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Association of exercise with smoking-related symptomatology, smoking behavior and impulsivity in men and women

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Abstract

Introduction: Despite extensive efforts to develop effective smoking cessation interventions, 70–85% of American cigarette smokers who quit relapse within one year. Exercise has shown promise as an intervention; however, many results have been equivocal. This study explored how exercise is associated with smoking-related symptomatology, smoking behavior and impulsivity in male and female smokers.

Methods: Participants were recruited throughout the United States using the on-line crowdsourcing platform, Amazon's Mechanical Turk. They completed a survey with self-report measures assessing exercise, smoking-related symptomatology, smoking behavior and impulsivity. Differences between men and women were tested using *t*- and chi-square tests. Regression analyses tested for associations between exercise and smoking-related symptomatology, smoking behavior and impulsivity.

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Contributors

Nicole Tosun, Sharon Allen, Lynn Eberly, William Stoops, Justin Strickland, Katherine Harrison, Mustafa al Absi and Marilyn Carroll developed the study concept. Nicole Tosun wrote the first draft of the manuscript. Nicole Tosun and Katherine Harrison managed all study set up and data management. Lynn Eberly and Meng Yao conducted the statistical analyses. All authors provided critical reviews and have approved the final version of the manuscript.

Conflict of interest

No conflict declared.

Results: Participants (N = 604) were, on average, 32 (SD = 6.2) years old, mostly Caucasian, with at least some college education and approximately half were women. Women exercised slightly less than men and had more negative affect, craving, physical symptoms and withdrawal. Women smoked more cigarettes per day, had greater nicotine dependency and more years of smoking. Positive affect was positively associated with exercise for both men and women; however, this association was significantly stronger in women. Negative affect and withdrawal were inversely associated with exercise for women only. Impulsivity was inversely associated with exercise for both men and women.

Conclusion: Exercise was significantly associated with several smoking-related symptomatology, smoking behavior and impulsivity variables for both men and women, suggesting that exercise may be a useful intervention for smoking cessation. Future prospective research should determine how exercise directly impacts smoking cessation.

Keywords

Exercise; Physical activity; Smoking; Smoking-related symptomatology; Smoking behavior; Impulsivity; Amazon's Mechanical Turk

1. Introduction

Cigarette smoking remains the single largest preventable cause of death and disease in the United States (USDHHS, 2014). In 2015, an estimated 15.1% (36.5 million) of U.S. adults were current cigarette smokers (Jamal et al., 2016). The public health implications of this are substantial. Smoking-related illness in the United States costs more than \$300 billion a year, including nearly \$170 billion in direct medical care for adults and \$156 billion in lost productivity (USDHHS, 2014; Xu et al., 2015). Although extensive research has been conducted on effective smoking cessation interventions [i.e., computer/electronic aids (Chen et al., 2012), behavioral interventions (Wilson et al., 2017) and pharmacotherapy (Raupach and Van Schayck, 2011)], nearly 70–85% of Americans still relapse within one year after quitting smoking (Fiore et al., 2008). Effective, long-term treatment approaches are severely lacking.

Some research has shown that men and women differ in their ability to quit smoking (Gritz et al., 1996; Tanoue, 2000) while others dispute this gender disparity (Jarvis et al., 2013). One study found that women smoke fewer cigarettes per day, they smoke cigarettes with lower nicotine content and do not inhale as deeply as men (Melikian et al., 2007). However, other studies have found that women tend to have greater nicotine dependency (Smith et al., 2014), have higher rates of relapse (Perkins, 2001; Weinberger et al., 2014), they are less likely to achieve long-term abstinence (Smith et al., 2016) and have greater difficulty quitting than men (McKee et al., 2016; Wetter et al., 1999). These seemingly contradictory findings may be attributable to differences in methodology (i.e., how abstinence is defined or whether the study accounted for the use of other types of nicotine), as well as in the generalizability of samples used in clinical settings to the general population of smokers. Therefore, continued study of these factors in more representative samples may help inform future treatment approaches for both men and women.

Physical activity (i.e., exercise) has been studied over the past several years as a potential treatment for drug abuse, as well as for smoking cessation; however, the results have been equivocal (Buchowski et al., 2011; Lynch et al., 2010; Rawson et al., 2015; Taylor et al., 2007). Methodological limitations (e.g., small sample sizes and poor adherence to exercise programs) and variations in implementation of exercise into smoking cessation programs (e.g., timing, duration and intensity) have prevented definitive conclusions about its efficacy. In an extensive review by Ussher et al. (2008), it was reported that only one of 13 trials offered significant reduction in smoking at the 12-month follow-up. The other trials were either too small to reliably detect an effect or included an exercise intervention which was not intense enough to achieve the desired level of physical effort (Ussher et al., 2008). However, a more recent meta-analysis by Wang et al. (2014), investigating exercise for substance use disorders, indicated that a moderate to high-intensity aerobic exercise program may be an effective and persistent treatment for those with substance use disorders, including tobacco use disorder (Wang et al., 2014). In a recent review, Bardo and Compton (2015) also reported promising evidence for exercise as a treatment for substance abuse. They reported that the preclinical literature consistently showed that physical activity may serve as both a preventive and treatment intervention that reduces drug use, although alcohol use appeared to be an exception. The clinical literature has provided some evidence, although mixed, to suggest a beneficial effect of physical activity specifically on tobacco dependent individuals (Bardo and Compton, 2015).

