Associations of Exercise Types with All-Cause Mortality among U.S. Adults

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ABSTRACT

SHEEHAN, C. M., and L. LI. Associations of Exercise Types with All-Cause Mortality among U.S. Adults. *Med. Sci. Sports Exerc.*, Vol. 52, No. 12, pp. 2554–2562, 2020. **Purpose:** Exercising benefits physical and mental health as well as longevity. However, the extent to which different types of exercise are differentially associated with the risk of mortality is less clear. This study examined whether 15 different types of exercise were uniquely associated with all-cause mortality in a nationally representative sample of noninstitutionalized American adults between 18 and 84 yr old. **Methods:** A total of 26,727 American adults in the National Health Interview Survey who reported their exercise type (s) in 1998 were prospectively followed for all-cause mortality through the end of 2015. We applied a series of discrete time logistic models to estimate odds ratios (OR) and 95% confidence intervals (CI) for all-cause mortality. **Results:** During 17 yr of follow-up, 4955 deaths occurred. After adjusting for total volume of other exercises and confounders (demographic factors, socioeconomic status, and health behaviors and status), walking, aerobics, stretching, weight lifting, and stair climbing were related to lower risks of mortality (OR ranged from 0.78 to 0.93). When adjusting for engagement in all exercise types and confounders, stretching (OR = 0.90, 95% CI = 0.83–0.97) and playing volleyball (OR = 0.53, 95% CI = 0.31–0.93) were uniquely associated with lower risks of mortality. **Conclusion:** These findings suggest that some types of exercise have unique benefits for longevity, but most are indistinguishable in relation to longevity. Future studies should further investigate the unique contribution of specific exercises and the joint contribution of multiple exercises and how to promote greater exercise participation.
Key Words: SPORTS, MORTALITY, PROSPECTIVE STUDY, NATIONAL HEALTH INTERVIEW SURVEY

Epidemiologists have extensively documented the benefits of exercise for physical and mental health as well as longevity (1–4). Although these benefits are well publicized, recent estimates indicate that only 23% of Americans 18–64 yr old get the recommended amount of exercise (5). Among those who exercise, there is substantial variation in the types of exercise, including engaging in activities such as baseball, running, weight training, etc. Most epidemiological research has focused either on one type of exercise (e.g., running [6,7]) or on the total volume of various exercises (e.g., [3,8]). However, different types of exercise could have substantially differential physiological, social, and psychological implications for longevity (9,10). Yet the extent to which specific exercise types are differentially associated with risk of mortality in the United States remains unclear. Indeed, the 2018 Physical Activity Guidelines Advisory Committee suggested that more information regarding the unique benefits of specific exercises is needed (11).

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A few studies have compared the life expectancy benefits of various types of exercise. For example, a Danish study comparing eight types of exercise suggested that tennis players have the longest gain in life expectancy (9.7 yr) when compared with sedentary individuals, followed by people who engage in badminton, soccer, cycling, swimming, jogging, calisthenics, and health club activities (1.5–6.2 yr) (9). An English study investigated six types of exercise and indicated that cycling, swimming, racquet sports, and aerobics were related to lower risks of all-cause mortality, whereas football (i.e., soccer) and running were not (10). Notably, these studies focused on several exercise types that were especially prevalent in their contexts (i.e., England and Denmark). Of course, of those who do exercise, many participate in more than one type of exercise (9), and the popularity and meaning of exercise types varies considerably between the United States, Denmark, and England (12). 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, including total volume of other exercises as well as engagement in other exercise types.

Analyzing the association between exercise and mortality is complicated by the fact that Americans choose different exercises based on social characteristics, their own level of health, and their propensity to engage in other forms of exercise (13,14). That is, Americans who do exercise often participate in multiple forms of exercise (14), so to isolate the influence of specific exercises on mortality (e.g., basketball), here we statistically control for participation in other exercises. We do so in two important ways: first we control for total volume of all other exercises (in MET-hours per week), and second, we control for engagement in all the other exercises. 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 sociodemographic covariates when examining the associations between exercise types and mortality. Americans may also choose certain exercises based on their level of health or even to minimize the long-term implications of certain health conditions or behaviors (15,16). Thus, we statistically account for not only other exercises and sociodemographic characteristics but also the health behaviors, conditions, and disability level of the respondents.

Previous 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., [3,8]). Although these specifications of exercise are critically important for understanding the direct physiological benefits of exercise, they may overlook other important aspects of exercise (e.g., social meaning, goals, or social interaction and support) that may vary across exercise types and may be beneficial for health and longevity (9,13). Partiality because of the importance of other aspects of exercise for health, Saint Onge and Krueger (13) developed an alternate approach to stratify various exercises (fitness, team, and facilities categories) and found that who engaged in specific categories of exercise was socially patterned. Thus, we also briefly document how engagement in these different classifications of exercises is associated with mortality.

