Original Article

Nicotine Dependence, Physical Activity, and Sedentary Behavior among Adult Smokers

Paul D. Loprinzi, Jerome F. Walker[1]

Center for Health Behavior Research, Department of Health, Exercise Science and Recreation Management, University of Mississippi, Mississippi, [1]Department of Respiratory Therapy, Lansing School of Nursing and Health Sciences, Bellarmine University, Louisville, Kentucky, USA

Abstract

Background: Research has previously demonstrated an inverse association between smoking status and physical activity; however, few studies have examined the association between nicotine dependence and physical activity or sedentary behavior. **Aim:** This study examined the association between nicotine dependence and accelerometer-determined physical activity and sedentary behavior. **Materials and Methods:** Data from the 2003-2006 National Health and Nutrition Examination Survey (NHANES) were used. A total of 851 adult (≥20 years) smokers wore an accelerometer for ≥4 days and completed the Fagerstrom Test for Nicotine Dependence scale. Regression models were used to examine the association between nicotine dependence and physical activity/sedentary behavior. **Results:** After adjusting for age, gender, race-ethnicity, poverty level, hypertension, emphysema, bronchitis, body mass index (BMI), cotinine, and accelerometer wear time, smokers 50 + years of age with greater nicotine dependence engaged in more sedentary behavior ($\beta = 11.4$, $P = 0.02$) and less light-intensity physical activity ($\beta = -9.6$, $P = 0.03$) and moderate-to-vigorous physical activity (MVPA; $\beta = -0.14$, $P = 0.003$) than their less nicotine dependent counterparts. **Conclusion:** Older adults who are more nicotine dependent engage in less physical activity (both MVPA and light-intensity) and more sedentary behavior than their less nicotine dependent counterparts.

Keywords: Accelerometry, Addiction, Epidemiology, Older adults, Smoking

Address of correspondence: Dr. Paul D. Loprinzi, Center for Health Behavior Research The University of Mississippi, 229 Turner Center, University, Mississippi - 38677, USA. E-mail: pdloprin@olemiss.edu

Introduction

Research has previously demonstrated an inverse association between smoking status and physical activity (PA).[1] Less research, however, has examined the specific association between nicotine dependence and PA, which is worth considering as individuals with greater nicotine dependence often have worse health outcomes (e.g., depression).[2,3] To our knowledge, few studies have examined the association between nicotine dependence and PA.[4-7] Each of these studies showed an inverse association between nicotine dependence and PA, suggesting that smokers with greater nicotine dependence engage in less PA and more sedentary behavior than their counterparts with less nicotine dependence. A limitation of these studies, however, was their exclusive use of self-report PA, which is prone to considerable measurement error.[8] Validation studies examining the association between self-report PA and some gold-standard (e.g., accelerometry, indirect calorimetry, and doubly labeled water) typically show a poor correlation in the range of 0.3-0.5.[9] Thus, these 'validated', self-report questionnaires only account for 9-25% of the variance in the outcome parameter, and are therefore likely to result in considerable misclassification.

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Based on this gap in the literature, the purpose of this study was to examine the association between nicotine dependence and accelerometer-determined PA behavior (both light-intensity and moderate-to-vigorous PA (MVPA)) among a national sample of US adult smokers. We also explored the association between nicotine dependence and accelerometer-determined sedentary behavior given the emerging research demonstrating

that sedentary behavior, independent of PA, is associated with worse health outcomes (e.g., cardiovascular disease).[10]

Materials and Methods

Design and participants

Data for the present study were obtained from the 2003-2006 National Health and Nutrition Examination Survey (NHANES). NHANES uses a representative sample of noninstitutionalized US civilians, selected by a complex, multistage probability design. The survey consists of two primary components, including participants being interviewed in their homes and subsequently examined in mobile examination centers (MECs). With regard to the study variables, the self-reported smoking questions were asked in the home interviews. Participants then wore the accelerometer the week following their visit to the MEC. The study was approved by the National Center for Health Statistics ethics review board, with informed consent obtained from all participants prior to data collection.

In the 2003-2006 NHANES cycles, 1,844 participants indicated they smoked every day. Among these, 1,818 provided data assessing nicotine dependence. Among these, 1,451 provided data on the covariates (e.g., age, gender, race-ethnicity, poverty level, emphysema, bronchitis, hypertension, cotinine, body mass index (BMI)), not including accelerometer wear time. Lastly, after excluding those with missing or insufficient accelerometry data (<4 days of 10 + h/day of monitoring data), 851 adult (20-85 years) participants remained, with these individuals constituting the analytic sample. When comparing the analytic sample to the 600 participants that were excluded because of missing or insufficient accelerometry data, there were no differences by race-ethnicity (P = 0.21), BMI (P = 0.07), cotinine (P = 0.15), and bronchitis (P = 0.84); however, those excluded were more likely to be female (47.6 vs 39.1%; P = 0.001), younger (40.4 vs 47.3 years; P < 0.001), had a lower poverty level score (2.0 vs 2.3; P < 0.001), and were less likely to have emphysema (2.8 vs 4.9%; P = 0.04) or hypertension (22.5 vs 30.4%; P = 0.001). These are unweighted estimates.