Withdrawal symptoms, craving and negative affect are all known risk factors for relapse (al' Absi et al., 2015; Allen et al., 2017, 2010, 2008; Doherty et al., 1995; Garvey et al., 1992; Piasecki et al., 2000; Shiffman et al., 1996). Some research has shown that exercise may attenuate these symptoms, further validating its effectiveness for smoking cessation. In a systematic review by Roberts et al. (2012), 12 of 15 studies showed a favorable effect of exercise on acute cigarette craving with immediate results lasting up to 30 min. It was also reported that four of the five studies that examined the impact of exercise on affect found a positive influence of exercise on various measures of affect. Smoking withdrawal symptoms included irritability, tension, restlessness and difficulty concentrating. Three out of the five studies that assessed this construct using the Mood and Physical Symptoms Scale (West and Hajek, 2004) reported a positive effect of exercise on at least one withdrawal symptom (Roberts et al., 2012).

Another key factor related to smoking cessation and relapse is impulsivity (a multidimensional trait comprised of attentional, motor and non-planning factors), which has been discussed and reviewed in recent studies (Balevich et al., 2013; Carroll et al., 2009; Carroll and Holtz, 2014; Carroll and Smethells, 2016; Flory and Manuck, 2009; Mitchell, 1999; Perry and Carroll, 2008; Reynolds et al., 2004; Smethells et al., 2016; Swalve et al., 2017). Recent studies have shown that the non-planning facet is specifically associated with poorer response to smoking cessation treatments (López-Torrecillas et al., 2014) and impulsivity/disinhibition may predict successful smoking cessation through treatment (Stevens et al., 2014). However, much less is known about how exercise may influence impulsivity and in turn, effect smoking cessation and relapse. One preclinical study by Strickland et al. (2016b) found that in rats, physical activity decreased sensitivity to reinforcement amount and sensitivity to reinforcement delay, two behavioral processes that

contribute to delay discounting (i.e., a decline in the present value of a reward with delay to its receipt) (Strickland et al., 2016b). A second clinical study by Sofis et al. (2017) found limited support showing that exercise reduced delay discounting in humans (Sofis et al., 2017). Further research is needed in this area.

The main goal of the present study was to examine the association of physical activity (i.e., exercise) with smoking-related symptomatology (e.g., withdrawal, craving, physical symptoms and positive/negative affect), smoking behavior and impulsivity in a large cross-sectional sample of participants who smoke; while also considering mean differences between men and women.

2. Methods

2.1. Study design

Participants were recruited for this study through the on-line crowdsourcing platform, Amazon's Mechanical Turk (mTURK; www.mturk.com). The mTURK platform is a convenient, reliable and cost-effective tool for collecting survey data (Buhrmester et al., 2011; Chandler and Shapiro, 2016; Hauser and Schwarz, 2016; Mason and Suri, 2012; Shapiro et al., 2013; Strickland et al., 2016a; Strickland and Stoops, 2015). All participants for this study were required to have a 95% or higher approval rating from investigators on previously submitted mTURK tasks, over 100 approved prior mTURK tasks and current residence within the United States. Respondents were asked to read an informed consent document describing the study procedures, compensation and anonymity terms. All participants indicated that they understood this document and agreed to participate via electronic confirmation. The University of Minnesota IRB approved all procedures.

Participants were asked to complete the survey in one sitting and were informed that it would take approximately 1–15 minutes based on their eligibility. Eligible participants were required to smoke cigarettes on a daily basis and be between 18–45 years of age. Forty-five years of age was chosen as a cutoff as a section of this survey (to be presented elsewhere) focused on the menstrual cycle and, therefore, it was imperative to restrict the sample to women who were more likely to be premenopausal and have regular menstrual cycles. In an effort to keep groups comparable, we opted to restrict the male age as well. Recruitment was initially restricted to those living in the upper Midwest; however, after encountering slower than expected accrual, the survey was opened to all respondents residing in the United States. If the participant failed to qualify, he or she was provided \$0.05 compensation for completing the screening portion of the study. Participants who qualified and completed any portion of the main survey were compensated \$1.05.

