklin, 2006), mood is likely more closely intertwined with urges than behavior. That is, longstanding, ubiquitous models of drug use propose that urges are, in fact, subjective, emotional-motivational states (Tiffany, 1990). As Tiffany contended, in contrast to urges, the actual act of drug use (e.g., smoking) relies on myriad other factors (e.g., access, social environment) that may impede automatic processes linking urges to use. These barriers may be particularly evident within the context of young adults, who may still reside in parents' homes or campus housing, and whose smoking continues to be significantly influenced by social influences (i.e., peer and parent smoking behavior; Hu, Davies, & Kandel, 2006). Measurement and timing differences in smoking level and urges may also be a factor in this difference, as described, suggesting that alternative methodology might better elucidate these associations.

F. **Conclusions, Limitations, and Future Directions**

This study had several strengths, including its innovative, multi-method approach, and translational implications. However, limitations should not go unnoted. First, self-report data is inherently biased, and it is not uncommon in self-reports of PA for individuals to over-estimate, and at times, under-estimate the amount of daily PA performed (Prince et al., 2008). Nonetheless, data likely reflect sound approximations, particularly when collapsed across an entire day. Further, even within the context of estimation errors, we were still able to examine *associations* between PA, smoking, and mood, which was the main goal of the study. Future research might consider alternative methods of evaluating PA (e.g., combining accelerometer data with qualitative methods) to reduce the impact of this issue and enhance the accuracy of reporting.

The second limitation of the study is the inability to disentangle temporal precedence, despite predictions relying upon such theory. Accordingly, although implications regarding the time-ordered nature of these effects can be drawn, present analyses do not allow for more specific causal pathways to be understood. For example, perhaps individuals who experienced lower negative moods on a given day were simply more likely to engage in PA versus the converse. Nonetheless, this is the first study to date to examine all of the associations between PA, smoking, and mood at the daily level and in a similar analytic capacity, rendering findings a good first step. Third, the size of the current sample prevented the inclusion of other confounding factors (e.g., race/ethnicity, educational status, level of employment) that might contribute to the present findings. It also potentially precluded our ability to detect more modest effects. Fourth, the current study did not ultimately explore whether reducing the association between mood and smoking outcomes actually resulted in future smoking reduction and cessation. However, this can be explored with data in future waves of the current study. Despite limitations, present results still have significant implications not only to our theoretical understanding of the function of PA within a highly-smoking sample, but they also have strong implications to clinical interventions using PA for smoking cessation in young adults.

Finally, the motivation and/or intention for engaging in PA are important components of PA not able to be differentiated within the current study but warrant future research. Specifically, the current interview did not assess for the intention of the PA, such as exercise versus transportation, which would be valuable for better understanding the results and their implications. For example, particularly within the context of young adulthood during which PA tends to exhibit such a strong decline (e.g., Kwan et al., 2012), understanding ways to enhance the sustainability of interventions by creating lifestyle as opposed to temporary changes in behavior would be beneficial. As Iso-Ahola & Clair (2000) asserted, for PA to become routine, it has to have elements of intrinsic motivation; otherwise, barriers (e.g., weather, time, etc.) are more easily a deterrent to activity. The role of barriers in PA is particularly important within the context of smoking reduction. That is, based on described behavioral economic theories regarding access and availability to alternative reinforcers (Madden, 2000), the ease with which one can engage in an alternate behavior likely increases its utility. Walking, for example, has gained public health appeal as a universal activity that can be performed by a variety of individuals without specialized equipment or skill (Lee & Buchner, 2008). Yet, this must also be considered within the context of present results, particularly regarding gender differences. Given existing doubt of PA interventions as a tool for long-term cessation (Ussher et al., 2012), sustainability considerations should be a priority of future research endeavors.