Measurement of nicotine dependence

Using the Fagerstrom Test for Nicotine Dependence scale,[11] two self-reported questions were used to assess nicotine dependence: i) "On average, how many cigarettes do you now smoke per day?" (responses of 10 or less, 11-20, 21-30, and 31 +, respectively, were coded as 0, 1, 2, and 3), and ii) "How soon after you wake up do you smoke?" (responses: Within 5 min, from 6 to 30 min, from more than 30 min to 1 h, and more than 1 h, respectively, were coded as 3, 2, 1, and 0). As a result, this nicotine dependence scale ranged from 0 to 6, with higher scores indicating greater nicotine dependence.

Measurement of PA

At the MEC, participants who were not prevented by impairments of walking or wearing an accelerometer were issued an ActiGraph 7164 accelerometer. Participants were asked to wear the accelerometer on the right hip for 7 days following their examination. Detailed information on the ActiGraph accelerometer can be found elsewhere.[12] For the present study, activity counts were summarized in 1-min bout intervals. Sedentary behavior was determined from activity counts <100/min.[13] Activity counts between 100 and 2,019 counts per min were used to classify time spent in light-intensity PA; activity counts between 2,020 and 5,998 counts per min were used to classify time spent at moderate-intensity;[14] and activity counts at or greater than 5,999 counts per min were used to classify time spent at vigorous-intensity.[14] Given that participants spent little time at or above vigorous intensity (mean = 0.62 min/day, standard error (SE) = 0.1), moderate and vigorous intensity PA was combined as an estimate of MVPA. For the analyses described here, and to ensure habitual PA patterns were assessed, only those participants with at least 4 days with 10 or more h/day of monitoring data were included in the analyses.[14] Nonwear of the accelerometer was defined by a period of a minimum of 60 consecutive min of zero activity counts, with the allowance of 1-2 min of activity counts between 0 and 100.[14]

Measurement of covariates

Covariates included age (continuous), gender (male/female), race-ethnicity (Mexican American, other Hispanic, non-Hispanic white; non-Hispanic black, and other race), poverty level (range = 0-5), measured hypertension (≥140 mmHg(systolic) or ≥90 mmHg (diastolic) or if they were taking blood pressure lowering medication), physician-diagnosed emphysema, physician-diagnosed bronchitis, measured BMI (kg/m^2), cotinine (continuous; ng/mL), and accelerometer wear time (h/day).

As a measure of socioeconomic status, poverty level was assessed from the poverty-to-income ratio, with a value below 1 considered below the poverty threshold. The poverty level is calculated by dividing the family income by the poverty guidelines, which is specific to the family size, year assessed, and state of residence.[15] Serum cotinine was measured by an isotope dilution-high performance liquid chromatography/atmospheric pressure chemical ionization tandem mass spectrometry.

Data analysis

Statistical analyses (STATA, version 12.0, College Station, TX) accounted for the complex survey design used in NHANES. To account for oversampling, nonresponse, noncoverage, and to provide nationally representative estimates, all analyses included the use of survey sample weights, stratum, and primary sampling units.

Multivariable regression analysis was used to examine the association between nicotine dependence (predictor variable) and PA/sedentary behavior; models were computed separately for sedentary behavior, light-intensity PA, and MVPA. Linear regression analyses were computed for sedentary behavior and light-intensity PA. A negative binomial regression analysis was computed for the MVPA model given that MVPA was considerably skewed. All models were adjusted for age, gender, race-ethnicity, poverty level, hypertension, emphysema, bronchitis, BMI, cotinine, and accelerometer wear time.

Interaction analyses were first computed to examine if there was an interaction effect of nicotine dependence and age; nicotine dependence and gender; and nicotine dependence and race-ethnicity. To examine a potential interaction effect, the cross-product term of nicotine dependence and the demographic variable (i.e., age, gender, or race-ethnicity) was entered into the model, along with the main effect variables and the covariates. These three interaction models (with MVPA as the outcome variable) showed that the interaction variable for nicotine dependence and age was significant ($\beta = -0.07$; $P = 0.02$); however, the models examining an interaction effect for nicotine dependence and gender ($\beta = -0.83$; $P = 0.30$) and nicotine dependence and race-ethnicity ($\beta = 1.06$; $P = 0.13$) were not significant.