2.2. Study measures

Data for this analysis came from a battery of self-report measures assessing physical activity and exercise, smoking-related symptomatology, smoking behavior and impulsivity. Study data were collected and managed using REDCap electronic data capture tools hosted at the University of Minnesota (Harris et al., 2009). To ensure that participants remained engaged in the study tasks, attention checks were performed periodically throughout the study

(Oppenheimer et al., 2009). Eighty-seven percent ($n = 604$) of participants passed all five checks and were included in the analysis. The remaining 13% ($n = 88$) were removed prior to data analysis (all participants removed were demographically similar to those included in the analysis).

2.2.1. Physical activity—Baecke's Questionnaire for Habitual Physical Activity (Baecke et al., 1982; Florindo et al., 2003) is a 16-item measure assessing three dimensions: (1) occupational physical activity, (2) physical exercises in leisure and (3) leisure and locomotion activities. In this study, we focused on dimension three, the leisure and locomotion activities scale (LLA; higher scores indicate more physical activity) as well as two questions from dimension two: item 2, "Compared to others of my age, I think my physical activity during leisure hours is..." (labeled below as sport/exercise compared to others; response options: much less, less, the same, more, much more) and item 4, "During leisure hours, I practice sport or physical exercises" (labeled below as sport/exercise frequency; response options: never, seldom, sometimes, often, very often).

2.2.2 Smoking-related symptomatology.—The Subjective State Scale (al' Absi et al., 2004, 2003) is a 24-item measure used to assess five subscales regarding smoking-related symptomatology; each item in each subscale uses a seven-point Likert-type scale. (1) Positive affect was defined as an average of the Likert responses to feeling cheerful, content, calm, in control and interested. (2) Negative affect was defined as an average of feeling anxious, irritable, impatient and restless. (3) Craving was defined as a desire to smoke. (4) Physical symptoms were defined as an average of feeling a headache, tremor, cough, stomach problems, sweating, tiredness and drowsiness. (5) Withdrawal was defined as an average of feeling irritable, angry, anxious, having difficulty concentrating, restlessness, sadness and hunger.

2.2.2. Smoking behavior—Several items were included regarding smoking behavior. They were: (1) cigarettes per day, (2) years of smoking, (3) motivation to quit (10 point Likert-type scale with 10 indicating higher motivation), and (4) nicotine dependency, evaluated by time to first morning cigarette (Baker et al., 2007).

2.2.3. Impulsivity—The Barrett Impulsiveness Scale (BIS) is a 30-item measure of the personality/behavioral construct of impulsiveness (Patton et al., 1995). This scale yields six first-order factors and three second-order factors. This study focused on the total score and three second-order factors: attentional, motor and non-planning.

2.3. Statistical analysis

Means and standard deviations were calculated and two-sample *t*-tests were used to compare continuous variables across sexes. Counts and frequencies were reported and chi-square tests were used to compare categorical variables across sexes. To estimate the associations of exercise with smoking-related symptomatology, smoking behavior and impulsivity, each of these sub-scales or factors was used as a response variable in a regression model. LLA score, sex, and their interaction were the predictors of interest, adjusting for demographic covariates. Sport/exercise frequency was analyzed in a similar way, assuming a continuous

linear scale across the five categories. Multiple linear regression was used for smoking-related symptomatology and impulsivity. Negative binomial regression was used for smoking frequency and years of smoking, while equal slopes adjacent categories logit regression was used for time to first morning cigarette. Regressions adjusted for participant characteristics (those shown in Table 1). All statistical analyses were conducted with SAS 9.4 (SAS Institute Inc., Cary, NC). *P*-values less than 0.05 were considered statistically significant.

3. Results

Overall, participants (*N* = 604) were on average 32 (*SD* = 6.2) years of age, mostly Caucasian (85%), with at least some college education (48%). They were evenly divided by sex (55.6% female, 45.3% male) and about half were never married (52.3%). All four census regions (Northeast, Midwest, South, West) were represented with the largest proportion of participants residing in the south (41.1%). Average BMI for all participants was in the overweight range (*M* = 27.9, *SD* = 7.1).

Age (*p* = 0.019), BMI (*p* = 0.005), marital status (*p* < 0.001), race (*p* = 0.009), and education (*p* < 0.001) were significantly different between men and women; however, these differences were small in magnitude (see Table 1). Women were slightly older, had a slightly higher BMI, were more likely to be married, included a higher proportion of Asians and a lower proportion of Black/African Americans, and included a higher proportion of high school and college graduates.

3.1. Physical activity

Total LLA scores (physical activity) showed a small but statistically significant difference between men and women (see Table 2 and Fig. 1). Women reported a mean LLA score of 2.23 (*SD* = 0.67) while men reported a mean score of 2.39 (*SD* = 0.68; *p* = 0.029). When asked about their physical activity compared to others of the same age (sport/exercise compared to others), 61.8% (*n* = 204) of women reported their physical activity as “less or much less” compared to 45.6% (*n* = 125) of men (*p* < 0.001). When asked about practicing sport or physical exercise (sport/exercise frequency), 53.6% (*n* = 177) of women reported “never or seldom” compared to 42.7% (*n* = 117) of men (*p* = 0.056).