Results have important clinical implications for current and future PA programs to reduce smoking or to help smokers quit. Specifically, despite limitations, results from this novel study showed that PA is associated with lower smoking and urges to smoke; however, there are specific contexts in which these associations exist, both in terms of gender and the type of PA. This highlights the need for more tailored approaches, most notably gender-specific, when incorporating PA into smoking interventions. Furthermore, results suggested that PA might function to reduce the association between PosA and smoking urges, whereas NegA appears to be too strongly intertwined with smoking urges, regardless of the level of PA. As such, within the context of PA interventions, reducing the association between NegA and urges to smoke might require an alternative approach. Findings thus set a sound framework and highlight important considerations for further exploration of these associations and the application of PA interventions in young adult smoking.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL LETTER

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice
Continuing Review

September 27, 2013

Robin J. Mermelstein, PhD
Psychology
1747 W Roosevelt
Room 558, M/C 275
Chicago, IL 60612
Phone: (312) 996-7222 / Fax: (312) 413-0474

RE: Protocol # 2004-0621
"Social-Emotional Contexts of Adolescent Smoking - Longitudinal Study"

Dear Dr. Mermelstein:

Your Continuing Review was reviewed and approved by the Expedited review process on September 24, 2013. You may now continue your research.

Please note the following information about your approved research protocol:

Protocol Approval Period: October 3, 2013 - October 3, 2014
Approved Subject Enrollment #: 3080
Additional Determinations for Research Involving Minors: The Board determined that this research satisfies 45CFR46.404, research not involving greater than minimal risk. Therefore, in accordance with 45CFR46.408, the IRB determined that only one parent's/legal guardian's permission/signature is needed. Wards of the State may not be enrolled unless the IRB grants specific approval and assures inclusion of additional protections in the research required under 45CFR46.409. If you wish to enroll Wards of the State contact OPRS and refer to the tip sheet.
Performance Sites: UIC, Northwestern University, Loyola University, Georgia State University, University of Wisconsin - Madison, University of

APPENDIX A (continued)

Missouri-Columbia, University of Utah, West Virginia University, Wesleyan University, University of Kansas

Sponsor: NCI - National Cancer Institute, NIH-National Institutes of Health, NIH/National Cancer Institute, National Cancer Institute, NIDA

PAF#: - 2009-06591,2009-01725,2011-02902,2010-01561,2003-02925

Grant/Contract No: 3 P01 CA098262-05S1,1 R21 CA140696-01,1F31DA032244-01,2 P01 CA098262-06A1,CA 9862-01A5

Grant/Contract Title: Social-Emotional Contexts of Adolescent Smoking Patterns,Variance Modeling of Smoking-related EMA Data,A Situational Examination of Neurocognition and Affect with Simultaneous Cannabis and Tobacco Use,Social-Emotional Contexts of Adolescent Smoking Patterns,Social-Emotional Contexts of Adolescent Smoking Patterns

Research Protocols:

a) Project 3: Social-Emotional Contexts of Adolescent Smoking-Smoking and Emotions Version 1, 04/05/2011
b) Project 1, Health Habits, Version 3.0, 05/23/2011
c) Genetic Marker Project 4, Version 1, 09/24/10
d) Application for Initial Review (as approved under UIC Amendment #26)
e) Project 2, Electronic Diary, Version 4.0, 05/21/2012

Recruitment Material:

a) Hard to Reach Participant Recruitment Letter, 1/10/2012, Version 1

Informed Consents:

a) Consent by Phone/Web Script SHORT 5-year Health Habits Version 1, 05/23/2011
b) Project 1 Extended Health Habits Consent Version 2, 09/06/2011
c) Alteration of informed consent [45 CFR 46.116(d)], administered over phone/web, for the short version of the 5-year Health Habits Questionnaire

Your research meets the criteria for expedited review as defined in 45 CFR 46.110(b)(1) under the following specific category:

(9) Continuing review of research, not conducted under an investigational new drug application or investigational device exemption where categories two (2) through eight (8) do not apply but IRB has determined and documented at a convened meeting that the research involves no greater than minimal risk and no additional risks have been identified.

