**Associations of Exercise with All-cause Mortality among Adults in the United States**

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Abstract

Participation in exercise benefits physical and mental health as well as longevity. However, the extent to which specific exercise types are associated with mortality remains unclear. This study examined whether 15 different types of exercise were independently and uniquely associated with lower risks of all-cause mortality in a nationally representative sample of noninstitutionalized American adults aged between 18 and 84 years. A total of 26,727 American adults in the National Health Interview Survey (NHIS) who reported their exercise or sports in 1998 were prospectively followed for all-cause mortality through the end of 2015. We then applied a series of discrete hazard models to estimate adjusted odds ratios (OR) and 95% confidence intervals (CI) for all-cause mortality. During 17 years of follow-up, 4,955 deaths occurred. After adjusting for potential confounders (demographic factors, socioeconomic status, health behaviors, and health status), walking, running, aerobics, stretching, weight lifting, cycling, stair climbing, and volleyball were independently related to lower risks of mortality (ORs ranged from 0.57 to 0.92). When adjusting for other exercises, stretching (OR = 0.90, 95%CI = 0.83–0.97) and playing volleyball (OR = 0.54, 95%CI = 0.31–0.93) were uniquely associated with lower risks of mortality. These findings suggest that participation in different types of exercise may have differential benefits for longevity. Future studies should further investigate the unique contribution of specific exercises to public health and how to promote greater exercise participation.

*Keywords:* Exercise, sports, mortality, prospective study, American adults, National Health Interview Survey

**1. Introduction**

Epidemiologists have extensively documented the benefits of exercise for physical and mental health as well as longevity (Bauman, 2004; Chekroud et al., 2018; Loprinzi, 2015; Wen et al., 2011). While these benefits are well-publicized, recent estimates suggest that only 23% of Americans aged 18–64 get the recommended amount of exercise (Blackwell & Clarke, 2018). Among those who exercise, there is substantial variation in the types of exercise, including engaging in activities such as baseball, running, weight training, etc. However, most epidemiological research has focused either on one type of exercise (e.g., running: Chakravarty et al., 2008; Lee et al., 2014) or on the combined energy expenditure of various exercises (e.g., Lee et al., 2018; Wen et al., 2011). Given that different types of exercise have substantially different physiological, social, and psychological implications for longevity (Kekäläinen, Freund, Sipilä, & Kokko, 2019; Oja et al., 2017; Schnohr et al., 2018), it is important to investigate the extent to which specific exercise types are associated with mortality.

A few studies have compared the life expectancy benefits of various types of exercise. For example, a Danish study that compared eight types of exercise suggested that tennis players had the longest gain in life expectancy (9.7 years) when compared with sedentary individuals, followed by people who engaged in badminton, soccer, cycling, swimming, jogging, calisthenics, and health club activities (1.5–6.2 years) (Schnohr et al., 2018). An English study investigated six types of exercise and indicated that cycling, swimming, racquet sports, and aerobics were related to lower risk of all-cause mortality, while football (i.e., soccer) and running were not (Oja et al., 2017). Notably, these studies focused on a limited number of exercise types that were especially prevalent in their contexts (i.e., England and Denmark), and did not adjust for other types of exercise. Of course, of those who do exercise, they may participate in more than one type of exercise (Schnohr et al., 2018), and the popularity of exercise types varies considerably between the United States, Denmark, and England (Hulteen et al., 2017). Thus, to gain a greater understanding of the associations between specific types of exercise and all-cause mortality in American adults, we used an extensive list of exercises (15 types), adjusted for potential confounders, analyzed the types of exercise individually, and then adjusted for engagement in other exercise types.

Other research interested in the relationship between exercise and health has classified exercises into different groups according to the frequency, duration, or intensity of exercises (e.g., Lee et al., 2018; Wen et al., 2011). While this specification is critically important for understanding the direct physiological benefits of exercise, it may overlook other important aspects of exercise (e.g., social meaning, goals, or social interaction and support) that may be beneficial for health and longevity (Andersen, Ottesen, & Thing, 2018; J. M. Saint Onge & Krueger, 2011; Schnohr et al., 2018). Partiality because of the importance of other aspects of exercise for health, Saint Onge and Krueger (2011)developed an alternate approach to stratify various exercise types (fitness, team, and facilities categories) and indicated that who engaged in specific categories of exercise was socially patterned. While there is evidence that different segments of the population tend to perform different types or categories of exercise (Saffer, Dave, Grossman, & Ann Leung, 2013; J. M. Saint Onge & Krueger, 2011), it is not yet clear whether these types or categories are differently related to risks of mortality and whether mortality benefits from doing exercise vary across different segments of the population. The fact that certain segments of the population are more likely to engage in certain types of exercise also stresses the importance of adjusting for covariates when examining the associations between exercise types and mortality.

This study builds on previous research regarding exercise types and mortality by analyzing associations between different types of exercise and the risk of mortality in the U.S. while accounting for important covariates. Specifically, our first aim was to include an extensive set (15 types) of exercise and examine how each type was associated with the risk of mortality while adjusting for detailed confounders in a large nationally representative sample of American adults. Our second goal was to isolate the association of each type of exercise by additionally controlling for the contributions of other types or categories of exercise. As past work has stressed the importance of measuring the volume of exercise (Dayoung Lee et al., 2018; Wen et al., 2011) in relation to mortality, we gauged the sensitivity of our results by accounting for the volume of each exercise type rather than a simple measure of participation. Finally, we also examined if the associations between exercise types or categories and mortality varied systematically across population groups by fitting interaction models between engagement in each type or category of exercise and age, sex, race/ethnicity, or educational attainment on the risk of mortality.

**2. Data and Method**

*2.1 Data*

The data for this analysis were from the 1998 National Health Interview Survey (NHIS) and the National Health Interview Survey Linked Mortality File (NHIS-LMF). The NHIS is a nationally representative survey of noninstitutionalized American households, which is conducted annually to systematically measure the health of the U.S. population. In each household one adult (the sample adult) is selected at random to respond to detailed questions regarding his or her life and health. In 1998, the Sample Adult Prevention Module (NHIS-SAPM) included detailed questions about what types of exercise the respondent participated in. The NHIS has been linked to a national vital death registry to create the NHIS-LMF, using a 13-point matching algorithm including characteristics such as the respondent’s Social Security number (Lochner, Hummer, Bartee, Wheatcroft, & Cox, 2008). The NHIS-LMF is currently updated through December 31, 2015, so we were able to follow the respondent’s vital status from the interview in 1998 to the end of 2015. We excluded respondents who had missing data on all (*n* = 947) or some exercise types (*n* = 32), did not engage in any of the 15 exercise types because of physical handicap (*n* = 2,964), were ineligible for mortality follow-up (*n* = 1,415), or were 85 years old or older (the NHIS top-coded age at 85 years, *n* = 355), leaving 26,727 respondents and 413,583.25 person-years of follow-up. All participants provided written informed consent and all procedures were approved by the Research Ethics Review Board at the National Center for Health Statistics.

*2.2 Person-quarter file*

The quarter of birth, interview quarter, and quarter of death or right censoring (Singer & Willett, 2003)were used to create a person-quarter file (quarters were the finest specification of time available in the publicly released version of the NHIS). Those who died were censored in the quarter when they died, whereas those who lived to the end of the LMF follow-up period (the fourth quarter of 2015) were right censored. Quarters were coded “0” when the respondent was alive and “1” when s/he died. To test the validity of the person-quarter file, we also employed other types of models such as Cox proportional hazard models (Singer & Willett, 2003), which provided the same substantive results.

*2.3 Exercises*

For each of the 15 types of exercise: walking, running, aerobics, stretching, weight lifting, cycling, stair climbing, baseball, basketball, volleyball, soccer, football, swimming, tennis, and golf, responses were coded “1” if participants indicated that they engaged in the exercise in the past two weeks and “0” if they did not. Next, following Saint Onge and Krueger (2011), we used an exploratory factor analysis (EFA) and found the same three categories of exercise (see Supplemental Table S1 and S2 for Tetrachoric correlations among the 15 types of exercise and their factor loadings, respectively), which they titled fitness, team, and facilities. Accordingly, three dummy variables were created for the three categories (0 = did not engage in any exercise in the category, 1 = engaged in one or more exercises in the category).

*2.4 Covariates*

Covariates reported in 1998 were classified into four groups: (1) demographic information (time-varying age, sex, nativity status, census region of residence, marital status, and race/ethnicity), (2) socioeconomic measures (educational attainment, household income, and home ownership), (3) health behaviors (smoking, drinking alcohol, and body mass index), and (4) health status (self-reported health status, physical handicap, and health condition). These factors have been previously identified as contributors to the risk of mortality (Berchick & Lynch, 2017; Borrell & Crawford, 2009; Hart, Smith, Gruer, & Watt, 2010; Long, Hanlon, & Pellegrin, 2018; Prospective Studies Collaboration, 2009). Detailed coding information for covariates is presented in the supplemental material.