3.2. Smoking-related symptomatology

Smoking-related symptomatology significantly differed in all five subscales between men and women (see Table 2 and Fig. 2) and although these differences were small in magnitude, they were consistent across all five subscales. Women reported slightly less positive affect (4.16 ± 1.66 vs. 4.44 ± 1.49 , *p* = 0.029) and more negative affect (2.63 ± 1.73 vs. 2.19 ± 1.66 , *p* = 0.002), more craving (5.20 ± 1.67 vs. 4.81 ± 1.77 , *p* = 0.006), more physical symptoms (1.85 ± 1.34 vs. 1.48 ± 1.20 , *p* < 0.001) and more withdrawal (2.38 ± 1.54 vs. 2.08 ± 1.41 , *p* = 0.014) than men.

3.3. Smoking behavior

Smoking behavior also significantly differed between men and women and these differences were a bit larger in magnitude (see Table 2 and Fig. 2). Women smoked on average almost two more cigarettes per day (13.92 ± 8.44 vs. 11.95 ± 7.76 , $p = 0.003$) and had on average 1.4 more years of smoking (13.73 ± 6.94 vs. 12.32 ± 6.48 , $p = 0.011$). Time to first morning cigarette significantly differed with 35.2% ($n=115$) of women reporting smoking their first cigarette within 5 min of waking compared to 23.9% ($n=65$) of men ($p = 0.027$). In contrast, motivation to quit did not significantly differ between men and women ($p = 0.466$).

3.4. Impulsivity

BIS total score did not significantly differ between men and women ($p = 0.394$; see Table 2 and Fig. 2). However, the second-order factor, attentional impulsivity, did significantly differ with women reporting slightly higher scores (16.4 ± 4.69 vs. 15.08 ± 4.10 , $p = 0.008$). No differences were found between the other two second-order factors: motor and non-planning.

3.5. Associations of exercise with smoking-related symptomatology, impulsivity and smoking behavior

3.5.1 Exercise with smoking-related symptomatology.—Associations of exercise with smoking-related symptomatology are shown in Table 3a. For women, LLA score was positively associated with positive affect (0.502 ± 0.134 , $p < 0.001$) and inversely associated with negative affect (-0.284 ± 0.143 , $p = 0.047$). For men, LLA score was positively associated with positive affect only (0.383 ± 0.142 , $p = 0.007$). There were no sex differences in these associations ($p = 0.538$). Furthermore, for women, sport/exercise frequency was positively associated with positive affect (0.383 ± 0.142 , $p = 0.007$), while there was no such association for men ($p = 0.730$). However, that strong positive association for women was significantly different from the null association for men ($p < 0.001$). For women, sport/exercise frequency was also inversely associated with negative affect (-0.303 ± 0.094 , $p = 0.001$) and withdrawal (-0.220 ± 0.083 , $p = 0.008$), while no such associations were found for men.

3.5.1. Exercise with impulsivity—Associations of exercise with impulsivity are shown in Table 3b. For women, LLA score was inversely associated with BIS-attentional (-0.730 ± 0.363 , $p = 0.045$) and BIS non-planning (-1.078 ± 0.469 , $p = 0.002$). For men, LLA score was inversely associated with BIS attentional (-0.819 ± 0.384 , $p = 0.033$), BIS non-planning (-1.840 ± 0.497 , $p < 0.001$) and BIS total (-2.674 ± 1.111 , $p = 0.016$). There were no sex differences in these associations. Furthermore, for women, sport/exercise frequency was inversely associated with BIS attentional (-0.653 ± 0.240 , $p = 0.006$), BIS non-planning (-1.061 ± 0.313 , $p < 0.001$) and BIS total (-1.843 ± 0.696 , $p = 0.008$). For men, no such associations of exercise frequency were found, and there were no sex differences in these associations.

3.5.2. Exercise with smoking behavior—Associations of exercise with smoking behavior are shown in Table 3c. For cigarettes per day, years of smoking and time to first morning cigarette, no significant associations were found for either men or women for LLA score or for sport/exercise frequency. However, for time to first morning cigarette, the female

odds ratio associated with sport/exercise frequency was significantly different from the male odds ratio associated with sport/exercise frequency ($p = 0.043$). For example, for women, the odds ratio for smoking within 5 min, relative to smoking within 6–30 minutes, was less than 1 (0.933) for a 1-unit higher sport/exercise frequency, indicating more frequent exercise was associated with first cigarette being later in the morning. For men, this odds ratio was greater than 1 (1.027), indicating more frequent exercise was associated with first cigarette being earlier in the morning. However, the magnitude of these effects as well as the magnitude of the sex difference suggests minimal clinical relevance.