Overall, this study builds on previous research regarding exercise types and mortality by analyzing the associations between different types of exercise and the risk of mortality in the United States while accounting for important covariates. Specifically, our major aim is to isolate the association of each type of exercise with mortality by progressively controlling for contributions of other types of exercise (i.e., total volume of other exercises or engagement in other exercises) and confounders in a nationally representative sample of American adults. As past work has stressed the importance of measuring the volume of exercise (3,8), in relation to mortality, we gauge the sensitivity of our results by examining the volume of each exercise type rather than a simple measure of participation. Accomplishing this should help to elucidate if different exercises have unique influences on longevity for the American adult population.

METHODS

Data. The data for this analysis came 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/her life and health. In 1998, the Sample Adult Prevention Module (NHIS-SAPM) included questions about what types of exercise the respondent participated, allowing us to analyze the exercise participation of this sample adult. The NHIS has been linked to the 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 (17). Previous research has highlighted strong concordance between the public use NHIS-LMF file and the restricted use file as well as national vital statistics (17,18). The NHIS-LMF is currently updated through December 31, 2015, so we were able to follow the respondent's vital status (i.e., mortality) from the quarter of interview in 1998 to the end of 2015. We excluded respondents who had missing data on all exercises (n = 947) or some exercises (n = 32), did not engage in any of the 15 exercises because of physical handicap (n = 2,964), were ineligible for mortality follow-up (n = 1,415), or were 85 yr old or older (the NHIS top-codes age at 85 yr, n = 355), leaving 26,727 respondents and 425,576.50 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.

Person-quarter file. The quarter of birth, interview quarter, and quarter of death or right censoring (19) were calculated to create a person-quarter file (N of person-quarters = 1,702,306). 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 (fourth quarter of 2015) were right censored. Quarters were coded "0" when the respondent was alive and "1" when s/he died.

Exercises. We classified engagement in exercise in two ways. First, participants reported their participation, frequency, duration, and intensity of 15 types of exercise/sports (e.g., "How many times in the past 2 wk did you walk for exercise?" "How many times in the past 2 wk did you play basketball?"). 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 2 wk and "0" if they did not. Next, following Saint Onge and Krueger (13), we coded the 15 types of exercise into three categories: fitness (i.e., walking, running, aerobics, stretching, weight lifting, cycling, and stair climbing), team (i.e., baseball, basketball, volleyball, soccer, and football), and facilities (i.e., swimming, tennis, and golf). Accordingly, three dummy variables were created for the three categories (0 = did not engage in any exercises in the category, 1 = engaged in one or more exercises in the category).

Second, we calculated the volume of each type of exercise using the METs of each exercise provided by NHIS (see https://www.cdc.gov/nchs/nhis/physical_activity/pa_recodes.htm). NHIS used participants' self-reported changes of heart

EPIDEMIOLOGY

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). MET-hours per week for each exercise were calculated by multiplying the weekly amount of time spent on the exercise by its METs for the respondent (e.g., the METs 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 used the median volume of each type of exercise to categorize the exercise either no participation, low volume (below or equals to the median value), or high volume (above the median value). Other specifications (e.g., using 4 $\text{MET}\cdot\text{h}\cdot\text{wk}^{-1}$ as a cutoff for all exercise types) yielded similar results. For the first models analyzing individual type or of exercise, we also included the total volume of the other exercises (i.e., MET-hours per week excluding the volume of the type or category of exercise that was included in the corresponding model) as a covariate (10).

Covariates. Covariates reported in 1998 were classified into three groups: 1) demographic information, 2) socioeconomic measures, and 3) health behaviors and status. These factors have been identified as contributors to the risk of mortality in previous studies (20–24). 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). We tested the potential impact of multicollinearity of the socioeconomic measures using variance inflation factors and found no evidence that the socioeconomic measures led to significant multicollinearity problems.

Health behaviors and status included smoking (current smoker [reference], former smoker, or never smoker), drinking alcohol (current drinker [reference], former drinker, or abstainer), body mass index, self-reported health status, physical handicap, and health condition(s). For body mass index, we coded values consistent with recommendations from the Centers for Disease Control and Prevention (25): 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. 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 being 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, and "0" if otherwise [reference].