*2.5 Statistical analysis*

First, weighted descriptive statistics of all used variables were analyzed in Stata 15.0. Next, a series of discrete hazard models (logistic) on the person-quarter file were tested. Specifically, discrete hazard models first linked the type or category of exercise individually (i.e., each exercise type or category had its own model) to mortality (Model 1), then in the next model adjusted for demographic information (Model 2), then additionally controlled for socioeconomic measures (Model 3), then added health behaviors (Model 4), and finally added health status (Model 5). In the next analyses, all types or categories of exercise were examined in combined models (i.e., all types or categories of exercise were simultaneously entered in the same model) and then followed the same progressive adjustment strategy (i.e., Models 1–5). Missing data (family income had the highest rate of absence at 13.39%) were handled with Stata’s multiple imputation suite, creating and combining 20 datasets using Rubin’s rule.

**3. Results**

*3.1 Descriptive statistics*

Weighted descriptive statistics of mortality status, exercise, and covariates are presented in Supplemental Table S3. Around 16.5% of participants died between 1998 and 2015. Among the 15 exercise types investigated in 1998, walking was the most popular, with 47.6% of participants reporting engaging in this exercise in the past two weeks. Stretching (30.3%) was the second most popular, followed by weight lifting (17.4%), cycling (13.8%), and running (11.9%). The lowest percentage of participants played soccer (1.6%), followed by football (1.7%), tennis (1.9%), volleyball (2.0%), and baseball (3.3%). Consistent with the results of individual exercise types, the highest percentage of participants engaged in the category of fitness exercise (63.1%), around 12.2% in the category of facilities exercise, and about 11.2% in the category of team exercise. Approximately 67.0% of participants reported having engaged in at least one exercise type in the past two weeks.

*3.2 Individual type or category of exercise and mortality risk*

First, we examined how each type or category of exercise was linked to the risk of mortality. Results are presented in Table 1. When no covariates were considered, all exercise types but walking were associated with lower risks of mortality (Model 1). After controlling for demographic information, basketball, soccer, football, and tennis were no longer significantly related to the risk of mortality; walking was linked to a lower risk of mortality; and baseball was associated with a higher risk of mortality (Model 2). Swimming and golf were no longer linked to the risk of mortality once controls of socioeconomic measures were included. Walking, running, aerobics, stretching, weight lifting, cycling, stair climbing, and volleyball were still related to lower risks of mortality, whereas baseball was linked to higher risk of mortality (Model 3). Similar significant associations remained after health behaviors and health status were progressively added in models (Models 4 and 5; see also Figure 1A for Model 5).

[Insert Table 1 about here]

Among the broader categories, Table 1 shows that fitness exercise and any exercise were consistently related to lower risks of mortality, both without and with controls for covariates (see also Figure 1A for Model 5). Team exercise was related to a lower risk of mortality only when no covariates were included. Facilities exercise was associated with a lower risk of mortality when no covariates, or only demographic information, were controlled for, but this association disappeared after socioeconomic measures were also adjusted for.

[Insert Figure 1 about here]

*3.3 All types or categories of exercise and mortality risk*

Next, all types or categories of exercises were included in the same models to examine how each type or category of exercise was uniquely related to the risk of mortality after accounting for the influences of other exercise types or categories on mortality (see Table 2). When no covariates were controlled for, all but walking, cycling, football, swimming, tennis, and golf were related to lower risks of mortality. When progressively adjusting for demographic information, socioeconomic measures, health behaviors, and health status, stretching and volleyball were consistently related to lower risks of mortality, while baseball was consistently linked to a higher risk; cycling, stair climbing, basketball, soccer, football, swimming, and tennis were consistently not related to the risk of mortality; and other exercises were not consistently associated with the risk of mortality (see also Figure 1B for Model 5).

[Insert Table 2 about here]

When the three categories of exercise simultaneously entered into the same models (see Table 2), fitness, team, and facilities exercise were all related to lower risk of mortality when no covariates were considered. Team exercise was no longer linked to the risk of mortality after demographic information were controlled for, and facilities exercise was no longer associated with the risk of mortality after socioeconomic measures were additionally controlled for. However, fitness exercise was consistently related to a lower risk of mortality when covariates were added (see also Figure 1B for Model 5).

*3.4 Sensitivity analyses*

Sensitivity analyses were conducted to examine whether volumes of specific exercise types were related to the risk of mortality. Detailed information of analyses is provided in the supplemental material. Compared with analyses with dummy-coded exercise types, there were minimal substantial changes in effects on mortality when volumes of each exercise type were accounted for (see Supplemental Table S4). We also examined whether the associations between exercise types and mortality varied across age, sex, race/ethnicity, or educational attainment. Only a few interaction effects were statistically significant. For instance, reporting running increased the risk of mortality for non-Hispanic Blacks and Hispanics relative to non-Hispanic Whites. The full results are presented in Supplemental Table S5-S8.

**4. Discussion**

In the current study, we analyzed the associations between 15 types of exercise (and their volumes) and mortality using a nationally representative sample of Americans. This study contributes to previous research by using the most comprehensive list of exercise heretofore investigated while also controlling for extensive potential confounders. Our first goal was to examine how each exercise type was independently related to mortality when progressively accounting for detailed sets of confounders. Yet our results replicated some of the findings of Oja et al. (2017) and Schnohr et al. (2018) regarding the associations of running, aerobics, and cycling with lower risks of all-cause mortality. However, swimming, soccer, and tennis, which were associated with lower risks of mortality in their studies, were not linked to mortality in this study. One possible explanation for these discrepancies is that we analyzed a different country where these exercises had different engagement levels as well as meanings and because we controlled for more factors, including socioeconomic measures. Indeed, our results showed that swimming and golf were no longer related to the risk of mortality after adjustment for socioeconomic measures. This is not surprising, as both exercises require relatively high socioeconomic resources for consistent engagement (J. M. Saint Onge & Krueger, 2011).

This study advances our understanding of the unique association between each exercise type and mortality, controlling for engagement in other types of exercise. This is important as of those who exercised, most (59.42% in our sample) participated in more than one type of exercise. Our results suggested that stretching, volleyball, and baseball were uniquely associated with the risk of mortality when controlling for both detailed confounders and other types of exercise. Notably, these associations still existed when the volumes of each exercise rather than a mere binary measure of participation were specified. Stretching has substantial mental and physical benefits (Bennie et al., 2018), including prolonging engagement in other exercise. While we could not statistically explain the benefit of volleyball, we can only hypothesize. The injury risk of playing volleyball is very low, especially when compared with other team sports such as football and soccer (Bere, Kruczynski, Veintimilla, Hamu, & Bahr, 2015; Tirabassi et al., 2016). Volleyball generally requires social groups and social contact that combined with exercise is beneficial for health (Cedergren, King, Wagner, & Wegley, 2007).

Playing baseball was related to a lower risk of mortality when no covariates were considered but was linked to a higher risk of mortality after adjusting for demographic information. The suppression effect emerged when time-varying age was included, suggesting that among people of similar ages, baseball players, particularly those who played in a low volume (< 4 MET-hours per week), were at a higher risk of mortality. This result is consistent with one study suggesting that professional baseball players were exposed to a higher risk of cancer mortality than the general population (Nguyen, Zafonte, Kponee-Shovein, Paganoni, & Weisskopf, 2019). The potential reasons for the higher mortality risk among baseball players may be that injuries from playing (Makhni et al., 2015) and certain lifestyle habits (e.g., consumption of smokeless tobacco (“chewing tobacco”)) have important consequences for their health (Ernster et al., 1990; Walsh, Ellison, Hilton, Chesney, & Ernster, 2000)and may outweigh the potential benefit of the sport. However, given that previous studies often found greater life expectance of Major League Baseball players than general population (e.g., Nguyen et al., 2019; Onge et al., 2008), more research focusing on the association between playing baseball and mortality in general population is needed.

Given the distinct characteristics of the three major categories of exercise (e.g., number of participants, competitive levels, and demand for facilities), it is not surprising to find that they displayed differential benefits for mortality. Only the fitness exercise was consistently related to lower risks of mortality (7%–17%) after adjustment for multiple covariates. Exercises in the fitness category require minimal facilities and can be performed individually, so people from diverse backgrounds can easily engage in them—a potential reason why the association between fitness exercise and mortality remained robust after progressive adjustment for confounders. Given the magnitude of our findings regardless of controls, our results stress the importance of making exercise foundational to preventative health programs. Also briefly worth noting, this study found little systematic evidence that the associations between exercise types or categories and mortality varied by age group, gender, race/ethnicity, or educational attainment, emphasizing that promoting exercise will likely not worsen health inequality.