4. Discussion

While the main purpose of this study was to examine the association of physical activity (i.e., exercise) with smoking-related symptomatology (e.g., withdrawal, craving, physical symptoms and positive/negative affect), smoking behavior and impulsivity, we also considered mean differences between men and women as well. We found that women in this study reported slightly less exercise than men, which is consistent with prior literature (Azevedo et al., 2007; Burton and Turrell, 2000; Martínez-González et al., 2001; Steptoe et al., 2002) and 62% of women compared to 46% of men felt as though they exercised less compared to others of the same age. We also found that smoking-related symptomatology significantly differed between men and women. Although these differences were small in magnitude and should be regarded with caution, they were consistent across all five subscales. Women reported less positive affect and more negative affect, craving, physical symptoms and withdrawal than men. Further, we found that women showed significantly greater nicotine dependence than men: 35% of women compared to 24% of men reported smoking their first morning cigarette within five minutes of waking. Women also smoked significantly more cigarettes per day and had more years of smoking.

In contrast, impulsivity did not vary greatly between men and women. Only inattentiveness and cognitive instability were significantly different between sexes with women showing slightly higher impulsivity. Prior literature on sex differences in impulsivity vary depending on the construct assessed and the specific test used (Weafer and de Wit, 2014). For instance, in continuous performance and go/no-go tasks, when impulsive action is measured as absolute number of inhibitory failures, men showed greater impulsivity (Saunders et al., 2008). By contrast, on stop signal tasks, when stimulus presentation is adjusted to maintain a 50% inhibition rate, women required more time to inhibit a prepotent response (Morgan et al., 2011). In our study we used a self-report measure. Since the current knowledge regarding sex differences in impulsivity varies across many tasks, more research is needed regarding the degree to which men and women differ in impulsivity. This may allow for more specific prevention and treatment interventions.

Understanding the associations between exercise, smoking-related symptomatology, smoking behavior and impulsivity was of particular interest in this study. We found that positive affect for both men and women was significantly associated with exercise. In other words, the more positive affect a person experiences, the more exercise he or she self-reports. Conversely, we found the opposite for negative affect and withdrawal in women, but not in men. Additional novel findings were observed in the relationships between

impulsivity and exercise. First, we found that inattentiveness and cognitive instability were inversely associated with exercise for both men and women. We also found that lack of self-control and cognitive complexity were inversely associated with exercise for both men and women. We know from previous literature that impulsivity is strongly associated with smoking (Amlung et al., 2017; Ku et al., 2017; MacKillop et al., 2011; Mitchell, 1999; Stillwell and Tunney, 2012); however, the present study is among the first to describe the inverse association between impulsivity and exercise among smokers. These findings suggest that addressing smoking-related symptomatology and impulsivity may be beneficial in increasing exercise among smokers in a smoking cessation treatment intervention.

This study included noteworthy and innovative contributions. It is among the first to utilize Amazon's Mechanical Turk (mTURK) to evaluate the association of exercise with smoking-related symptomatology, smoking behavior and impulsivity. mTURK has been in existence for over a decade; however, only over the past several years have academic researchers begun to use it as a tool for data collection in the field of addiction research (Bauhoff et al., 2017; Brewer et al., 2017; Chandler and Shapiro, 2016; Hall et al., 2014; Pacek et al., 2017; Strickland et al., 2016a; Strickland and Stoops, 2015). One of the most valued aspects of this technology was the speed and cost effectiveness of collecting high quality data. We were able to collect data from over 600 participants across the US in just a few weeks' time while keeping expenses well below typical costs usually required for other methods (e.g., Facebook, mailing, in-person data collection). The use of online samples can also increase the external validity of research studies by providing more geographically and demographically diverse samples than traditional research. These features combined with the rising rates on internet accessibility in clinical and non-clinical populations (Fox and Rainie, 2014; McClure et al., 2013) supports the use of crowdsourcing techniques for research purposes.

Although this study is strengthened by a large sample size and strict data quality criteria, its limitations are worth noting. First, smoking status could not be biologically verified. It is possible that non-smokers took part in the study and did not answer questions truthfully. However, the consistency between smoking behavior and smoking-related symptomatology reported in our study with that of the published literature suggests that our respondents were truly smokers. Second, these data were self-reported and cross sectional. Self-reported data are subject to error due to social desirability bias (the tendency of survey respondents to answer questions in a manner that will be viewed favorably by others). Longitudinal studies are necessary to examine if the observed associations are pre-existing or a consequence of exercise. Third, although 64% of participants indicated they were employed full-time, it is unknown if these participants work from home. This may bias our sample, as stay at home workers may be less likely to commute or even leave the home on a regular basis, thus, contributing to a more sedentary lifestyle. Finally, the nonprobability sampling approach and low inclusion of minority respondents may limit the generalizability of our findings. However, comparisons across different convenience sampling methods suggests that mTURK samples may actually be more representative than college samples or those drawn from college towns (Berinsky et al., 2012). Problematic responding (e.g., responding in socially acceptable ways) also does not systematically differ between mTURK, college, and community sources (Necka et al., 2016).