Please note the Review History of this submission:

APPENDIX A (continued)

Receipt Date	Submission Type	Review Process	Review Date	Review Action
09/16/2013	Continuing Review	Expedited	09/24/2013	Approved

Please remember to:

→ Use your **research protocol number** (2004-0621) on any documents or correspondence with the IRB concerning your research protocol.

→ Review and comply with all requirements on the enclosure,
"UIC Investigator Responsibilities, Protection of Human Research Subjects"
(http://tigger.uic.edu/depts/ovcr/research/protocolreview/irb/policies/0924.pdf)

Please note that the UIC IRB has the right to seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact OPRS at (312) 996-1711 or me at (312) 413-3788. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Rachel Olech, B.A., CIP
Assistant Director, IRB # 3
Office for the Protection of Research Subjects

Enclosures:

1. **Informed Consent Documents:**
   a) Consent by Phone/Web Script SHORT 5-year Health Habits Version 1, 05/23/2011
   b) Project 1 Extended Health Habits Consent Version 2, 09/06/2011
2. **Recruiting Material:**
   a) Hard to Reach Participant Recruitment Letter, 1/10/2012, Version 1

cc: Michael E. Ragozzino, Psychology, M/C 285
OVCR Administration, M/C 672

APPENDIX B

PHYSICAL ACTIVITY RECALL AMENDMENT APPROVAL LETTER

UNIVERSITY OF ILLINOIS
AT CHICAGO

Office for the Protection of Research Subjects (OPRS)
Office of the Vice Chancellor for Research (MC 672)
203 Administrative Office Building
1737 West Polk Street
Chicago, Illinois 60612-7227

Approval Notice
Amendment to Research Protocol and/or Consent Document – Expedited Review
UIC Amendment # 26

June 7, 2011

Robin J. Mermelstein, PhD
Psychology
1747 W Roosevelt
Room 558, M/C 528
Chicago, IL 60612
Phone: (312) 996-1469 / Fax: (312) 413-4750

RE: Protocol # 2004-0621
"Social-Emotional Contexts of Adolescent Smoking - Longitudinal Study"

Dear Dr. Mermelstein:

Members of Institutional Review Board (IRB) #3 have reviewed this amendment to your research and consent form under expedited procedures for minor changes to previously approved research allowed by Federal regulations [45 CFR 46.110(b)(2)]. The amendment to your research was determined to be acceptable and may now be implemented.

Please note the following information about your approved amendment:

<u>Amendment Approval Date:</u> June 3, 2011

<u>Amendment:</u>

Summary: UIC Amendment #26 received May 24, 2011 involves several investigator-initiated changes. 1) Addition of key research personnel Katarzyna Zoszak. 2) Addition of funding source, NIDA Predoctoral Fellowship Award granted to Randi Schuster, doctoral student in psychology and Research Assistant on the project. The goal of this project is to conduct a dissertation project addressing the topic of cognitive and affective situational factors surrounding cannabis and tobacco

APPENDIX B (continued)

use. IRB approval for the study procedures included in this grant were previously granted under UIC Amendment #21. 3) Addition of a brief (approximately 10 minute) semi-structured interview (7-Day Physical Activity Recall and Interviewer Instructions) to the Electronic Diary (ED) debriefing appointments that will ask subjects to recall the type, duration, and level of physical activity over the ED assessment week. Also recorded are the duration of sleep, work, and school and whether the reported physical activities were performed alone or with others. 4) Addition of a short version of the 5-year Health Habits questionnaire to the approved protocol. This short questionnaire would take about 10 minutes to complete and would only contain the most critical outcome measures so that it can be provided as an alternative to not participating in the data collection for those participants who are unable to complete the full 5-year questionnaire. This would only be offered to participants who decline the standard 5-year Health Habits assessment because they do not have the time to fully complete the full questionnaire and interview. Participants who complete the survey would receive $10. The short version questionnaire would be administered over the phone or via the web, and includes the request for an alteration of consent for this portion of the research as well as a new phone script. Online questionnaires would use the IHRP installation of REDCap to collect the data.

