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Exercise facilitates smoking cessation indirectly via improvements in smoking-specific self-efficacy: Prospective cohort study among a national sample of young smokers

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ABSTRACT

Objective. The purpose of this study was to examine whether exercise is associated with 2-year follow-up smoking status through its influence on smoking-specific self-efficacy.

Methods. Longitudinal data from the 2003–2005 National Youth Smoking Cessation Survey were used, including 1,228 participants (16–24 years). A questionnaire was used to examine baseline exercise levels, baseline smoking-specific self-efficacy, follow-up smoking status, and the covariates.

Results. Baseline exercise was associated with baseline self-efficacy ($\beta = 0.04$, $p < 0.001$) after adjusting for age category, sex, race–ethnicity, education, and nicotine dependence. Baseline self-efficacy, in turn, was associated with 2-year smoking status ($\beta = 0.23$, $p < 0.001$) after adjustments. There was no adjusted direct effect of baseline exercise on 2-year smoking status ($\beta = 0.001$, $p = 0.95$); however, the adjusted indirect effect of baseline self-efficacy on the relationship between exercise and 2-year smoking status was significant ($\beta = 0.008$, bootstrapped lower and upper CI: 0.002–0.02; $p < 0.05$). The *mediation ratio* was 0.837, which indicates that smoking-specific self-efficacy mediates 84% of the total effect of exercise on smoking status.

Conclusions. Among daily smokers, exercise may help to facilitate smoking cessation via exercise-induced increases in smoking-specific self-efficacy.

Introduction

Self-efficacy is the extent to which an individual has confidence in her or his ability to perform a particular behavior or attain a certain goal. Self-efficacy is believed to be situation-specific and malleable. For example, regular exercise participation has been shown to increase exercise-related self-efficacy (McAuley et al., 1993). Smoking-related self-efficacy, or her or his confidence in their ability to quit smoking, has been posited as a dynamic regulator of smoking behavior and may be a central cause of relapse to smoking (Niaura, 2000; Niaura et al., 1988). It is plausible to suggest that if exercise can increase exercise-related self-efficacy, then exercise may increase self-efficacy for other behaviors (or cognitions/emotions related to behavior), such as smoking abstinence. In partial support of this, the Exercise and Self-Esteem Model (McAuley et al., 2005) postulates that physical activity may influence self-efficacy, which in turn may influence global self-esteem, with global self-esteem being linked to smoking behavior (Abernathy et al., 1995; Kawabata et al., 1999). Further, research on multiple risk factors suggests that smoking-related and exercise-related self-efficacy are positively associated in adults, and smokers who exercise regularly have more self-efficacy for smoking abstinence than those who do not exercise regularly (King et al., 1996). However, the cross-sectional design of this previous study (King et al., 1996) does not allow for arguments of causality. Thus, we are aware of no study examining if exercise is longitudinally associated with smoking-related self-efficacy and, in turn, smoking behavior.

Studies have shown that exercise may help to reduce smoking cravings (Roberts et al., 2012), but other mechanisms by which exercise may exert its influence have not been clearly identified. Although speculative, exercise may help to facilitate smoking-specific self-efficacy via several mechanisms. For example, exercise is a complex behavior influenced by a multitude of factors (Bronfenbrenner, 1977), and successful engagement and maintenance of this complex behavior may increase an individual's confidence that they can initiate and maintain other complex health behaviors (e.g., smoking avoidance) (King et al., 1996). Applicable to the experience of exercise, personal self-efficacy is enhanced through successful experiences that include personal effort and perseverance, by reducing one's stress reactions (i.e., interpreting

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one's physiological states including fatigues and aches as signs of physical debility), and by enhancing mood (Bandura, 1998). Relatedly, exercise-related improvements in perceptions of physical status and in general mood may foster other positive health-related attitudes and motivations. Further, there is evidence of global psychological needs satisfaction associated with physical activity (Edmunds et al., 2007), as well as indirect effects of autonomy and self-efficacy satisfaction on other health-related behaviors, including smoking, within a physical activity context (Ryan and Deci, 2000; Williams et al., 2011). Also, exercise may help to enhance cognitive-related executive functioning (Diamond, 2012; Loprinzi et al., 2013; Oaten and Cheng, 2006), which is responsible for self-regulation and goal-oriented behavior via inhibitory control (e.g., behavioral inhibition) and interference control (e.g., cognitive inhibition and selective attention). Further, improved exercise-induced executive function may improve our ability to plan, schedule, initiate, filter competing information, and update and monitor relevant information (e.g., self-monitoring and self-evaluation) to facilitate behavioral adoption (Posner and DiGirolamo, 1998).

The identification of strategies to facilitate smoking cessation is of critical importance as smoking is associated with numerous negative health outcomes, and few patients (~3%) (Benowitz, 2010; Hughes et al., 1992) are able to successfully quit smoking without intervention. Such efforts may be particularly important in younger populations (e.g., adolescents and young adults), as this is a developmental time period in which smoking behavior may initiate (Hammond, 2005) and develop into full nicotine dependence (Benowitz, 1988). Therefore, using 2-year longitudinal data from the National Youth Smoking Cessation Survey (NYSCS), the aim of this study was to determine if exercise can help facilitate smoking cessation via improvements in smoking-specific self-efficacy.