The current study has several notable strengths. First, we analyzed a nationally representative sample that conducted a 17-year prospective investigate and included 15 types of exercise and multiple important confounders. Second, in addition to examining individual types of exercise separately, we also simultaneously included them in the same model. Thus, we were able to not only replicate findings from previous studies (Chakravarty et al., 2008; Kraschnewski et al., 2016; Duck-chul Lee et al., 2014; Oja et al., 2017) but also extend prior research by emphasizing the unique contribution of each exercise, which is important given that most people who exercise engage in multiple types of exercise (Schnohr et al., 2018). Our results were largely supported by analyzing the volumes of each exercise rather than analyzing self-reported participation in the activity. The third strength is that we validate the classification scheme used by Saint Onge and Krueger (2011) as an alternative choice for future studies. Finally, we documented that the association between exercise type and mortality generally varied little by population subgroup.

There are two limitations that should be considered. First, although we used one of the most comprehensive lists of exercise heretofore analyzed, this list is not totally comprehensive. Second, one study of British men at midlife suggested that men changed their exercise profiles as they aged (Aggio et al., 2019). This study was unable to include longitudinal analyses because the NHIS did not collect information regarding participation in specific types of exercise after 1998. Accordingly, future cohort-based studies should analyze how one’s exercise types, and their associations with mortality, change over time, although such studies will likely lack the generalizability to the adult population that studies such as this one can provide.

**5. Conclusion**

This study showed that walking, running, aerobics, stretching, weight lifting, cycling, stair climbing, and volleyball were independently related to lower risks of mortality. After adjusting for engagement in other types of exercise, stretching and volleyball remained protective against mortality risk. Furthermore, after classifying exercises into fitness, team, and facilities categories, only the fitness category of exercise was protective against mortality. These findings suggest that participation in different types of exercise is related to different mortality risk and highlight the importance of considering engagement in multiple types of exercise when analyzing the effect of specific exercise on mortality.

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Table 1

*Odds Ratios from Logistic Regression Models Predicting Mortality of U.S. Adults from Individual Types or Categories of Exercise in the National Health Interview Survey 1998 (N = 26,727)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Model 1OR (95%CI) | Model 2OR (95%CI) | Model 3OR (95%CI) | Model 4OR (95%CI) | Model 5OR (95%CI) |
| Individual Exercise Type |  |  |  |  |  |
|  Walking | 1.00 (0.95, 1.06) | 0.85\*\*\* (0.81, 0.90) | 0.90\*\*\* (0.85, 0.95) | 0.94\* (0.88, 0.99) | 0.92\*\* (0.87, 0.98) |
|  Running | 0.27\*\*\* (0.24, 0.32) | 0.66\*\*\* (0.56, 0.77) | 0.73\*\*\* (0.62, 0.86) | 0.80\*\* (0.68, 0.93) | 0.84\* (0.71, 0.98) |
|  Aerobics | 0.36\*\*\* (0.31, 0.43) | 0.65\*\*\* (0.55, 0.77) | 0.71\*\*\* (0.60, 0.84) | 0.75\*\* (0.63, 0.89) | 0.77\*\* (0.65, 0.91) |
|  Stretching | 0.61\*\*\* (0.57, 0.65) | 0.77\*\*\* (0.72, 0.82) | 0.83\*\*\* (0.77, 0.89) | 0.86\*\*\* (0.80, 0.92) | 0.85\*\*\* (0.80, 0.91) |
|  Weight lifting | 0.46\*\*\* (0.42, 0.51) | 0.74\*\*\* (0.67, 0.81) | 0.81\*\*\* (0.73, 0.89) | 0.86\*\* (0.78, 0.95) | 0.87\*\* (0.79, 0.96) |
|  Cycling | 0.68\*\*\* (0.62, 0.75) | 0.84\*\*\* (0.76, 0.92) | 0.89\* (0.81, 0.98) | 0.92 (0.83, 1.01) | 0.90\* (0.82, 0.99) |
|  Stair climbing | 0.57\*\*\* (0.50, 0.65) | 0.74\*\*\* (0.65, 0.84) | 0.79\*\* (0.69, 0.90) | 0.81\*\* (0.71, 0.93) | 0.84\* (0.74, 0.96) |
|  Baseball | 0.43\*\*\* (0.34, 0.55) | 1.31\* (1.01, 1.70) | 1.34\* (1.03, 1.75) | 1.38\* (1.06, 1.8) | 1.43\*\* (1.10, 1.86) |
|  Basketball | 0.28\*\*\* (0.23, 0.35) | 0.92 (0.74, 1.14) | 0.95 (0.76, 1.18) | 1.00 (0.80, 1.23) | 1.05 (0.84, 1.30) |
|  Volleyball | 0.14\*\*\* (0.08, 0.24) | 0.50\* (0.29, 0.86) | 0.52\* (0.31, 0.89) | 0.54\* (0.32, 0.93) | 0.57\* (0.33, 0.97) |
|  Soccer | 0.26\*\*\* (0.17, 0.41) | 0.98 (0.63, 1.51) | 0.99 (0.63, 1.53) | 1.04 (0.67, 1.63) | 1.11 (0.71, 1.73) |
|  Football | 0.29\*\*\* (0.19, 0.45) | 0.95 (0.59, 1.53) | 0.91 (0.56, 1.47) | 0.95 (0.59, 1.53) | 1.02 (0.64, 1.62) |
|  Swimming | 0.66\*\*\* (0.57, 0.75) | 0.85\* (0.74, 0.98) | 0.95 (0.82, 1.10) | 0.96 (0.83, 1.11) | 0.98 (0.85, 1.13) |
|  Tennis | 0.56\*\*\* (0.42, 0.74) | 0.77 (0.56, 1.05) | 0.96 (0.69, 1.33) | 0.98 (0.71, 1.36) | 1.01 (0.72, 1.4) |
|  Golf | 0.85\* (0.75, 0.98) | 0.77\*\*\* (0.68, 0.88) | 0.89 (0.78, 1.02) | 0.89 (0.78, 1.02) | 0.90 (0.79, 1.03) |
| Individual Exercise Category |  |  |  |  |  |
|  Fitness | 0.85\*\*\* (0.80, 0.90) | 0.83\*\*\* (0.79, 0.88) | 0.88\*\*\* (0.84, 0.94) | 0.93\* (0.87, 0.98) | 0.89\*\*\* (0.84, 0.94) |
|  Team | 0.28\*\*\* (0.24, 0.33) | 0.96 (0.81, 1.14) | 0.99 (0.84, 1.17) | 1.04 (0.88, 1.24) | 1.09 (0.92, 1.29) |
|  Facilities | 0.71\*\*\* (0.65, 0.79) | 0.80\*\*\* (0.72, 0.88) | 0.92 (0.83, 1.02) | 0.93 (0.84, 1.03) | 0.94 (0.85, 1.04) |
| Any Exercise | 0.81\*\*\* (0.77, 0.86) | 0.83\*\*\* (0.78, 0.88) | 0.89\*\*\* (0.84, 0.94) | 0.93\* (0.88, 0.99) | 0.89\*\*\* (0.84, 0.95) |

*Note*. OR = odds ratio; CI = confidence interval. Model 1 did not include covariates. Model 2 controlled for demographic information (time-varying age, sex, nativity status, census region of residence, marital status, and race/ethnicity). Model 3 controlled for demographic information and socioeconomic measures (educational attainment, household income, and home ownership). Model 4 controlled for demographic information, socioeconomic measures, and health behaviors (smoking, drinking alcohol, and body mass index). Model 5 controlled for demographic information, socioeconomic measures, health behaviors, and health status (self-reported health status, physical handicap, and health condition).

\**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001.