Approved Subject Enrollment #: 3080

Performance Sites: UIC, Georgia State University, University of Utah, Glenbard East High School, West Virginia University, Wesleyan University

Sponsors: NIDA

PAF#: 2011-02902

Grant/Contract #: 1F31DA032244-01

Grant/Contract Title: A Situational Examination of Neurocognition and Affect with Simultaneous Cannabis and Tobacco Use

Research Protocols:

a) Project 1, Health Habits, Version 3.0, 05/23/2011
b) Project 2 Electronic Diary Version 2.0 05/23/2011

Consents:

a) Alteration of informed consent [45 CFR 46.116(d)], administered over phone/web, for the short version of the 5-year Health Habits Questionnaire
b) Consent by Phone/Web Script SHORT 5-year Health Habits, Version 1, 05/23/11

Please note the Review History of this submission:

Receipt Date	Submission Type	Review Process	Review Date	Review Action
05/24/2011	Amendment	Expedited	06/03/2011	Approved

Please be sure to:

→ Use your research protocol number (2004-0621) on any documents or correspondence with the IRB concerning your research protocol.

APPENDIX B (continued)

→ Review and comply with all requirements on the enclosure,
"**UIC Investigator Responsibilities, Protection of Human Research Subjects**"

Please note that the UIC IRB #3 has the right to ask further questions, seek additional information, or monitor the conduct of your research and the consent process.

Please be aware that if the scope of work in the grant/project changes, the protocol must be amended and approved by the UIC IRB before the initiation of the change.

We wish you the best as you conduct your research. If you have any questions or need further help, please contact the OPRS at (312) 996-1711 or me at (312) 355-2764. Please send any correspondence about this protocol to OPRS at 203 AOB, M/C 672.

Sincerely,

Betty Mayberry, B.S.
IRB Coordinator, IRB # 3
Office for the Protection of Research Subjects

Enclosures:

1. **UIC Investigator Responsibilities, Protection of Human Research Subjects**
2. **Data Security Enclosure**
3. **Consent:**
   a) Consent by Phone/Web Script SHORT 5-year Health Habits, Version 1, 05/23/11

cc: Gary E. Raney, Psychology, M/C 285

APPENDIX C

REUSE PERMISSIONS

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The final publication is available at: http://link.springer.com/article/10.1007/s11121-011-0261-2

APPENDIX C (continued)

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Melanie J. Nadell, M.A.
Doctoral Candidate
Department of Psychology
University of Illinois at Chicago
Behavioral Sciences Building (BSB)
1007 W. Harrison Street
Chicago, IL 60607

Dear Mrs. Nadell:

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VITA

MELANIE J. NADELL, M.A.
formerly Melanie J. Richmond

EDUCATION

08/08 – Present **University of Illinois at Chicago**, Chicago, IL
Ph.D. in Clinical Psychology, expected in June of 2014
Dissertation (Chair: Robin Mermelstein, Ph.D.): *Daily Physical Activity, Smoking, and Mood in High-Risk Young Adults* – Defended 12/17/2013

M.A. in Clinical Psychology, May 2010
Thesis (Chair: Robin Mermelstein, Ph.D.): *Heterogeneous Friendship Affiliation and Behavioral and Emotional Outcomes in Adolescence*
Cumulative GPA: 4.0

09/04 – 03/08 **Northwestern University**, Evanston, IL
B.A. in Psychology, summa cum laude and departmental honors
Honors Thesis *(Mentor: Emily Durbin, Ph.D.)*: *The Effects of Parental Psychopathology: Examining Parenting Behavior as a Mediator between Parental Depression and Anxiety and Child Internalizing Outcomes*
Cumulative GPA: 3.97

