Short Communication

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Potential mediational role of cognitive function on physical activity and smoking behavior among older adults

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ABSTRACT

Purpose: We recently proposed a conceptual smoking cessation model suggesting the potential for physical activity to facilitate smoking cessation via improvements in neurocognition and executive function. Here, we provide a preliminary empirical evaluation of this model. **Methods:** Data from the 1999 to 2002 National Health and Nutrition Examination Survey were used; 2,299 older adult (60-84 years) participants provided data on the study variables. Moderate-to-vigorous physical activity (MVPA) and smoking status (yes/no) were assessed via self-report; the digit symbol substitution test (DSST) was used to assess cognitive function. **Results:** After adjustments, adults meeting MVPA guidelines had 61% lower odds of being a smoker (odd ratio [OR] = 0.39; 95% confidence interval [CI]: 0.25-0.61; $P < 0.001$). After adjustments, participants meeting MVPA guidelines had a higher cognitive function score ($\beta = 6.95$; 95% CI: 5.21-8.69; $P < 0.001$). Then, a 1-SD (DSST score of 18) increase in DSST was associated with a 24% (OR = 0.76; 95% CI: 0.64-0.90; $P = 0.003$) reduced odds of being a smoker after adjustments. The indirect beta coefficient was statistically significant ($\beta = -0.01$; 95% CI: −0.03 to −0.0004). The proportion of the total effect of MVPA on smoking that was mediated by cognitive function was 6.2%. **Conclusion:** These preliminary findings provide empirical support for the possibility of cognitive function playing a mediating role regarding the relationship between physical activity and smoking behavior.

KEY WORDS: Elderly, epidemiology, executive function, exercise, neurocognition

INTRODUCTION

Recently [1], we proposed a conceptual smoking cessation model suggesting the potential for physical activity to facilitate smoking cessation via improvements in neurocognition and executive function. More specifically, we suggested that physical activity may foster improvements in executive function or the ability to engage in goal-directed, purposeful behaviors, and based on this definition, these individuals with higher physical activity-induced executive function would be less likely to smoke; or if already a smoker, more likely to quit smoking.

This conceptual model has yet to be empirically tested. Here, we use epidemiological data from the National Health and Nutrition Examination Survey (NHANES) to begin testing this conceptual model. Specifically, the purpose of this short communication was to examine whether cognitive function among older adults mediates the relationship between physical activity and smoking behavior. Our future work will continue this investigation by focusing on current smokers, and determining if indeed, physical activity may help to facilitate smoking cessation via physical activity-induced improvements in executive function.

METHODS

Design and Participants

Data from the 1999 to 2002 NHANES were used; only current NHANES cycles with cognitive function assessment. Study procedures were approved by the NCHS ethics review board, with informed consent obtained before data collection. 2,299 adult (60-84 years) participants provided data on the study variables.

The NHANES is an ongoing survey conducted by the Centers for Disease Control and Prevention that uses a representative sample of noninstitutionalized United States civilians selected by a complex, multistage, stratified, and clustered probability design. The multistage design consists of four stages, including the identification of counties, segments (city blocks), random selection of households within the segments, and random selection of individuals within the households. Further information on NHANES methodology and data collection is available on the NHANES website (http://www.cdc.gov/nchs/nhanes.htm).

Measurement of Smoking Status

Smoking status was self-reported and reported as current smoker or nonsmoker; self-reported smoking status has been shown to associate with cotinine levels [2].

Measurement of Cognitive Function

The digit symbol substitution test (DSST) was used to assess cognitive function. The DSST, a component of the Wechsler adult intelligence test and a test of visuospatial and motor speed of processing has a considerable executive function component and is frequently used as a sensitive measure of frontal lobe executive functions [3,4]. Participants 60 years of age and older were asked to copy symbols that were paired with numbers within 2 min. Following the standard scoring method, one point is given for each correctly drawn symbol.

Physical Activity

As described elsewhere [5], participants were asked open-ended questions about participation in leisure time physical activity over the past 30 days. Data were coded into 48 activities, including 16 sports-related activities, 14 exercise-related activities, and 18 recreational-related activities.

For each of the 48 activities where participants reported moderate or vigorous intensity for the respective activity, they were asked to report the number of times they engaged in that activity over the past 30 days and the average duration they engaged in that activity.

For each activity, metabolic equivalent of task (MET)-min-month was calculated by multiplying the number of days, by the mean duration, by the respective MET level (MET-min-month = days*duration*MET level). The MET levels for each activity are provided elsewhere. Participants engaging in 2000+ moderate-to-vigorous physical activity (MVPA) MET-min-month were defined as meeting physical activity guidelines. As described elsewhere [5], this self-reported physical activity measure has demonstrated evidence of convergent validity.

Measurement of Covariates

Covariates included: Age, sex, race-ethnicity (Mexican American, other Hispanic, non-Hispanic white, non-Hispanic black, and other), measured waist circumference (cm), and C-reactive protein (CRP; mg/dL), which is a biomarker of systemic inflammation, associated with physical activity, smoking and cognition [6,7].

Statistical Analyses

In Stata (version 12), Barron and Kenny mediational analysis, using bootstrapped confidence interval (CI), were computed: This mediational model examined whether cognitive function mediated the relationship between physical activity (independent variable) and smoking status (outcome variable). This mediation approach includes a 3-step regression process (1. IV → DV; 2. IV → M; 3. M → DV while controlling for IV), indirect effects were calculated using the product of coefficients approach, with bootstrapping used to calculate CI [8]. Analyses were adjusted for the complex survey design employed in NHANES. Statistical significance was established as $P < 0.05$.