Table 2

*Odds Ratios from Logistic Regression Models Predicting Mortality of U.S. Adults from 15 Types or 3 Categories of Exercise in the National Health Interview Survey 1998 (N = 26,727)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Model 1OR (95%CI) | Model 2OR (95%CI) | Model 3OR (95%CI) | Model 4OR (95%CI) | Model 5OR (95%CI) |
| 15 Exercise Types |  |  |  |  |  |
|  Walking | 1.20\*\*\* (1.13, 1.27) | 0.92\*\* (0.86, 0.97) | 0.94\* (0.89, 1.00) | 0.97 (0.92, 1.03) | 0.95 (0.90, 1.01) |
|  Running | 0.42\*\*\* (0.36, 0.49) | 0.79\*\* (0.67, 0.93) | 0.82\* (0.69, 0.97) | 0.87 (0.73, 1.03) | 0.91 (0.77, 1.08) |
|  Aerobics | 0.51\*\*\* (0.43, 0.60) | 0.79\*\* (0.66, 0.93) | 0.81\* (0.68, 0.96) | 0.83\* (0.70, 0.99) | 0.84 (0.71, 1.00) |
|  Stretching | 0.84\*\*\* (0.78, 0.91) | 0.87\*\*\* (0.81, 0.94) | 0.90\*\* (0.83, 0.97) | 0.91\* (0.84, 0.98) | 0.90\*\* (0.83, 0.97) |
|  Weight lifting | 0.75\*\*\* (0.67, 0.83) | 0.89\* (0.80, 0.99) | 0.92 (0.83, 1.03) | 0.95 (0.85, 1.06) | 0.96 (0.86, 1.07) |
|  Cycling | 0.94 (0.86, 1.04) | 0.96 (0.87, 1.05) | 0.97 (0.88, 1.07) | 0.98 (0.89, 1.08) | 0.96 (0.86, 1.06) |
|  Stair climbing | 0.86\* (0.75, 0.99) | 0.88 (0.77, 1.01) | 0.89 (0.78, 1.02) | 0.88 (0.77, 1.02) | 0.92 (0.81, 1.06) |
|  Baseball | 0.73\* (0.57, 0.93) | 1.59\*\* (1.22, 2.07) | 1.57\*\* (1.20, 2.06) | 1.58\*\* (1.20, 2.06) | 1.59\*\* (1.22, 2.09) |
|  Basketball | 0.47\*\*\* (0.38, 0.59) | 1.05 (0.83, 1.33) | 1.04 (0.82, 1.32) | 1.06 (0.83, 1.34) | 1.09 (0.86, 1.38) |
|  Volleyball | 0.25\*\*\* (0.15, 0.43) | 0.54\* (0.32, 0.93) | 0.53\* (0.31, 0.92) | 0.53\* (0.31, 0.92) | 0.54\* (0.31, 0.93) |
|  Soccer | 0.50\*\* (0.32, 0.78) | 1.13 (0.72, 1.76) | 1.10 (0.71, 1.73) | 1.14 (0.73, 1.78) | 1.17 (0.75, 1.84) |
|  Football | 0.68 (0.44, 1.06) | 1.05 (0.64, 1.73) | 0.96 (0.58, 1.61) | 0.96 (0.58, 1.60) | 1.00 (0.61, 1.63) |
|  Swimming | 0.88 (0.76, 1.01) | 0.97 (0.84, 1.12) | 1.03 (0.89, 1.19) | 1.03 (0.89, 1.19) | 1.04 (0.90, 1.20) |
|  Tennis | 0.89 (0.67, 1.19) | 0.94 (0.69, 1.27) | 1.09 (0.80, 1.48) | 1.08 (0.79, 1.48) | 1.10 (0.80, 1.52) |
|  Golf | 1.08 (0.94, 1.23) | 0.83\*\* (0.72, 0.94) | 0.91 (0.80, 1.05) | 0.91 (0.79, 1.04) | 0.92 (0.80, 1.05) |
| 3 Exercise Categories |  |  |  |  |  |
|  Fitness | 0.92\*\* (0.87, 0.97) | 0.84\*\*\* (0.80, 0.89) | 0.89\*\*\* (0.84, 0.94) | 0.93\* (0.87, 0.98) | 0.89\*\*\* (0.84, 0.94) |
|  Team | 0.30\*\*\* (0.25, 0.35) | 1.04 (0.88, 1.23) | 1.03 (0.87, 1.22) | 1.08 (0.91, 1.28) | 1.14 (0.96, 1.35) |
|  Facilities | 0.83\*\*\* (0.75, 0.92) | 0.83\*\*\* (0.75, 0.91) | 0.94 (0.84, 1.04) | 0.94 (0.84, 1.04) | 0.95 (0.86, 1.05) |

*Note*. OR = odds ratio; CI = confidence interval. Model 1 did not include covariates. Model 2 controlled for demographic information (time-varying age, sex, nativity status, census region of residence, marital status, and race/ethnicity). Model 3 controlled for demographic information and socioeconomic measures (educational attainment, household income, and home ownership). Model 4 controlled for demographic information, socioeconomic measures, and health behaviors (smoking, drinking alcohol, and body mass index). Model 5 controlled for demographic information, socioeconomic measures, health behaviors, and health status (self-reported health status, physical handicap, and health condition).

\**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001

*Figure 1* Adjusted mortality odds ratio for individuals who did the exercise compared with individuals who did not do the exercise (reference).

*Note.* Individual types or individual categories of exercise were examined separately in Figure 1A; all types or all categories of exercise were examined together in Figure 1B. Covariates are demographic information (time-varying age, sex, nativity status, census region of residence, marital status, and race/ethnicity), socioeconomic measures (educational attainment, household income, and home ownership), health behaviors (smoking, drinking alcohol, and body mass index), and health status (self-reported health status, physical handicap, and health condition).

**Supplemental File**

***Coding of Covariates***

We classified covariates reported in 1998 into four groups: demographic information, socioeconomic measures, health behaviors, and health status.

Demographic information included time-varying age, sex (male [reference] or female), nativity status (born outside [reference] or inside the United States), census region of residence (Northeast [reference], North Central/Midwest, South, or West), marital status (married/cohabiting [reference], separated/divorced, widowed, or never married), and race/ethnicity (non-Hispanic White [reference], non-Hispanic Black, Hispanic, or non-Hispanic other).

Socioeconomic measures included educational attainment (below high school [reference], high school diploma or equivalent, some college, or bachelor’s degree or above), household income (less than $35,000 [reference], $35,000 to $75,000, or more than $75,000), and home ownership (owned [reference], being bought, rented, or other arrangement).

Health behaviors included smoking (current smoker [reference], former smoker, or never smoker), drinking alcohol (current drinker [reference], former drinker, or abstainer), and body mass index. For body mass index, values below 18.5 were coded as underweight, between 18.5 and 30 were coded as normal weight [reference], and above 30 were coded as obese.

Health status included self-reported health status, physical handicap, and health condition. Self-reported health status was coded “1” if participants reported good, very good, or excellent health status and “0” if they reported fair or poor health status [reference]. Physical handicap was coded “1” if participants reported physical handicap in any exercises, otherwise “0” [reference]. Health condition was coded “1” if participants indicated that they had ever been told they had any of the following conditions: cancer, coronary heart disease, heart attack, heart condition/disease, angina pectoris, asthma, diabetes, emphysema, hypertension, stroke, ulcer, and trouble seeing, otherwise “0” [reference].

***Sensitivity Analyses***

Sensitivity analyses were conducted to examine whether the volume of exercise was related to the risk of mortality. Metabolic equivalents (METs) for each exercise were provided by NHIS (see https://www.cdc.gov/nchs/nhis/physical\_activity/pa\_recodes.htm). NHIS used participants’ self-reported changes of heart rate/breathing to assign METs to exercises (e.g., the METs for walking are 3, 4, and 5 for no or small, moderate, and large heart rate changes, respectively). The change of heart rate/breathing was not collected for stretching and golf, NHIS assigned no or small change of heart rate/breathing to them. Duration of golf was not collected as well, and NHIS imputed it as 120 minutes per week. MET-hours per week for each exercise were calculated by multiplying the weekly amount of time spent in the exercise by its MET for that respondent (e.g., the MET of walk is 3 if the respondent reported no or small change of heart rate/breathing). To ensure that each cell would have a sufficient number of observations, we categorized exercises as low volume (≤ 4 MET-hours per week) or high volume (> 4 MET-hours per week). Discrete hazard models were employed to examine links between all types of exercise and mortality, both without covariates (Model A) and with all covariates (Model B). Compared with analyses with dummy-coded exercises, there were minimal substantial changes in effects on mortality when volumes of each exercise were accounted for (see Supplemental Table S4). However, one notable exception was the association between low volume of tennis per week and a higher risk of mortality (OR = 2.56, 95% CI = 1.58-4.14) after adjustments for all covariates.