HONORS AND DISTINCTIONS

01/12 – 06/13	**University of Illinois at Chicago**	Chancellor's Graduate Research Fellowship
05/12	**University of Illinois at Chicago**	Department of Psychology's Award for Excellence in Clinical Psychology
11/11	**University of Illinois at Chicago**	Commendation on Preliminary Exam
04/09 – 05/13	**University of Illinois at Chicago**	Conference Travel Awards: Graduate College and Department of Psychology
09/04 – 03/08	**Northwestern University**	Dean's List
06/07	**Northwestern University**	Department of Psychology's Underwood Fellowship for Research
06/07	**Northwestern University**	Undergraduate Research Grant (declined for Underwood Fellowship)
05/07	**Northwestern University**	Phi Beta Kappa

CLINICAL EXPERIENCE

07/13 – Present **Pre-doctoral Psychology Intern, Child Track (APA-accredited)**
Department of Psychiatry, Institute for Juvenile Research
University of Illinois at Chicago, Chicago, Illinois

01/13 – 06/13 **Advanced Psychology Extern**
Craniofacial Center
Department of Surgery, University of Illinois at Chicago, Chicago, IL

07/12 – 06/13 **Advanced Psychology Extern**
Hyperactivity, Attention, and Learning Problems Clinic (HALP)
Institute for Juvenile Research, University of Illinois at Chicago, Chicago, IL

07/11 – 06/12 **Advanced Psychology Extern**
John H. Stroger Jr., Hospital of Cook County, Chicago, IL

08/08 – 06/11 **<u>Graduate Therapy and Assessment Clinician</u>**
Office of Applied Psychological Services (OAPS)
University of Illinois at Chicago, Chicago, IL

07/09 – 05/10 **<u>Research Clinician</u>**
Preschool Disruptive Behavior Clinic
Institute for Juvenile Research, University of Illinois at Chicago, Chicago, IL

RESEARCH EXPERIENCE

01/12 – 06/13 **<u>Chancellor's Research Fellow</u>**
Physical Activity, Smoking, and Mood in High Risk Young Adults
University of Illinois at Chicago, Chicago, IL

08/08 – 05/13 **<u>Graduate Research Assistant</u>**
Social and Emotional Contexts of Adolescent Smoking
Institute for Health Research and Policy
University of Illinois at Chicago, Chicago, IL

05/11 – 02/12 **<u>Graduate Research Assistant</u>**
Youth Obesity Prevention Intervention Development
Institute for Health Research and Policy
University of Illinois at Chicago, Chicago, IL

03/06 – 06/08 **<u>Undergraduate Research Assistant</u>**
Early Risk Factors for Depression in Children
Northwestern University, Evanston, IL

06/06 – 09/06 **<u>Research Intern</u>**
Township Alliance for Youth Community Needs Assessment
Links Youth Organization, Northfield, IL

PUBLICATIONS

Pugach, O., Hedeker, D., **Richmond, M**., Sokolovsky, A., & Mermelstein, R. (in press). Modeling mood variation and covariation among adolescent smokers: Application of a bivariate location-scale mixed-effects model. *Nicotine and Tobacco Research.*

Mermelstein, R.J., & **Richmond, M.J.** (in press). Prevention of tobacco use. In T. Gullotta & M. Bloom (Eds.), *Encyclopedia of Primary Prevention and Health Promotion* (2nd ed.). New York: Kluwer Academic/Plenum Publishers.

Richmond, M.J., Mermelstein, R.J., & Wakschlag, L. (2013). Direct observations of parenting and real-time negative affect among adolescent smokers and non-smokers. *Journal of Clinical Child and Adolescent Psychology, 42,* 617- 628.

Richmond, M.J., Mermelstein, R.J., & Metzger, A. (2012). Heterogeneous friendship affiliation, problem behaviors, and emotional outcomes among high-risk adolescents. *Prevention Science, 13,* 267-277.

Mermelstein, R., **Richmond, M.**, Schuster, R. (2011). Smoking and youth. In J.M. Rippe (Ed.), *Encyclopedia of Lifestyle Medicine and Health*. Sage Publications.