RESULTS

Among the evaluated 2,299 older adult (60-84 years) participants, the weighted mean (SE) age was 69.38 years (0.22); waist circumference, 99.78 cm (0.31); CRP, 0.51 mg/dL (0.01); MVPA, 3662.6 MET-min-month (297.3). In the sample, 13.0% self-reported smoking; 37.9% met MVPA guidelines; 54.9% were female; 83.3% were non-Hispanic white.

As shown in Figure 1, and after adjusting for age, gender, race-ethnicity, waist circumference and CRP, adults meeting MVPA guidelines had a 61% lower odds of being a smoker (odd ratio [OR] = 0.39; 95% [CI]: 0.25-0.61; $P < 0.001$). After adjusting for age, gender, race-ethnicity, waist circumference and CRP, participants meeting MVPA guidelines had a higher cognitive function score ($\beta = 6.95$; 95% CI: 5.21-8.69; $P < 0.001$). Then, a 1-SD (DSST score of 18) increase in DSST was associated with a 24% (OR = 0.76; 95% CI: 0.64-0.90; $P = 0.003$) reduced odds of being a smoker after adjusting for age, gender, race-ethnicity, waist circumference and CRP. When meeting MVPA guidelines was added to this last model, cognitive function remained significantly associated with smoking (OR = 0.83; 95% CI: 0.71-0.97; $P = 0.03$), suggesting a partial mediation effect.

When employing the Barron and Kenny bootstrapping mediational model, the indirect beta coefficient was statistically significant ($\beta = -0.01$; 95% CI: -0.03 to -0.0004). The proportion of the total effect mediated was 6.2%. The ratio of the indirect to direct effect was 6.6%. Finally, the ratio of the total to direct effect was 1.07.

DISCUSSION

The purpose of this brief report was to preliminarily evaluate our physical activity, neurocognition, and smoking cessation model recently published in RQES [1]. In this previous publication [1], we have comprehensively described this model,

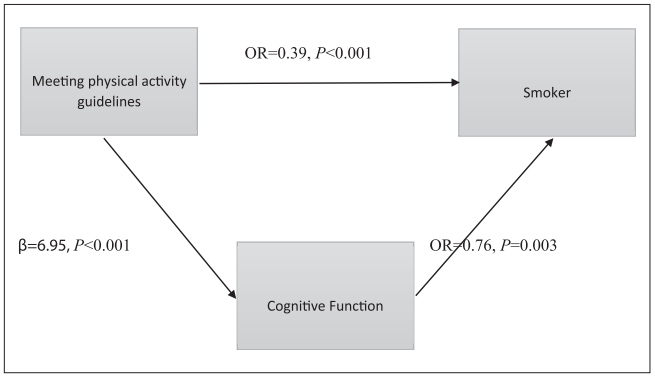

Figure 1: Mediational analysis examining the mediational role of cognitive function on the relationship between physical activity and smoking status

but in brief, this model hypothesizes that physical activity may help to facilitate smoking cessation and smoking behavior via physical activity-induced changes in neurocognition. The present findings provide some preliminary empirical support for this conceptual model. That is, albeit of a small magnitude, in this representative sample of older adults, cognitive function partially mediated the relationship between physical activity and smoking behavior. Of course, these findings should be interpreted in the context of the study's limitations, which include, for example, the cross-sectional study design, self-report measure of physical activity, and restriction to one singular assessment of cognitive function. Further, like most epidemiological studies, we cannot discount the possibility of residual confounding. These findings do, however, provide justification for further empirical evaluation of this model. Our future work will longitudinally evaluate this conceptual model. Specifically, we plan to longitudinally evaluate whether various executive function-related cognitive parameters mediate the relationship between objectively-measured physical activity and smoking status in the general population, as well as smoking cessation rates among baseline smokers. Further, given that higher-intensity physical activity may be less practical among older adults, future work evaluating this model in the context of light-intensity physical activity, is warranted.

Notably, although there was some evidence of a mediational role of cognitive function, a marginal proportion of the direct relationship between physical activity and smoking behavior was explained by cognitive function. There are several potential explanations for this. First, cognitive function, by itself, may only play a small part in explaining the relationship between physical activity and smoking behavior, which is not unrealistic as smoking and physical activity are both complex behaviors influenced by a multitude of factors. Second, the minimal proportion mediated may, in part, be a result of the subjective assessments of physical activity and smoking behavior, with subjective assessments often attenuating associations [9]. Third, the DSST is not a complete assessment of executive function and a greater mediated proportion may occur when a comprehensive battery of executive function tests are evaluated. And fourth, physical activity may influence smoking behavior via factors or other than, or in addition to, cognitive function. For example, previous research demonstrates that physical activity may influence smoking behavior via smoking-specific self-efficacy [10], reduced smoking cravings [11-13], and/or attenuating withdrawal symptoms [12,13].

This brief report provides some preliminary empirical support for our physical activity, neurocognition and smoking cessation model. That is, in this national sample of older adults, cognitive function partially mediated the relationship between physical activity and smoking behavior. These preliminary findings provide motivation and justification for further evaluation of our conceptual model using more robust study designs and robust study measures.

In conclusion, this article provides some suggestive evidence that physical activity may influence smoking behavior via its potential role on cognitive function. Future confirmatory research is needed, and in particular, future research should evaluate the potential mediational role of cognitive function on the relationship between physical activity and smoking cessation rates among daily smokers. These findings contribute valuable suggestive information that one of the potential ways in which physical activity may influence smoking behavior is via its effect of cognition. As such, this information may help identify individuals who may be at a greater risk of engaging in smoking behavior, and thus, these older adults with worse cognitive function may be a unique population to target physical activity behavior change.

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