Table S1

*Tetrachoric Correlations among 15 Types of Exercise in U.S. Adults of the National Health Interview Survey 1998 (N = 26,727)*

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1. Walking | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 2. Running | 0.31 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 3. Aerobics | 0.30 | 0.40 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| 4. Stretching | 0.46 | 0.59 | 0.60 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| 5. Weight | 0.26 | 0.65 | 0.52 | 0.68 | 1 |  |  |  |  |  |  |  |  |  |  |
| 6. Cycling | 0.33 | 0.40 | 0.31 | 0.47 | 0.48 | 1 |  |  |  |  |  |  |  |  |  |
| 7. Stair climbing | 0.43 | 0.45 | 0.45 | 0.55 | 0.51 | 0.44 | 1 |  |  |  |  |  |  |  |  |
| 8. Baseball | 0.10 | 0.40 | 0.15 | 0.31 | 0.33 | 0.28 | 0.21 | 1 |  |  |  |  |  |  |  |
| 9. Basketball | 0.08 | 0.50 | 0.11 | 0.35 | 0.44 | 0.28 | 0.23 | 0.55 | 1 |  |  |  |  |  |  |
| 10. Volleyball | 0.15 | 0.39 | 0.23 | 0.32 | 0.33 | 0.27 | 0.24 | 0.50 | 0.56 | 1 |  |  |  |  |  |
| 11. Soccer | 0.08 | 0.46 | 0.15 | 0.29 | 0.29 | 0.24 | 0.20 | 0.43 | 0.49 | 0.44 | 1 |  |  |  |  |
| 12. Football | 0.09 | 0.42 | 0.05 | 0.32 | 0.43 | 0.24 | 0.21 | 0.54 | 0.68 | 0.44 | 0.50 | 1 |  |  |  |
| 13. Swimming | 0.24 | 0.31 | 0.25 | 0.35 | 0.30 | 0.32 | 0.27 | 0.31 | 0.29 | 0.33 | 0.27 | 0.29 | 1 |  |  |
| 14. Tennis | 0.19 | 0.42 | 0.18 | 0.35 | 0.31 | 0.26 | 0.23 | 0.33 | 0.29 | 0.40 | 0.34 | 0.26 | 0.35 | 1 |  |
| 15. Golf | 0.14 | 0.23 | -0.02 | 0.27 | 0.23 | 0.25 | 0.09 | 0.37 | 0.31 | 0.24 | 0.20 | 0.27 | 0.24 | 0.34 | 1 |

Table S2

*Varimax Rotated Tetrachoric Factor Loadings for 15 Types of Exercise in U.S. Adults of the National Health Interview Survey 1998 (N = 26,727)*

|  |  |  |  |
| --- | --- | --- | --- |
|   | Fitness | Team | Facilities |
| Walking | 0.49 | -0.05 | 0.25 |
| Running | 0.56 | 0.47 | 0.19 |
| Aerobics | 0.69 | 0.04 | 0.01 |
| Stretching | 0.79 | 0.23 | 0.22 |
| Weight | 0.71 | 0.42 | 0.05 |
| Cycling | 0.50 | 0.19 | 0.28 |
| Stair climbing | 0.66 | 0.13 | 0.13 |
| Baseball | 0.12 | 0.59 | 0.37 |
| Basketball | 0.14 | 0.82 | 0.16 |
| Volleyball | 0.19 | 0.54 | 0.34 |
| Soccer | 0.15 | 0.56 | 0.23 |
| Football | 0.11 | 0.77 | 0.14 |
| Swimming | 0.29 | 0.22 | 0.41 |
| Tennis | 0.23 | 0.26 | 0.51 |
| Golf | 0.07 | 0.25 | 0.47 |

Table S3

*Descriptive Statistics for U.S. Adults in the National Health Interview Survey 1998 (N = 26,727)*

|  |  |
| --- | --- |
| Variables | % or *M* (*SE*) |
| Mortality Status  | Dead (by December 31, 2015; %) | 16.5 |
| Exercise Types | Walking (%) | 47.6 |
|  | Running (%) | 11.9 |
|  | Aerobics (%) | 7.0 |
|  | Stretching (%) | 30.3 |
|  | Weight lifting (%) | 17.4 |
|  | Cycling (%) | 13.8 |
|  | Stair climbing (%) | 7.4 |
|  | Baseball (%) | 3.3 |
|  | Basketball (%) | 6.8 |
|  | Volleyball (%) | 2.0 |
|  | Soccer (%) | 1.6 |
|  | Football (%) | 1.7 |
|  | Swimming (%) | 6.2 |
|  | Tennis (%) | 1.9 |
|  | Golf (%) | 5.5 |
| Exercise Categories | Fitness (%) | 63.1 |
|  | Team (%) | 11.2 |
|  | Facilities (%) | 12.2 |
| Any Exercise | Any exercise (%) | 67.0 |
| Demographic Information | Age in 1998 (*M* (*SE*)) | 43.11 (0.15) |
|  | Female (%) | 51.4 |
|  | Born in US (%) | 87.4 |
|  | Census region of residence |  |
|  |  Northeast (%) | 19.7 |
|  |  North Central/Midwest (%) | 26.0 |
|  |  South (%) | 35.3 |
|  |  West (%) | 19.0 |
|  | Marital status |  |
|  |  Married/cohabiting (%) | 66.1 |
|  |  Separated or divorced (%) | 9.8 |
|  |  Widowed (%) | 5.0 |
|  |  Never married (%) | 19.1 |
|  | Race/ethnicity |  |
|  |  Non-Hispanic White (%) | 75.1 |
|  |  Non-Hispanic Black (%) | 10.8 |
|  |  Hispanic (%) | 10.3 |
|  |  Non-Hispanic other (%) | 3.8 |
| Socioeconomic Measures | Educational attainment |  |
|  |  Below high school (%) | 16.4 |
|  |  High school (%) | 30.5 |
|  |  Some college (%) | 29.3 |
|  |  Bachelor's degree or above (%) | 23.8 |
|  | Household income |  |
|  |  Less than 35k (%) | 42.5 |
|  |  35 to 75k (%) | 37.1 |
|  |  More than 75k (%) | 20.4 |
|  | Home ownership |  |
|  |  Owned (%) | 36.6 |
|  |  Being bought (%) | 33.4 |
|  |  Rented (%) | 27.9 |
|  |  Other arrangement (%) | 2.0 |
| Health Behaviors | Smoking |  |
|  |  Current smoker (%) | 24.3 |
|  |  Former smoker (%) | 22.4 |
|  |  Never smoke (%) | 53.2 |
|  | Drinking alcohol |  |
|  |  Current drinker (%) | 65.3 |
|  |  Former drinker (%) | 14.5 |
|  |  Abstainer (%) | 20.2 |
|  | Body mass index |  |
|  |  Under weight (%) | 2.0 |
|  |  Normal weight (%) | 78.3 |
|  |  Obese (%) | 19.6 |
| Health Status | Self-reported good, very good, or excellent (%) | 92.2 |
|  | Any physical handicap (%) | 2.6 |
|   | Any health condition (%) | 42.4 |

 Table S4

*Odds Ratios from Logistic Regression Models Predicting Mortality of U.S. Adults from the Volumes of 15 Types of Exercise in the National Health Interview Survey 1998 (N = 26,727)*