In conclusion, this study is among the first to utilize Amazon's Mechanical Turk (mTURK) to examine the association of physical activity (i.e., exercise) with smoking-related symptomatology (e.g., withdrawal, craving, physical symptoms and positive/negative affect), smoking behavior and impulsivity in a large, cross-sectional sample of participants who smoke; while also considering mean differences between men and women. Results indicated that exercise was significantly associated with several of these variables and, therefore, may be a useful intervention for smoking cessation. Future prospective research should utilize fitness trackers such as ActiGraphs or Fitbits in order to objectively measure both intensity of exercise and physical movement. Employing a randomized controlled trial would be best to determine how exercise directly impacts smoking cessation for men and women.

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Fig. 1.

Differences in physical activity measures between men and women ($n = 604$). Bars in chart A represent means with one standard deviation. * $p < 0.05$. Bars in charts B and C represent frequencies (Chart B $p < 0.001$; Chart C $p = 0.057$).

Fig. 2. Differences in (A) smoking-related symptomatology, (B) impulsivity and (C, D, E and F) smoking behavior between men and women ($n = 604$). Bars in charts A through E represent means with one standard deviation. * $p < 0.05$. Bars in chart F represent frequencies ($p = 0.029$).

Table 1**Participant Characteristics.**

	Total	Women	Men	<i>P</i>-value^I
Age (years)	32.40 ± 6.23	32.94 ± 6.34	31.75 ± 6.05	0.019
N	604	330	274	
BMI	27.91 ± 7.05	28.65 ± 7.70	27.02 ± 6.08	0.005
N	602	329	273	
Marital status (N,%)				
Never married	316 (52.3%)	148 (44.8%)	168 (61.3%)	<0.001
Married	227 (37.5%)	142 (43.0)	85 (31.0%)	
Separated/Divorced	57 (9.4%)	36 (10.9%)	21 (7.7%)	
Widowed	4 (0.7%)	4 (1.2%)	0 (0.0%)	
N	604 (100.0%)	330 (100.0%)	274 (100.0%)	
Census Regions (N,%)				
Northeast	97 (16.1%)	57 (17.3%)	40 (14.6%)	0.097
Midwest	172 (28.5%)	95 (28.8%)	77 (28.1%)	
South	248 (41.1%)	141 (42.7%)	107 (39.1%)	
West	87 (14.4%)	37 (11.2%)	50 (18.2%)	
N	604 (100.0%)	330 (100.0%)	274 (100.0%)	
Race (N,%)				
Native American/Alaskan	5 (0.8%)	4 (1.2%)	1 (0.4%)	0.009
Asian	23 (3.8%)	4 (1.2%)	19 (6.9%)	
Hawaiian/Pacific Islander	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Black/African American	39 (6.5%)	24 (7.3%)	15 (5.5%)	
White	513 (84.9%)	284 (86.1%)	229 (83.6%)	
More than one race	20 (3.3%)	12 (3.6%)	8 (2.9%)	
Unknown	4 (0.7%)	2 (0.6%)	2 (0.7%)	
N	604 (100.0%)	330 (100.0%)	274 (100.0%)	
Ethnicity (N,%)				
Hispanic	41 (6.8%)	19 (5.8%)	22 (8.0%)	0.520
Non-Hispanic	555 (91.9%)	307 (93.0%)	248 (90.5%)	
Unknown	8 (1.3%)	4 (1.2%)	4 (1.5%)	
N	604 (100.0%)	330 (100.0%)	274 (100.0%)	
Yearly household income (N,%)				
Less than \$15,000	63 (10.4%)	33 (10.0%)	30 (10.9%)	0.985
\$15,001-\$30,000	154 (25.5%)	85 (25.8%)	69 (25.2)	
\$30,001-\$60,000	234 (38.8%)	128 (38.9%)	106 (38.7)	
More than \$60,000	152 (25.2%)	83 (25.2%)	69 (25.2)	
N	603 (100.0%)	329 (100.0%)	274 (100.0%)	
Education(N,%)				
Some high school	13 (2.2%)	9 (2.7%)	4 (1.5%)	<0.001
High school graduate	113 (18.7%)	54 (16.4%)	59 (21.5%)	

	Total	Women	Men	<i>P</i> -value ^{<i>I</i>}
Some college/2-year degree	292 (48.4%)	183 (55.6%)	109 (39.8%)	
College graduate	138 (22.9%)	57 (17.3%)	81 (29.6%)	
Post-graduate degree	47 (7.8%)	26 (7.9%)	21 (7.7%)	
N	603 (100.0%)	329 (100.0%)	274 (100.0%)	

^{*I*} *P*-value is for difference among sex groups. *P*-values for continuous predictors are from *t*-tests while *p*-values for categorical variables are from chi-square tests.

