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Breif communication

The effects of smoking and physical inactivity on advancing mortality in U.S. adults

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ABSTRACT

Purpose: The aim of the study was to calculate the rate advancement period (RAP) by which deaths for all-cause and cardiovascular disease (CVD)-specific mortality is advanced by smoking and physical inactivity among U.S. adults aged 18 years or more who participated in the Third National Health and Nutrition Examination Survey and were followed to December 31, 2006.
Methods: Mortality status was determined using the underlying cause of death. Cox regression was used to calculate the advanced time of deaths for all-cause and CVD-specific mortality among exposed adults relative to their nonexposed counterparts.
Results: Deaths for all-cause and CVD-specific mortality were advanced by 7.9 and 5.1 years among current smoker adults. For physically inactive adults, the RAPs for all-cause and CVD-specific mortality were 4.0 and 2.4 years, respectively. The joint effects of current smoking, physical inactivity, and obesity resulted in early all-cause and CVD-specific deaths of 14.2 and 12.2 years. For current smokers, physically inactive, and overweight adults, the RAPs for all-cause and CVD-specific deaths were 7.9 and 8.9 years, respectively.
Conclusions: Our findings suggest that smoking and physical inactivity could significantly advance the time of death associated with all-cause and CVD-specific mortality by at least 2.4 years among U.S. adults. Moreover, the advancement death period for the joint effects of smoking, physical inactivity, and overweight or obesity could be at least 7.9 years.

Health-related behaviors such as smoking and physical inactivity continue to be important causes of deaths in the U.S. population [1–3], with 33% of deaths attributed to smoking, diet and physical activity in 1990 [3] and 2000 [1,2]. Moreover, these negative behaviors affect an individual's life expectancy. For example, a recent study estimates that smoking could be associated with an 11-year loss of quality–adjusted life expectancy for an adult aged 18 years in 2009 [4]. Alternatively, physical activity could increase life expectancy from 1.8 years for adults with physical activity at low metabolic equivalent of task levels (0–3.74 hours/week) to 4.5 years for those at the highest metabolic equivalent of task levels per week (22.5+) [5]. Although increased death rates among obese adults advanced death by 3.7 years (grades II and III) for all-cause mortality and by at least 1.6 years for CVD-specific mortality [6], it is unknown whether smoking status and physical inactivity may contribute to early or advanced deaths among U.S. adults. Thus, we propose to calculate the rate advancement period (RAP) [7] or the average time by which the rate of death for all-cause and cardiovascular disease (CVD)-specific mortality is advanced by smoking and physical inactivity among U.S. adults aged 18 years or more. In addition, we also calculate the RAP for the joint effects of smoking, physical inactivity, and overweight or obesity. To address these aims, we use data from the Third National Health and Nutrition Examination Survey (NHANES) III linked to the National Death Index (NDI) mortality file with follow-up to December 31, 2006.

Methods

We used public data from NHANES III and the NHANES III–NDI Linked Mortality Files obtained from the Centers for Disease Control and Prevention, National Center for Health Statistics website [8]. NHANES III is a national survey conducted to assess the health status of a representative sample of the civilian noninstitutionalized U.S. population [9]. For this analysis, NHANES III datasets (household adult, examination, and laboratory files) were linked to death certificate records from the 2010 NDI Linked Mortality Public-use File with NHANES participants follow-up through December 31, 2006 (n = 20,050) [8]. To link these two datasets, National Center for Health Statistics used a probabilistic matching algorithm based on social security number, first name, middle initial, last name or surname, month, day and year of birth, sex, father's surname, state of birth, race, state of residence, and marital status [10].

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Using the underlying cause of death according to the International Classification of Diseases (ICD), Ninth and Tenth Revisions [11], we used mortality status to define all-cause mortality and ICD-10 codes 100–I78 from the 113 underlying cause of death to determine CVD-specific deaths. Time at risk of death was calculated from the interview date through December 31, 2006, as person-years of follow-up using the NHANES III interview date through the date of death for participants who died and from NHANES III interview date to December 31, 2006, for participants assumed to be alive [12].

Smoking status was defined using two self-report questions showing strong agreement with serum cotinine levels (92.5% for smokers and 98.6% for nonsmokers) in NHANES III [13]: "Have you smoked 100 cigarettes in your lifetime?" and "Do you smoke now?" with possible answers of yes or no. Individuals who answered, "yes" to both questions were considered current smokers; those who answered "yes" to the first question and "no" to the second were categorized as former smokers; and those who answered "no" to both questions were considered as never smokers. Leisure-time physical activity (LTPA) in the past month was defined using the following questions: "In the past month, did you … jog or run; ride bicycle/exercise bicycle; swim; do aerobics or aerobic dancing; do other dancing, calisthenics, or exercises; do garden/yard work; lift weights; or any other exercises or sports?" with any answer of "yes" considered as being physically active in their leisure time. A three-category definition was also considered according to the number of activities reported per week to classify participants as inactive (0–1 activity/week), infrequently active (1–5 activities/week), and active (5+ activities/week). This definition was used to specify the joint effects of smoking, physical inactivity, and overweight or obesity.