|  |  |  |  |
| --- | --- | --- | --- |
|   |  | Model A | Model B |
| *n* (%) | OR (95%CI) | OR (95%CI) |
| Walking (MET-hours per week) |  |  |  |
| None | 13952 (52.20) | 1.00 | 1.00 |
| Low | 6353 (23.77) | 1.08\* (1.00, 1.16) | 0.96 (0.89, 1.03) |
| High | 6422 (24.03) | 1.32\*\*\* (1.24, 1.42) | 0.95 (0.88, 1.01) |
| Running (MET-hours per week) |  |  |  |
| None | 23707 (88.70) | 1.00 | 1.00 |
| Low | 797 (2.98) | 0.57\*\*\* (0.44, 0.73) | 1.10 (0.84, 1.45) |
| High | 2223 (8.32) | 0.36\*\*\* (0.30, 0.44) | 0.82 (0.67, 1.00) |
| Aerobics (MET-hours per week) |  |  |  |
| None | 24821 (92.87) | 1.00 | 1.00 |
| Low | 647 (2.42) | 0.55\*\*\* (0.41, 0.72) | 0.88 (0.67, 1.15) |
| High | 1259 (4.71) | 0.49\*\*\* (0.39, 0.60) | 0.81 (0.65, 1.01) |
| Stretching (MET-hours per week) |  |  |  |
| None | 18732 (70.09) | 1.00 | 1.00 |
| Low | 7556 (28.27) | 0.83\*\*\* (0.77, 0.89) | 0.91\* (0.84, 0.98) |
| High | 439 (1.64) | 1.10 (0.87, 1.38) | 0.77\* (0.6, 1.00) |
| Weight lifting (MET-hours per week) |  |  |  |
| None | 22290 (83.40) | 1.00 | 1.00 |
| Low | 2140 (08.01) | 0.75\*\*\* (0.66, 0.86) | 0.88 (0.76, 1.00) |
| High | 2297 (08.59) | 0.75\*\*\* (0.64, 0.87) | 1.07 (0.91, 1.24) |
| Cycling (MET-hours per week) |  |  |  |
| None | 23067 (86.31) | 1.00 | 1.00 |
| Low | 1905 (7.13) | 0.94 (0.83, 1.07) | 0.99 (0.87, 1.12) |
| High | 1755 (6.57) | 0.93 (0.82, 1.07) | 0.92 (0.79, 1.07) |
| Stair climbing (MET-hours per week) |  |  |  |
| None | 24702 (92.42) | 1.00 | 1.00 |
| Low | 1441 (5.39) | 0.97 (0.84, 1.13) | 0.95 (0.82, 1.10) |
| High | 584 (2.19) | 0.58\*\*\* (0.43, 0.78) | 0.82 (0.61, 1.11) |
| Baseball (MET-hours per week) |  |  |  |
| None | 25941 (97.06) | 1.00 | 1.00 |
| Low | 462 (1.73) | 0.82 (0.60, 1.12) | 1.74\*\* (1.25, 2.44) |
| High | 324 (1.21) | 0.62\* (0.42, 0.94) | 1.39 (0.89, 2.17) |
| Basketball (MET-hours per week) |  |  |  |
| None | 25187 (94.24) | 1.00 | 1.00 |
| Low | 552 (2.07) | 0.42\*\*\* (0.29, 0.60) | 0.83 (0.57, 1.20) |
| High | 988 (3.70) | 0.52\*\*\* (0.40, 0.67) | 1.29 (0.97, 1.71) |
| Volleyball (MET-hours per week) |  |  |  |
| None | 26251 (98.22) | 1.00 | 1.00 |
| Low | 237 (0.89) | 0.23\*\*\* (0.11, 0.52) | 0.43\* (0.19, 0.95) |
| High | 239 (0.89) | 0.26\*\*\* (0.12, 0.55) | 0.65 (0.31, 1.33) |
| Soccer (MET-hours per week) |  |  |  |
| None | 26327 (98.50) | 1.00 | 1.00 |
| Low | 156 (0.58) | 0.61 (0.32, 1.18) | 1.15 (0.61, 2.16) |
| High | 244 (0.91) | 0.43\*\* (0.24, 0.79) | 1.17 (0.63, 2.18) |
| Football (MET-hours per week) |  |  |  |
| None | 26356 (98.61) | 1.00 | 1.00 |
| Low | 194 (0.73) | 0.73 (0.40, 1.33) | 0.97 (0.52, 1.82) |
| High | 177 (0.66) | 0.63 (0.33, 1.20) | 0.93 (0.43, 2.00) |
| Swimming (MET-hours per week) |  |  |  |
| None | 25128 (94.02) | 1.00 | 1.00 |
| Low | 998 (3.73) | 0.90 (0.75, 1.07) | 1.11 (0.92, 1.34) |
| High | 601 (2.25) | 0.84 (0.67, 1.04) | 0.91 (0.74, 1.14) |
| Tennis (MET-hours per week) |  |  |  |
| None | 26291 (98.37) | 1.00 | 1.00 |
| Low | 147 (0.55) | 1.38 (0.91, 2.10) | 2.56\*\*\* (1.58, 4.14) |
| High | 289 (1.08) | 0.68 (0.46, 1.01) | 0.69 (0.45, 1.07) |
| Golf (MET-hours per week) |  |  |  |
| None | 25402 (95.04) | 1.00 | 1.00 |
| High | 1325 (4.96) | 1.08 (0.94, 1.23) | 0.91 (0.79, 1.04) |

*Note*. OR = odds ratio; CI = confidence interval; MET = metabolic equivalent. Model A included all types of exercise and did not include covariates. Model B included all types of exercise and controlled for demographic information (time-varying age, sex, nativity status, census region of residence, marital status, and race/ethnicity), socioeconomic measures (educational attainment, household income, and home ownership), health behaviors (smoking, drinking alcohol, and body mass index), and health status (self-reported health status, physical handicap, and health condition).

\**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001.

Table S5

*Odds Ratios from Logistic Regression Models Predicting Mortality of U.S. Adults from the Interactions of 15 Types or 3 Categories of Exercise and Sex in the National Health Interview Survey 1998 (N = 26,727)*

|  |  |  |  |
| --- | --- | --- | --- |
|   | Model of Exercise Type by Sex |   | Model of Exercise Category by Sex |
| OR (95%CI) |   | OR (95%CI) |
| 15 Exercise Types |  | 3 Exercise Categories |  |
|  Walking | 0.98 (0.89, 1.06) |  Fitness | 0.91\* (0.83, 0.99) |
|  Running | 0.97 (0.79, 1.19) |  Team | 1.13 (0.94, 1.37) |
|  Aerobics | 0.84 (0.59, 1.19) |  Facilities | 0.99 (0.88, 1.12) |
|  Stretching | 0.84\*\* (0.74, 0.94) |  |  |
|  Weight lifting | 1.01 (0.88, 1.17) |  |  |
|  Cycling | 0.98 (0.85, 1.13) |  |  |
|  Stair climbing | 0.88 (0.70, 1.10) |  |  |
|  Baseball | 1.73\*\* (1.27, 2.36) |  |  |
|  Basketball | 1.00 (0.77, 1.30) |  |  |
|  Volleyball | 0.47\* (0.23, 0.97) |  |  |
|  Soccer | 1.11 (0.68, 1.80) |  |  |
|  Football | 0.93 (0.54, 1.61) |  |  |
|  Swimming | 1.15 (0.95, 1.4) |  |  |
|  Tennis | 0.97 (0.66, 1.43) |  |  |
|  Golf | 0.94 (0.8, 1.09) |  |  |
| Sex |  | Sex |  |
|  Female | 0.67\*\*\* (0.62, 0.73) |  Female | 0.68\*\*\* (0.62, 0.74) |
| Exercise Types × Sex |  | Exercise Categories × Sex |  |
|  Walking × Female | 0.96 (0.85, 1.08) |  Fitness × Female | 0.96 (0.86, 1.08) |
|  Running × Female | 0.78 (0.54, 1.15) |  Team × Female | 0.98 (0.64, 1.50) |
|  Aerobics × Female | 1.03 (0.69, 1.54) |  Facilities × Female | 0.88 (0.71, 1.08) |
|  Stretching × Female | 1.13 (0.97, 1.32) |  |  |
|  Weight lifting × Female | 0.87 (0.69, 1.08) |  |  |
|  Cycling × Female | 0.94 (0.77, 1.15) |  |  |
|  Stair climbing × Female | 1.08 (0.81, 1.43) |  |  |
|  Baseball × Female | 0.65 (0.33, 1.28) |  |  |
|  Basketball × Female | 1.58 (0.85, 2.93) |  |  |
|  Volleyball × Female | 1.41 (0.47, 4.26) |  |  |
|  Soccer × Female | 1.46 (0.41, 5.11) |  |  |
|  Football × Female | 1.54 (0.35, 6.75) |  |  |
|  Swimming × Female | 0.79 (0.59, 1.06) |  |  |
|  Tennis × Female | 1.41 (0.70, 2.81) |  |  |
|  Golf × Female | 0.89 (0.64, 1.24) |   |   |

*Note*. OR = odds ratio; CI = confidence interval; for sex, male served as a reference group; models controlled for demographic information (time-varying age, nativity status, census region of residence, marital status, and race/ethnicity), socioeconomic measures (educational attainment, household income, and home ownership), health behaviors (smoking, drinking alcohol, and body mass index), and health status (self-reported health status, physical handicap, and health condition).

\**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001.