Table 2

Physical Activity, Smoking-related Symptomatology, Impulsivity and Smoking Behavior by Sex.

	Total	Women	Men	<i>P</i> -value ^I
Physical Activity				
Total LLA score	2.30 ± 0.68	2.23 ± 0.67	2.39 ± 0.68	0.003
N	604	330	274	
Sport/exercise comp to others (N, %)				
Much More	23 (3.8%)	4 (1.2%)	19 (6.9%)	<0.001
More	84 (13.9%)	33 (10.0%)	51 (18.6%)	
The Same	167 (27.7%)	88 (26.7%)	79 (28.8%)	
Less	206 (34.2%)	124 (37.7%)	82 (29.9%)	
Much Less	123 (20.4%)	80 (24.3%)	43 (15.7%)	
N	603 (100.0%)	329 (100.0%)	274 (100.0%)	
Sports/exercise frequency (N, %)				
Never	101 (16.8%)	66 (20.0%)	35 (12.9%)	0.057
Seldom	193 (32.1%)	111 (33.6%)	82 (30.1%)	
Sometimes	210 (34.9%)	108 (32.7%)	102 (37.5%)	
Often	81 (13.5%)	37 (11.2%)	44 (16.2%)	
Very Often	17 (2.8%)	8 (2.4%)	9 (3.3%)	
N	602 (100.0%)	330 (100.0%)	272 (100.0%)	
Smoking-related Symptomatology				
Positive Affect	4.29 ± 1.59	4.16 ± 1.66	4.44 ± 1.49	0.029
N	604	330	274	
Negative Affect	2.43 ± 1.71	2.63 ± 1.73	2.19 ± 1.66	0.002
N	604	330	274	
Craving	5.02 ± 1.73	5.20 ± 1.67	4.81 ± 1.77	0.006
N	603	329	274	
Physical Symptoms	1.69 ± 1.29	1.85 ± 1.34	1.48 ± 1.20	<0.001
N	604	330	274	
Withdrawal	2.24 ± 1.49	2.38 ± 1.54	2.08 ± 1.41	0.014
N	604	330	274	
Impulsivity				
BIS Attentional	15.60 ± 4.45	16.04 ± 4.69	15.08 ± 4.10	0.008
N	604	330	274	
BIS Motor	21.09 ± 4.75	20.99 ± 4.93	21.20 ± 4.53	0.588
N	604	330	274	
BIS Non-planning	23.39 ± 5.60	23.44 ± 5.85	23.32 ± 5.29	0.791
N	604	330	274	
BIS Total	60.08 ± 12.52	60.48 ± 13.15	59.60 ± 11.72	0.394
N	604	330	274	
Smoking Behavior				
Cigs per day	13.03 ± 8.19	13.92 ± 8.44	11.95 ± 7.76	0.003

	Total	Women	Men	<i>P</i>-value^I
N	604	330	274	
Time to first morning cig (N, %)				
Within 5 min	180 (30.1%)	115 (35.2%)	65 (23.9%)	0.029
6–30 min	252 (42.1%)	126 (38.5%)	126 (46.3%)	
31–60 min	89 (14.9%)	46 (14.1%)	43 (15.8%)	
Longer than 1 hour	78 (13.0%)	40 (12.2%)	38 (14.0%)	
N	599 (100.0%)	327 (100.0%)	272 (100.0%)	
Years of smoking	13.09 ± 6.77	13.73 ± 6.94	12.32 ± 6.48	0.011
N	604	330	274	
Motivation to quit (1–10)	5.34 ± 2.71	5.41 ± 2.70	5.25 ± 2.73	0.466
N	587	316	271	

^I *P*-value is for difference among sex groups. *P*-values for continuous predictors are from *t*-tests while *p*-values for categorical variables are from chi-square tests.

Table 3a

Associations of Exercise and Activity with Smoking-related Symptomatology.