Consistent with previous studies [5,14], we included socio-demographic and health-related characteristics as covariates. We included age (continuous), gender (male or female), race/ethnicity (non-Hispanic white, non-Hispanic black, and Mexican American), marital status (married, divorced, single, and widowed), education (<high school diploma or general equivalency diploma (GED), high school diploma or GED, and >high school diploma or GED), total family 12-month income (≤$14999, $15000–$24999, and ≥$25000) and body mass index (BMI: >18.5 kg/m^2 [underweight], 18.5 kg/m^2 to <25.0 kg/m^2 [normal weight], 25.0 kg/m^2 to <30.0 kg/m^2 [overweight], 30.0 kg/m^2 to <35.0 kg/m^2 [obesity grade I], 35.0 kg/m^2 to <40.0 kg/m^2 [obesity grade II], and ≥40.0 kg/m^2 [extreme obesity or grade III]). For the joint effects, obesity was specified independent of grade.

We excluded records of individuals who were (1) aged <18 years at the time of the interview ($n = 432$); (2) ineligible for follow-up ($n = 25$); (3) did not have information on BMI ($n = 1854$) or mortality status ($n = 59$), reported a race/ethnicity as "other" ($n = 695$); and (4) did not have information on education ($n = 116$) and smoking status ($n = 1$). These exclusions yielded a final sample of 16,868, including 4401 deaths and approximately 222,933.25 person-years (median = 14.25, range: 0–18.2 years).

Statistical analysis

Prevalence of smoking, physical inactivity and their joint effects with BMI categories and death rates for all-cause and CVD-specific mortality were calculated for the total population. After examining the proportional hazards assumption [15], Cox proportional hazards regression was used to estimate hazard ratios (HRs) and 95% confidence intervals (CIs) for all-cause and CVD-specific mortality risks associated with smoking status, physical inactivity and the joint effects of smoking status, physical inactivity and BMI categories before and after controlling for age, sex, race/ethnicity, education, BMI, smoking (for LTPA), and LTPA (for smoking status). Marital status and income did not change our estimates, and therefore, were not included in the final models. In models for CVD-specific mortality, deaths attributed to other causes were treated as censored at the time the death occurred. To estimate the impact of each exposure on the timing of death occurrence, premature risk of death, aging effect on mortality risk or age difference between exposed and unexposed individuals at death [16–18], we used the coefficients for age and each exposure from the final Cox regression models for all-cause and CVD-specific mortality risks to calculate the RAPs or the time rate of death was advanced among exposed compared with their nonexposed counterparts. The variance for age and each exposure and their covariance estimates were used to calculate the 95% CIs.

All data management procedures were conducted with SAS for Windows Release 9.3 (SAS Institute Inc. Cary, NC), whereas statistical analyses were conducted with SUDAAN Release 11.0 (Research Triangle Institute, Research Triangle Park, NC). SUDAAN takes into account the complex sampling design used in NHANES [19]. Sample sizes presented in Table 1 were unweighted, but all other estimates (proportions, standard errors, rates, HRs, and RAPs with their 95% CIs) were weighted.

Results

Table 1 shows that 29% of U.S. adults report being current smokers and 79% report any LTPA in the past month with 31% reporting ≥5 activities/week. Among U.S. adults, 6.2% report being current smokers, physically inactive, and overweight or obese. Another 5.9% report current smoking, physically inactivity, and normal weight. Finally, 7.6% of U.S. adults report never smoking, being physically active, and normal weight. Higher death rates for all-cause and CVD-specific mortality were observed for former smoker (1933.4 and 830.8 per 100,000 person-years, respectively) and physically inactive (1751.9 and 794.4 per 100,000 person-years, respectively) adults. The all-cause and CVD-specific mortality death rates were higher among adults who were current smokers, physically inactive, and obese (2307.3 and 846.6/100,000 person-years) relative to their counterparts who did not smoke, were physically active and of normal weight (648.2 and 292.1/100,000 person-years).

Table 2 presents the HRs and RAPs associated with smoking and physical inactivity on all-cause and CVD-specific mortality risks. For the unadjusted analyses, significant increased death rates for all-cause and CVD-specific mortality were observed for smoking status, physical inactivity and the joint effects of smoking status, physical inactivity, and overweight or obesity. Compared with adults who never smoked, the rate of dying from all-cause was 2.11 (95% CI, 1.87–2.38) for current and 1.29 (95% CI, 1.16–1.44) for former smokers after controlling for age, sex, race/ethnicity, BMI, physical activity, and education. These rates were associated with early deaths of 7.9 and 2.7 years, respectively. When compared with adults reporting any LTPA, adults reporting no LTPA in the past month have a 46% increased rate of dying from all-cause, whereas those who report at least one activity in the past week have a 23% increase compared with their counterparts reporting being physically active. These rates were associated with an early death of 4.0 and 2.2 years, respectively.

For CVD-specific mortality risk, current and former smoker adults have increased death rates: 1.80 (95% CI, 1.52–2.12) and 1.14 (95% CI, 1.01–1.30) relative to their never smoker counterparts. Moreover, these rates were associated with advanced death periods of 5.1 and 1.2 years. For any LTPA in the past month, the HR for CVD-specific mortality was 1.52 (95% CI, 1.33–1.73) and was associated with an advanced death period of 3.7 years. When compared with physically active adults, inactive adults have a 32%