Table S6

*Odds Ratios from Logistic Regression Models Predicting Mortality of U.S. Adults from the Interactions of 15 Types or 3 Categories of Exercise and Age in the National Health Interview Survey 1998 (N = 26,727)*

|  |  |  |  |
| --- | --- | --- | --- |
|   | Model of Exercise Type by Age in 1998 |   | Model of Exercise Category by Age in 1998 |
|   | OR (95%CI) |   | OR (95%CI) |
| 15 Exercise Types |  | 3 Exercise Categories |  |
|  Walking | 1.07 (0.98, 1.17) |  Fitness | 0.92 (0.84, 1.01) |
|  Running | 0.94 (0.77, 1.14) |  Team | 1.13 (0.95, 1.35) |
|  Aerobics | 0.89 (0.71, 1.13) |  Facilities | 0.93 (0.80, 1.08) |
|  Stretching | 0.80\*\*\* (0.71, 0.90) |  |  |
|  Weight lifting | 0.99 (0.84, 1.15) |  |  |
|  Cycling | 0.92 (0.79, 1.06) |  |  |
|  Stair climbing | 0.93 (0.76, 1.14) |  |  |
|  Baseball | 1.69\*\*\* (1.29, 2.23) |  |  |
|  Basketball | 1.04 (0.81, 1.35) |  |  |
|  Volleyball | 0.53\* (0.31, 0.91) |  |  |
|  Soccer | 1.12 (0.71, 1.79) |  |  |
|  Football | 1.12 (0.69, 1.81) |  |  |
|  Swimming | 0.99 (0.80, 1.22) |  |  |
|  Tennis | 1.36 (0.93, 1.98) |  |  |
|  Golf | 0.87 (0.70, 1.08) |  |  |
| Age in 1998 |  | Age in 1998 |  |
|  65-84 years old | 1.17\*\* (1.05, 1.30) |  65-84 years old | 1.15\* (1.03, 1.29) |
| Exercise Types × Age in 1998 |  | Exercise Categories × Age in 1998 |  |
|      Walking × 65-84 years old | 0.82\*\* (0.73, 0.92) |      Fitness × 65-84 years old | 0.94 (0.83, 1.05) |
|      Running × 65-84 years old | 0.92 (0.61, 1.37) |      Team × 65-84 years old | 0.97 (0.49, 1.90) |
|      Aerobics × 65-84 years old | 0.88 (0.62, 1.24) |      Facilities × 65-84 years old | 1.04 (0.85, 1.27) |
|      Stretching × 65-84 years old | 1.23\*\* (1.06, 1.44) |  |  |
|      Weight lifting × 65-84 years old | 0.94 (0.76, 1.17) |  |  |
|      Cycling × 65-84 years old | 1.07 (0.87, 1.31) |  |  |
|      Stair climbing × 65-84 years old | 1.00 (0.76, 1.31) |  |  |
|      Baseball × 65-84 years old | 0.61 (0.20, 1.81) |  |  |
|      Basketball × 65-84 years old | 1.64 (0.87, 3.08) |  |  |
|      Volleyball × 65-84 years old | - |  |  |
|      Soccer × 65-84 years old | 3.32\*\*\* (1.85, 5.96) |  |  |
|      Football × 65-84 years old | 0.39 (0.04, 3.82) |  |  |
|      Swimming × 65-84 years old | 1.10 (0.83, 1.47) |  |  |
|      Tennis × 65-84 years old | 0.59 (0.31, 1.14) |  |  |
|      Golf × 65-84 years old | 1.08 (0.82, 1.42) |   |   |

*Note*. OR = odds ratio; CI = confidence interval; for age in 1998, age 18-64 served as a reference group; models controlled for demographic information (time-varying age, sex, nativity status, census region of residence, marital status, and race/ethnicity), socioeconomic measures (educational attainment, household income, and home ownership), health behaviors (smoking, drinking alcohol, and body mass index), and health status (self-reported health status, physical handicap, and health condition); the effect of volleyball × 65-84 years old was not estimated because of 0 cell frequency.

\**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001.

Table S7

*Odds Ratios from Logistic Regression Models Predicting Mortality of U.S. Adults from the Interactions of 15 Types or 3 Categories of Exercise and Race/ethnicity in the National Health Interview Survey 1998 (N = 26,727)*

|  |  |  |  |
| --- | --- | --- | --- |
|   | Model of Exercise Type by Race/ethnicity |   | Model of Exercise Category by Race/ethnicity |
| OR (95%CI) |   | OR (95%CI) |
| 15 Exercise Types |  | 3 Exercise Categories |  |
|  Walking | 0.93\* (0.87, 1.00) |  Fitness | 0.87\*\*\* (0.81, 0.93) |
|  Running | 0.74\*\* (0.60, 0.92) |  Team | 0.93 (0.74, 1.17) |
|  Aerobics | 0.84 (0.69, 1.01) |  Facilities | 0.94 (0.85, 1.05) |
|  Stretching | 0.93 (0.86, 1.01) |  |  |
|  Weight lifting | 0.89 (0.79, 1.01) |  |  |
|  Cycling | 0.97 (0.87, 1.09) |  |  |
|  Stair climbing | 0.94 (0.81, 1.09) |  |  |
|  Baseball | 1.77\*\*\* (1.29, 2.43) |  |  |
|  Basketball | 0.86 (0.62, 1.18) |  |  |
|  Volleyball | 0.30\* (0.12, 0.77) |  |  |
|  Soccer | 0.70 (0.30, 1.62) |  |  |
|  Football | 1.19 (0.64, 2.19) |  |  |
|  Swimming | 1.01 (0.87, 1.18) |  |  |
|  Tennis | 1.09 (0.76, 1.56) |  |  |
|  Golf | 0.94 (0.81, 1.08) |  |  |
| Race/ethnicity |  | Race/ethnicity |  |
|  Non-Hispanic Black | 0.93 (0.81, 1.06) |  Non-Hispanic Black | 0.90 (0.78, 1.03) |
|  Hispanic | 0.95 (0.83, 1.10) |  Hispanic | 0.94 (0.81, 1.10) |
|  Non-Hispanic other | 0.96 (0.71, 1.30) |  Non-Hispanic other | 0.96 (0.69, 1.34) |
| Exercise Types × Race/ethnicity |  | Exercise Categories × Race/ethnicity |  |
|      Walking × |  |      Fitness × |  |
|         Non-Hispanic Black | 1.14 (0.94, 1.37) |         Non-Hispanic Black | 1.18 (0.98, 1.41) |
|         Hispanic | 0.95 (0.77, 1.16) |         Hispanic | 0.94 (0.77, 1.14) |
|         Non-Hispanic other | 1.45\* (1.00, 2.09) |         Non-Hispanic other | 1.25 (0.83, 1.89) |
|      Running × |  |      Team × |  |
|         Non-Hispanic Black | 1.89\*\* (1.19, 3.01) |         Non-Hispanic Black | 1.44 (0.95, 2.20) |
|         Hispanic | 1.66\* (1.00, 2.75) |         Hispanic | 1.81\*\* (1.16, 2.81) |
|         Non-Hispanic other | 1.7 (0.79, 3.67) |         Non-Hispanic other | 1.20 (0.46, 3.09) |
|      Aerobics × |  |      Facilities × |  |
|         Non-Hispanic Black | 0.94 (0.55, 1.61) |         Non-Hispanic Black | 0.98 (0.55, 1.76) |
|         Hispanic | 1.64 (0.94, 2.84) |         Hispanic | 1.17 (0.74, 1.86) |
|         Non-Hispanic other | 0.36 (0.11, 1.21) |         Non-Hispanic other | 1.10 (0.60, 2.00) |
|      Stretching × |  |  |  |
|         Non-Hispanic Black | 1.01 (0.78, 1.30) |  |  |
|         Hispanic | 0.74 (0.54, 1.02) |  |  |
|         Non-Hispanic other | 0.70 (0.44, 1.10) |  |  |
|      Weight lifting × |  |  |  |
|         Non-Hispanic Black | 1.10 (0.76, 1.59) |  |  |
|         Hispanic | 1.30 (0.91, 1.87) |  |  |
|         Non-Hispanic other | 2.12\* (1.19, 3.77) |  |  |
|      Cycling × |  |  |  |
|         Non-Hispanic Black | 0.92 (0.65, 1.32) |  |  |
|         Hispanic | 0.75 (0.51, 1.10) |  |  |
|         Non-Hispanic other | 1.52 (0.78, 2.97) |  |  |
|      Stair climbing × |  |  |  |
|         Non-Hispanic Black | 0.79 (0.49, 1.27) |  |  |
|         Hispanic | 1.12 (0.63, 2.01) |  |  |
|         Non-Hispanic other | 0.70 (0.32, 1.52) |  |  |
|      Baseball × |  |  |  |
|         Non-Hispanic Black | 0.74 (0.30, 1.08) |  |  |
|         Hispanic | 0.81 (0.37, 1.77) |  |  |
|         Non-Hispanic other | 1.06 (0.14, 8.26) |  |  |
|      Basketball × |  |  |  |
|         Non-Hispanic Black | 1.54 (0.87, 2.71) |  |  |
|         Hispanic | 2.02 (0.95, 4.28) |  |  |
|         Non-Hispanic other | 0.73 (0.11, 4.67) |  |  |
|      Volleyball × |  |  |  |
|         Non-Hispanic Black | 2.67 (0.64, 11.26) |  |  |
|         Hispanic | 2.03 (0.42, 9.91) |  |  |
|         Non-Hispanic other | 4.94 (0.65, 37.47) |  |  |
|      Soccer × |  |  |  |
|         Non-Hispanic Black | - |  |  |
|         Hispanic | 2.74\* (1.02, 7.41) |  |  |
|         Non-Hispanic other | - |  |  |
|      Football × |  |  |  |
|         Non-Hispanic Black | 0.85 (0.28, 2.59) |  |  |
|         Hispanic | 0.46 (0.12, 1.78) |  |  |
|         Non-Hispanic other | 2.01 (0.10, 42.22) |  |  |
|      Swimming × |  |  |  |
|         Non-Hispanic Black | 0.99 (0.40, 2.46) |  |  |
|         Hispanic | 1.13 (0.65, 1.98) |  |  |
|         Non-Hispanic other | 1.66 (0.78, 3.53) |  |  |
|      Tennis × |  |  |  |
|         Non-Hispanic Black | 1.07 (0.39, 2.98) |  |  |
|         Hispanic | 2.32 (0.89, 6.08) |  |  |
|         Non-Hispanic other | 0.26 (0.03, 2.31) |  |  |
|      Golf × |  |  |  |
|         Non-Hispanic Black | 0.60 (0.18, 1.98) |  |  |
|         Hispanic | 0.68 (0.26, 1.81) |  |  |
|         Non-Hispanic other | 0.68 (0.22, 2.08) |   |   |