Given the nicotine dependence and age interaction effect, the results presented herein are stratified by age group (20-29 years, $n = 126$; 30-49 years, $n = 351$; and 50 + years, $n = 374$). More specifically, three multivariable regression analyses were computed that examined the association between nicotine dependence (predictor variable) and MVPA: One for 20-29-year-olds; one for 30-49-year-olds; and one for 50 + year olds. These age groups were chosen based on a visual inspection of a scatter plot (not shown) delineating a nonlinear relationship between age and nicotine dependence. Similarly, three separate age-stratified models were computed for light-intensity PA and three separate age-stratified models were computed for sedentary behavior. Statistical significance was established as $P < 0.05$.

Results

Older smokers, compared to younger smokers, had a higher poverty-to-income ratio, higher cotinine value, were more likely to be hypertensive, have emphysema, chronic bronchitis, engaged in more sedentary behavior, and less light-intensity PA and MVPA[Table 1]. Also, older smokers had greater nicotine dependence.

Multivariable regression analyses showed that there was no association between nicotine dependence and PA/sedentary behavior for the two younger age groups [Table 2]. However, among smokers 50 + years, those with greater nicotine dependence engaged in more sedentary behavior ($\beta = 11.4$, $P = 0.02$) and less light-intensity PA ($\beta = -9.6$, $P = 0.03$) and MVPA ($\beta = -0.14$, $P = 0.003$). Notably, after applying a Bonferroni-corrected P-value (i.e., $P < 0.005$), nicotine dependence was only associated with MVPA. These regression analyses were adjusted for age, gender, race-ethnicity, poverty level, hypertension, emphysema, bronchitis, accelerometer wear time, cotinine, and BMI. When additional covariates (e.g., pack years) were entered in the model, the results were unchanged (data not shown).

These findings suggest that nicotine dependence is only associated with PA among older individuals, with older individuals generally having greater nicotine dependence; nicotine dependence values across the three age groups, respectively, was 2.0, 2.5, and 3.0. Further analyses were computed to examine if a particular nicotine dependence threshold influenced the nicotine dependence-PA relationship. When nicotine dependence was divided into tertiles (1.06; tertile 1, 3.0, tertile 2; and 4.6, tertile 3 (values are means)), there was no association between these nicotine dependence categories and PA. For example, in a multivariable regression model among the entire sample, middle tertile (vs bottom tertile) of nicotine dependence ($\beta = 0.03$, $P = 0.75$) was not associated with MVPA nor was the top tertile (vs bottom tertile) ($\beta = -0.07$, $P = 0.47$).

Discussion

Although a considerable amount of research has demonstrated an inverse association between smoking status and PA, to our knowledge, few studies have examined the association between nicotine dependence and PA.[4-7] These studies showed that nicotine dependence was inversely associated with self-reported leisure-time PA. The present study adds to the literature by examining this understudied topic, stratifying analyses by age, employing a national sample of US adult smokers, employing an objective measure of PA, and also considering the influence that nicotine dependence may have on sedentary behavior and light-intensity PA. Overall, our findings demonstrate

Table 1: Weighted characteristics of US smokers across age groups, 2003-2006 NHANES (*n* = 851)

Variable	Mean/proportion (SE)			*P*-value†
	20-29 years	30-49 years	50 + years	
Age, (years)	24.5 (0.2)	40.2 (0.3)	58.9 (0.4)	<0.001
Gender, %				0.30
Male	62.2 (3.0)	54.7 (3.1)	57.1 (2.7)	
Female	37.7 (3.0)	45.2 (3.1)	42.8 (2.7)	
Race-ethnicity, %				0.17
Mexican American	7.4 (2.0)	4.1 (0.9)	3.2 (0.9)	
Other Hispanic	3.1 (1.6)	1.3 (0.6)	1.8 (0.9)	
Non-Hispanic white	76.4 (3.8)	75.2 (2.8)	80.4 (3.6)	
Non-Hispanic black	7.3 (2.5)	12.6 (2.1)	10.3 (2.0)	
Other race	5.7 (1.7)	6.6 (1.3)	4.1 (1.5)	
Poverty-to-income ratio	2.4 (0.1)	2.7 (0.1)	2.9 (0.1)	0.01
Body mass index (kg/m^2)	25.8 (0.5)	27.8 (0.3)	26.8 (0.3)	0.05
Cotinine (ng/mL)	219.9 (12.5)	256.4 (6.7)	258.2 (7.6)	0.01
Hypertension, %				
Yes	3.4 (1.7)	16.0 (2.5)	43.9 (2.7)	<0.001
Emphysema, %				
Yes	1.7 (1.2)	2.3 (0.9)	9.2 (2.1)	0.001
Chronic bronchitis, %				
Yes	5.7 (2.6)	8.4 (1.7)	16.0 (2.6)	0.02
Sedentary behavior, min/day	462.5 (14.9)	453.5 (6.6)	512.4 (7.5)	0.004
Light-intensity physical activity, min/day	375.9 (11.6)	382.0 (6.4)	333.5 (6.5)	0.002
MVPA, min/day	32.6 (3.4)	26.9 (1.4)	14.0 (0.9)	<0.001
Accelerometer wear time, h/day	14.5 (0.1)	14.3 (0.1)	14.3 (0.1)	0.36
Nicotine dependence	2.0 (0.1)	2.5 (0.1)	3.0 (0.1)	<0.001