CONFERENCE PRESENTATIONS

Nadell, M., Mermelstein, R., Marquez, D., & Hedeker, D. (April, 2014). *Physical activity, smoking urges, and mood in young adults.* Poster session presented at the 35th annual meeting of the Society of Behavioral Medicine, Philadelphia, Pennsylvania.

Boamah-Acheampong, A, Maass, A, **Nadell, M.**, Zoromski, A., & Rosenberg, J. (September, 2013). *Camp STAR-summer treatment program: A comparison of ADHD symptoms in new versus returner* *campers.* Poster session presented at the 5th annual meeting of the American Professional Society of ADHD and Related Disorders, Washington DC.

Rosenberg, J., **Nadell, M**., Crerand, C., Stein, M., Norman, R., & Broder, H. (May, 2013). *Resiliency and surgical status among youth with cleft lip/palate.* Paper presented at the 12th International Congress on Cleft Lip/Palate and Related Craniofacial Anomalies. Orlando, Florida.

Richmond, M.J., Mermelstein, R.J., & Marquez, D. (March, 2013). *The joint effects of work and non work physical activity on smoking in young adults*. Poster session presented at the 34th annual meeting of the Society of Behavioral Medicine, San Francisco, California.

Richmond, M.J., & Mermelstein, R.J. (April, 2012). *Physical activity and smoking progression among smoking adolescents*. Poster session presented at the 33rd annual meeting of the Society of Behavioral Medicine, New Orleans, Louisiana.

Richmond, M.J., Mermelstein, R.J., & Wakschlag, L. (June, 2011). *The longitudinal effects of general and smoking-specific parent-child communication on adolescent smoking.* Poster session presented at the 19th annual meeting of the Society for Prevention Research, Washington DC.

Richmond, M.J., Mermelstein, R.J., & Wakschlag, L. (April, 2011). *Parenting style predicts long-term daily affect in adolescent smokers***.** Poster session presented at the 32nd annual meeting of the Society of Behavioral Medicine, Washington DC.

Richmond, M.J., Mermelstein, R.J., & Wakschlag, L. (February, 2010). *Direct observations of parenting behavior and adolescent smoking escalation.* Poster session presented at the 16th annual meeting of the Society for Research on Nicotine and Tobacco, Baltimore, Maryland.

Richmond, M.J., Mermelstein, R.J., Metzger, A., Schuster, R.M., & Colvin, P.J. (April, 2009). *The longitudinal effects of complex friendship groups on adolescent health behaviors.* Poster session presented at the 30th annual meeting of the Society of Behavioral Medicine, Montreal, Quebec.

Schuster, R.M., Mermelstein, R.J., Colvin, P.J., & **Richmond, M.J.** (April, 2009). *Gender differences in sexual risk taking and smoking acceleration in adolescents.* Poster session presented at the 15th annual meeting of the Society for Research on Nicotine and Tobacco, Dublin, Ireland.

Wilson, S., Durbin, C. E., **Richmond, M.**, Carlson, D., & Molloy, E. (May, 2008). *Determinants of interaction: Parent and child contributors to mutual responsiveness.* Poster session presented at the 20th Annual Convention of the Association for Psychological Science, Chicago, IL.

Wilson, S., Durbin, C. E., **Richmond, M.**, Alla, S., Graham, R., & Reed, S. (September, 2008). *Determinants of parent child interaction: Parent and child personality and parental depression as contributors to the parent-child relationship.* Poster session presented at the 22nd Annual Meeting of the Society for Research in Psychopathology, Pittsburgh, PA.

TEACHING EXPERIENCE

08/09 – 05/11 **Teaching Assistant**
University of Illinois at Chicago, Chicago, IL
Introduction to Psychology, Community Psychology, Psychological Assessment

AD HOC REVIEWER FOR SCIENTIFIC JOURNALS

Journal of Adolescence	Prevention Science
Journal of Adolescent Health*	Health Education Research*

*conducted under the supervision of Robin Mermelstein, Ph.D.