Methods

Design and participants

Data from the 2003– to 2005 NYSCS were used, which is a 2-year prospective epidemiological study of young smokers. Details of the NYSCS can be found elsewhere (Walker and Loprinzi, 2014). All participants provided consent prior to participation, with parental consent provided for adolescents 16–17 years. Participants with complete data on the study variables across the 2-year time period constituted the analytic sample ($n = 1{,}228$). Notably, this is a 48% response rate from the original baseline sample of 2,582. Details on differences between those lost to follow-up and those retained have been reported in our previous work using this data set that examined demographic and psychosocial determinants of smoking cessation (Walker and Loprinzi, 2014); those lost to follow-up were less educated and less likely to be non-Hispanic white.

Demographics

Demographic-related parameters included self-report of age category (16–17, 18–20, and 21–24 years; continuous measure of age not available in NYSCS data set), sex (male/female), race–ethnicity (non-Hispanic white; non-Hispanic black; Hispanic; non-Hispanic other), and education (less than 12th grade, high school graduate, or some college/college degree).

Nicotine dependence

Baseline nicotine dependence was established using a modified Heaviness of Smoking Index (HSI), calculated as the numeric sum of two coded questions: (1) "In the past 30 days, how many cigarettes did you smoke per day?" (responses of *10 or less, 11–20, and 21 +*, respectively, were coded as 0, 1, and 2), and (2) "How soon after you wake up do you smoke?" (responses: *within 5 minutes, from 6 to 30 minutes, from more than 30 minutes to one hour*, and *more than one hour*, respectively, were coded as 3, 2, 1, and 0) (Kozlowski et al., 1994; Walker and Loprinzi, 2014). HSI has been reported as a valid indicator of dependence, having utility as a predictor of quit attempt maintenance (Borland et al., 2010).

Smoking status at 2-year follow-up

At the 2-year follow-up, current smoking was defined as self-reported smoking within the last 30 days, with no longer smoking defined as not smoking within the last 30 days. Although biochemical verification (e.g., urinary cotinine) of smoking status is the gold standard for determination of smoking status, self-report smoking status has demonstrated evidence of validity (Studts et al., 2006; Wong et al., 2012).

Baseline exercise

Participants were asked, "How many hours per week on average do you exercise? This includes playing sports, working out, aerobics, running, swimming, brisk walking, and other exercise activities." This item has demonstrated some evidence of construct validity as it has been shown to associate with nicotine dependence (Loprinzi et al., 2014).

Self-efficacy

Participants were asked, "Overall, on a scale from 0 to 10, where '0' is 'not at all confident', and '10' is 'extremely confident,' how confident are you right now that you can quit smoking if you decide to?" Similar smoking cessation self-efficacy scales have demonstrated evidence of validity (Etter et al., 2000; Spek et al., 2013).

Analysis

All statistical analyses were computed using procedures from sample survey data (SPSS, version 20.0). Survey sample weights were used to adjust for the complex survey design and to represent a national sample of young U.S. adult smokers. Hayes' mediational analysis (Hayes, 2013), using bootstrapped confidence interval, was used to examine whether baseline self-efficacy mediated the relationship between baseline exercise and 2-year follow-up smoking status. The relative magnitude (effect size) of the indirect effect was estimated by calculating the *mediation ratio* (P_M) (Ditlevsen et al., 2005), which is the ratio of the indirect effect to the total effect: $P_M = ab / (ab) + c$, where a is the slope linking exercise to self-efficacy, b is the conditional slope linking self-efficacy to smoking status, and c is the conditional slope linking exercise to smoking (Preacher and Kelley, 2011). The ratio of indirect effect to the direct effect was calculated as $R_M = ab / c$ (Sobel, 1982). Statistical significance was set at $p < 0.05$.

Results

Among the 1,228 participants, which represent 8,228,488 Americans, mean (95% CI) baseline levels for self-efficacy was 6.6 (6.4–6.7); number of hours/week of exercise was 5.5 (5.2–5.8); and baseline nicotine dependence was 1.3 (1.2–1.4). One-hundred and three participants (8%) were no longer smoking at the 2-year follow-up; 40.5% reported having some college/college degree; 73% were non-Hispanic white; 55.2% were male; and 55.3% were between 21 and 24 years.

The mediational analysis (Fig. 1) demonstrated that baseline exercise was associated with baseline self-efficacy ($\beta = 0.0358$, $p < 0.001$; represents a) after adjusting for age category, sex, race–ethnicity, education and nicotine dependence. Baseline self-efficacy, in turn, was associated with 2-year smoking status ($\beta = 0.2302$, $p < 0.001$; represents b) after adjusting for age category, sex, race–ethnicity, education, nicotine dependence and exercise. There was no adjusted direct effect of baseline exercise on 2-year smoking status ($\beta = 0.0016$, $p = 0.95$; represents c); however, the adjusted indirect effect of baseline self-efficacy on the relationship between exercise and 2-year smoking status was significant ($\beta = 0.008$, bootstrapped lower and upper CI: 0.002–0.02; $p < 0.05$). The *mediation ratio* ($P_M = ab / (ab) + c$) was 0.837 ([0.0358][0.2302] / [0.0358][0.2302] + 0.0016), which indicates that smoking-specific self-efficacy mediates 84% of the total effect of exercise on smoking status. The ratio of the indirect effect to the direct effect (R_M) was 5.15 ($R_M = ab / c$; ([0.0358][0.2302] / 0.0016)), indicating that the