MVPA = Moderate-to-vigorous physical activity, NHANES = National health and nutrition examination survey, SE = Standard error. †For continuous variables (e.g., age), a linear regression was used to make comparisons across the age groups, with the youngest age group (20-29 years) serving as the referent group. For categorical variables (e.g., gender), a design-based likelihood ratio test was used.

Table 2: Multivariable regression analysis examining the association between nicotine dependence (independent variable) and physical activity/sedentary behavior, 2003-2006 NHANES (*n* = 851)

Accelerometer variable	20-29 years (*n* = 126)		30-49 years (*n* = 351)		50 + years (*n* = 374)	
	β (SE)	*P*-value	β (SE)	*P*-value	β (SE)	*P*-value
Sedentary	−10.8 (6.4)	0.10	−1.4 (3.5)	0.67	11.4 (4.7)	0.02
Light-intensity	9.2 (6.6)	0.17	0.71 (3.4)	0.83	−9.6 (4.4)	0.03
MVPA	0.06 (0.03)	0.08	0.02 (0.02)	0.25	−0.14 (0.04)	0.003

Nine separate regression models were computed: For the younger age-group, three separate models were computed for sedentary behavior, light-intensity physical activity, and MVPA. Similarly, three separate models were computed for the 30–49-year-old age group and three separate models were computed for the 50 + year age group. For each model, the following covariates were included in the model: Age, gender, race-ethnicity, poverty level, hypertension, emphysema, bronchitis, accelerometer wear time, cotinine, and body mass index. MVPA = Moderate-to-vigorous physical activity, NHANES = National health and nutrition examination survey, SE = Standard error

an inverse association between nicotine dependence and MVPA, with some evidence of an association between nicotine dependence and light-intensity PA and sedentary behavior. Notably, these associations were only observed for adults 50 years and older. A possible explanation for the null findings for the younger age groups may be because of their lower degree of nicotine dependence. Nicotine dependence may displace the amount of time to engage in PA and is also associated with other outcomes (e.g., depression) that are associated with physical inactivity.

It is widely established that PA decreases with age.[14] Our findings further demonstrate that older adults who are more nicotine dependent engage in less PA (both MVPA and light-intensity) and more sedentary behavior than their less nicotine-dependent counterparts. As a result, older adults with greater nicotine dependence, in particular, are in need of PA promotion. PA promotion may be particularly difficult among this population given the established age- and smoking-induced effects, such as reduced mobility and diminished lung capacity,[16,17]

which may increase exercise intolerance.[17] Given the emerging research showing that sedentary behavior and light-intensity PA are independent predictors of health among older adults;[18,19] promoting light-intensity PA, at least initially, may be a sensible strategy to increase long-term PA engagement among nicotine dependent smokers. In turn, this may help prevent the development of numerous comorbidities associated with physical inactivity. Further, and although speculative, such PA promotion may help to facilitate the cessation of smoking as regular PA engagement has been shown to reduce nicotine dependence through reduced nicotine cravings,[20] more quit attempts,[21] and success in stopping smoking.[22,23]

Conclusion

In conclusion, our findings demonstrate that, among US adults 50 + years of age, nicotine dependence is inversely associated with MVPA and light-intensity PA and positively associated with sedentary behavior. A limitation of this study includes the cross-sectional design, which precludes the ability to render causation. As a result, future research employing an objective measure of PA and utilizing a prospective or experimental study design is warranted. Further, the included sample differed from the excluded sample on several parameters, including gender, age, poverty level, and health status. Thus, our findings may lack generalizability to these populations. Lastly, depression data was not available in both of the evaluated NHANES cycles; therefore, future research should consider the effects of depression when examining the relationship between nicotine dependence and objectively-measured PA.

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