*Note*. OR = odds ratio; CI = confidence interval; for race/ethnicity, non-Hispanic White served as a reference group; models controlled for demographic information (time-varying age, sex, nativity status, census region of residence, and marital status), socioeconomic measures (educational attainment, household income, and home ownership), health behaviors (smoking, drinking alcohol, and body mass index), and health status (self-reported health status, physical handicap, and health condition); effects of soccer × Non-Hispanic Black and soccer × Non-Hispanic other were not estimated because of 0 cell frequency.

\**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001

Table S8

*Odds Ratios from Logistic Regression Models Predicting Mortality of U.S. Adults from the Interactions of 15 Types or 3 Categories of Exercise and Educational Attainment in the National Health Interview Survey 1998 (N = 26,727)*

|  |  |  |  |
| --- | --- | --- | --- |
|   | Model of Exercise Type by Educational Attainment |   | Model of Exercise Category by Educational Attainment |
| OR (95%CI) |   | OR (95%CI) |
| 15 Exercise Types |  | 3 Exercise Categories |  |
|  Walking | 0.94 (0.84, 1.04) |  Fitness | 0.92 (0.83, 1.02) |
|  Running | 0.92 (0.56, 1.51) |  Team | 1.89\*\*\* (1.34, 2.67) |
|  Aerobics | 0.92 (0.57, 1.49) |  Facilities | 0.95 (0.67, 1.34) |
|  Stretching | 0.90 (0.76, 1.06) |  |  |
|  Weight lifting | 0.99 (0.78, 1.26) |  |  |
|  Cycling | 1.03 (0.83, 1.28) |  |  |
|  Stair climbing | 1.01 (0.75, 1.36) |  |  |
|  Baseball | 2.57\* (1.23, 5.37) |  |  |
|  Basketball | 1.79\* (1.07, 2.98) |  |  |
|  Volleyball | 0.22 (0.03, 1.52) |  |  |
|  Soccer | 1.32 (0.58, 3.03) |  |  |
|  Football | 0.67 (0.21, 2.10) |  |  |
|  Swimming | 0.91 (0.55, 1.49) |  |  |
|  Tennis | 5.36\*\* (1.83, 15.67) |  |  |
|  Golf | 0.94 (0.57, 1.56) |  |  |
| Educational Attainment |  | Educational Attainment |  |
|  High school | 0.94 (0.85, 1.04) |  High school | 0.97 (0.87, 1.08) |
|  Some college | 0.87\* (0.77, 0.99) |  Some college | 0.89 (0.78, 1.02) |
|  Bachelor's degree or above | 0.84\* (0.73, 0.97) |  Bachelor's degree or above | 0.85\* (0.72, 0.99) |
| Exercise Types × Educational Attainment |  | Exercise Categories × Educational Attainment |  |
|  Walking × |  |  Fitness × |  |
|  High school | 0.97 (0.84, 1.13) |  High school | 0.94 (0.81, 1.08) |
|  Some college | 1.14 (0.97, 1.35) |  Some college | 1.02 (0.86, 1.20) |
|  Bachelor's degree or above | 0.96 (0.80, 1.16) |  Bachelor's degree or above | 0.87 (0.72, 1.04) |
|  Running × |  |  Team × |  |
|  High school | 0.88 (0.47, 1.63) |  High school | 0.64 (0.4, 1.01) |
|  Some college | 1.25 (0.70, 2.21) |  Some college | 0.39\*\*\* (0.24, 0.63) |
|  Bachelor's degree or above | 0.86 (0.48, 1.54) |  Bachelor's degree or above | 0.58\* (0.36, 0.94) |
|  Aerobics × |  |  Facilities × |  |
|  High school | 0.90 (0.51, 1.60) |  High school | 0.97 (0.66, 1.44) |
|  Some college | 1.21 (0.69, 2.12) |  Some college | 1.03 (0.7, 1.52) |
|  Bachelor's degree or above | 0.65 (0.35, 1.22) |  Bachelor's degree or above | 1.02 (0.69, 1.50) |
|  Stretching × |  |  |  |
|  High school | 1.06 (0.86, 1.32) |  |  |
|  Some college | 0.97 (0.78, 1.21) |  |  |
|  Bachelor's degree or above | 0.93 (0.73, 1.18) |  |  |
|  Weight lifting × |  |  |  |
|  High school | 1.05 (0.77, 1.43) |  |  |
|  Some college | 0.79 (0.57, 1.08) |  |  |
|  Bachelor's degree or above | 1.07 (0.77, 1.49) |  |  |
|  Cycling × |  |  |  |
|  High school | 0.89 (0.67, 1.17) |  |  |
|  Some college | 0.87 (0.64, 1.19) |  |  |
|  Bachelor's degree or above | 0.98 (0.73, 1.32) |  |  |
|  Stair climbing × |  |  |  |
|  High school | 0.96 (0.64, 1.44) |  |  |
|  Some college | 1.01 (0.69, 1.47) |  |  |
|  Bachelor's degree or above | 0.68 (0.44, 1.05) |  |  |
|  Baseball × |  |  |  |
|  High school | 0.44 (0.18, 1.07) |  |  |
|  Some college | 0.52 (0.21, 1.27) |  |  |
|  Bachelor's degree or above | 0.88 (0.36, 2.11) |  |  |
|  Basketball × |  |  |  |
|  High school | 0.75 (0.39, 1.45) |  |  |
|  Some college | 0.40\* (0.20, 0.81) |  |  |
|  Bachelor's degree or above | 0.49 (0.23, 1.02) |  |  |
|  Volleyball × |  |  |  |
|  High school | 3.41 (0.42, 27.79) |  |  |
|  Some college | 2.09 (0.22, 19.84) |  |  |
|  Bachelor's degree or above | 2.76 (0.29, 25.94) |  |  |
|  Soccer × |  |  |  |
|  High school | 1.16 (0.35, 3.88) |  |  |
|  Some college | 0.62 (0.15, 2.57) |  |  |
|  Bachelor's degree or above | 0.62 (0.18, 2.18) |  |  |
|  Football × |  |  |  |
|  High school | 2.00 (0.51, 7.88) |  |  |
|  Some college | 1.11 (0.22, 5.64) |  |  |
|  Bachelor's degree or above | 1.51 (0.34, 6.76) |  |  |
|  Swimming × |  |  |  |
|  High school | 1.03 (0.59, 1.81) |  |  |
|  Some college | 1.25 (0.71, 2.21) |  |  |
|  Bachelor's degree or above | 1.24 (0.71, 2.15) |  |  |
|  Tennis × |  |  |  |
|  High school | 0.24\* (0.07, 0.81) |  |  |
|  Some college | 0.11\*\* (0.02, 0.45) |  |  |
|  Bachelor's degree or above | 0.22\* (0.07, 0.71) |  |  |
|  Golf × |  |  |  |
|  High school | 0.99 (0.56, 1.75) |  |  |
|  Some college | 0.97 (0.56, 1.69) |  |  |
|  Bachelor's degree or above | 0.96 (0.56, 1.66) |   |   |

*Note*. OR = odds ratio; CI = confidence interval; for educational attainment, below high school served as a reference group; models controlled for demographic information (time-varying age, sex, nativity status, census region of residence, marital status, and race/ethnicity), socioeconomic measures (household income and home ownership), health behaviors (smoking, drinking alcohol, and body mass index), and health status (self-reported health status, physical handicap, and health condition).

\**p* < 0.05, \*\**p* < 0.01, \*\*\**p* < 0.001.