	Total LLA Score			Sport/Exercise Frequency		
	Estimate	SE	P-value	Estimate	SE	P-value
Positive Affect	Female Slope	0.502 ¹	0.134	<0.001	0.407 ³	0.089
	Male Slope	0.383	0.142	0.007	-0.033	0.096
	Slope Difference			0.538 ²		<0.001
Negative Affect	Female Slope	-0.284	0.143	0.047	-0.303	0.094
	Male Slope	-0.233	0.151	0.123	-0.050	0.102
	Slope Difference			0.805		0.067
Craving	Female Slope	-0.191	0.150	0.202	-0.137	0.099
	Male Slope	-0.207	0.158	0.189	-0.011	0.107
	Slope Difference			0.940		0.384
Physical Symptoms	Female Slope	-0.075	0.110	0.493	-0.137	0.073
	Male Slope	-0.184	0.117	0.115	-0.108	0.079
	Slope Difference			0.494		0.781
Withdrawal	Female Slope	-0.191	0.125	0.127	-0.220	0.083
	Male Slope	-0.209	0.133	0.115	-0.008	0.089
	Slope Difference			0.920		0.081

¹ Interpretation: A female with a 1-unit higher LLA score (e.g., a score of 2.5 vs. 1.5) is predicted to have a 0.502 unit higher positive affect score. This is the female slope of positive affect on LLA.

² Interpretation: The male slope is not significantly different from the female slope (p = 0.538).

³ Interpretation: A female with a 1-unit higher sport/exercise frequency (e.g., often vs. sometimes) is predicted to have a 0.407 higher positive affect score. This is the female slope of positive affect on sport/exercise frequency.

Table 3b

Associations of Exercise and Activity with Impulsivity.

		Total LLA Score			Sport/Exercise Frequency		
		Estimate	SE	P-value	Estimate	SE	P-value
BIS Attentional	Female Slope	-0.730 ¹	0.363	0.045	-0.653 ³	0.240	0.006
	Male Slope	-0.819	0.384	0.033	-0.363	0.260	0.163
	Slope Difference			0.865 ²			0.409
BIS Motor	Female Slope	0.275	0.414	0.507	-0.128	0.274	0.638
	Male Slope	-0.009	0.438	0.983	-0.177	0.296	0.550
	Slope Difference			0.633			0.904
BIS Non-planning	Female Slope	-1.078	0.469	0.022	-1.061	0.313	<0.001
	Male Slope	-1.84	0.497	<0.001	-0.325	0.338	0.336
	Slope Difference			0.256			0.107
BIS Total	Female Slope	-1.534	1.051	0.145	-1.843	0.696	0.008
	Male Slope	-2.674	1.111	0.016	-0.865	0.751	0.249
	Slope Difference			0.450			0.335

¹ Interpretation: A female with a 1-unit higher LLA score (e.g., a score of 2.5 vs. 1.5) is predicted to have a 0.730 unit lower BIS Attentional score. This is the female slope of BIS Attentional on LLA.² Interpretation: The male slope is not significantly different from the female slope (p = 0.865).³ Interpretation: A female with a 1-unit higher sport/exercise frequency (e.g., often vs. sometimes) is predicted to have a 0.653 lower BIS Attentional score. This is the female slope of BIS Attentional on sport/exercise frequency.

Table 3c

Associations of Exercise and Activity with Smoking Behavior.

	Total LLA Score			Sport/Exercise Frequency		
	Estimate	SE	P-value	Estimate	SE	P-value
Cigs per day						
Exp (Female Slope)	0.951 ¹	0.046	0.304	0.969	0.030	0.329
Exp (Male Slope)	1.039	0.0554	0.463	0.961	0.034	0.270
Slope Difference			0.210 ²			0.849
Years of smoking						
Exp (Female Slope)	0.977	0.030	0.459	0.988	0.020	0.559
Exp (Male Slope)	1.039	0.035	0.255	1.022	0.023	0.345
Slope Difference			0.176			0.273
Time to first morning cig						
Female Odds Ratio	0.891 ³	0.089	0.252	0.933 ⁵	0.061	0.291
Male Odds Ratio	0.976	0.070	0.742	1.027	0.049	0.576
Relative Odds Ratio			0.197 ⁴			0.043

¹ Interpretation: A female with a 1-unit higher LLA score (e.g., a score of 2.5 vs. 1.5) is predicted to smoke 0.951 times fewer cigs per day. 0.951 is the relative rate of smoking for a 1-unit higher LLA score.

² Interpretation: The male slope is not significantly different from the female slope ($p = 0.210$).

³ Interpretation: A female with a 1-unit higher LLA score (e.g., a score of 2.5 vs. 1.5) has an 10.9% lower odds of smoking earlier (11% lower odds of having a shorter time to first morning cigarette), 0.891 is, for example, the odds ratio for smoking within 5 min. relative to smoking within 6–30 minutes, for a 1-unit higher LLA score.

⁴ Interpretation: The male odds ratio is not significantly different from the female odds ratio.

⁵ Interpretation: A female with a 1-unit higher sport/exercise frequency (e.g., often vs. sometimes) has a 6.7% lower.

odds of smoking earlier (6.7% odds of having a shorter time to first morning cigarette). 0.933 is, for example, the odds ratio for smoking within 5 min. relative to smoking within 6–30 minutes, for a 1-unit higher sport/exercise frequency.