Statistical analysis. First, weighted descriptive statistics of all the study variables were calculated. Next, a series of discrete time logistic models (26,27) were fit on the person-quarter file. These models are appropriate because the publicly released NHIS data only reported the quarter of death rather than precise date/time (27). To gauge the sensitivity of the modeling choice, we also employed other types of models such as Cox proportional hazard models (19), complementary log–log models (26,27), and discrete time logistic models (26) controlling for baseline age, which provided the same substantive results (available upon request). We first modeled types or categories of exercise separately (i.e., engagement in each exercise type or category such as playing basketball = 1, or not = 0, had its own model) in relation to mortality and adjusted for the total MET volume of all other exercises (i.e., aside from the focal exercise) (model 1), then in the next model additionally adjusted for demographic information (model 2), then additionally controlled for socioeconomic measures (model 3), and finally added health behaviors and status (model 4). Controlling for total volume of exercises may be inadequate, given that specific exercises may contribute to health and mortality differently (e.g., through social pathways) (9,10). Thus, in the next set of models, we controlled for engagement in individual exercises by examining all types or categories of exercise in combined models (i.e., engagement in individual types or categories of exercise were simultaneously entered in the same model), and then we followed the same progressive adjustment strategy. Finally, we assessed the volume levels of engaging in individual exercises by examining categorically coded (no participation [reference], low volume, or high volume) volume of exercise types in combined models, without covariates (model A) or with all covariates (model B). Missing data (family income had the highest rate of absence at 13.4%) were handled with Stata's multiple imputation suite, creating and combining 20 data sets using Rubin's rule (28).

RESULTS

Descriptive statistics. Weighted descriptive statistics of mortality status, exercises, and covariates are presented in Table 1. Approximately 16.5% of participants died between 1998 and 2015. Among the 15 exercises investigated in 1998, walking was the most popular, with 47.6% of participants reporting engaging in this exercise in the past 2 wk. 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%). Approximately 67.0% of participants reported engaging in at least one exercise in the past 2 wk.

TABLE 1. Weighted descriptive statistics for U.S. adults in the 1998 NHIS (N = 26,727).

Variables	Pct. or M (SE)
Mortality status	
Deceased (by December 31, 2015), %	16.5
Participation in 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
Participation in exercise categories	
Fitness (%)	63.1
Team (%)	11.2
Facilities (%)	12.2
Participation in any exercise	
Any exercise (%)	67.0
Demographic information	
Age in 1998, M (SE)	43.11 (0.15)
Female (%)	51.4
Born in the United States (%)	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 35,000 (%)	42.5
35,000 to 75,000 (%)	37.1
More than 75,000 (%)	20.4
Home ownership	
Owned (%)	36.6
Being bought (%)	33.4
Rented (%)	27.9
Other arrangement (%)	2.0
Health behaviors and status	
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
Self-reported good, very good, or excellent (%)	92.2
Any physical handicap (%)	2.6
Any health condition (%)	42.4

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 2. When adjusting for total volume of the other exercises aside from the focal exercise, all exercises but walking and golf were associated with lower risks of mortality (model 1). After controlling for demographic information, basketball, soccer, football, swimming, and tennis were no longer significantly related to the risk of mortality; walking and golf were linked to lower risks of mortality; and baseball was associated with a higher risk of mortality (model 2). Cycling and golf were no longer linked to the risk of mortality once controls for socioeconomic measures were included (model 3). When controls for health behaviors and status were added in models, walking, aerobics, stretching, weight lifting, and stair climbing were linked to lower risks of mortality, whereas baseball was related to a higher risk of mortality (model 4). To be conservative, we interpreted odds ratio (OR) of running as nonsignificant (OR = 0.85, P = 0.045, 95% confidence interval [CI] = 0.725–0.996) because the upper limit of its 95% CI was very close to 1. Among the categories, Table 2 indicated that fitness exercises and any exercise were consistently related to lower risks of mortality. Team exercises were related to a lower risk of mortality only when adjusting for total volume of other categories of exercise. Facilities exercises were associated with a lower risk of mortality when controlling for total volume of other categories of exercise or additionally adjusting for demographic information, but this association disappeared after socioeconomic measures were also adjusted.

All types or categories of exercise and mortality risk. Next, engagement in all individual types or categories of exercises was 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 engagement in other exercise types or categories on mortality (Table 3). When only engagement in other types of exercise was controlled, all but walking, cycling, football, swimming, tennis, and golf were related to lower risks of mortality. After adjusting for demographic information, socioeconomic measures, and health behaviors and status, stretching and volleyball were consistently related to lower risks of mortality, whereas baseball was consistently linked to higher risk. Cycling, stair climbing, basketball, soccer, football, swimming, and tennis were consistently not significantly associated with the risk of mortality, and other exercises were not consistently associated with the risk of mortality. To be conservative, we interpreted the OR of aerobics as nonsignificant (OR = 0.84, P = 0.048, 95% CI = 0.703–0.999) because the upper limit of its 95% CI was very close to 1.00. When the three categories of exercise simultaneously entered into the same models (see Table 3), fitness, team, and facilities exercises were all significantly associated with lower risks of mortality when no other covariates were considered. Team exercises were no longer significantly related to the risk of mortality after demographic information was controlled, and facilities exercises were no longer associated with the risk of mortality after socioeconomic

EPIDEMIOLOGY

TABLE 2. OR from discrete time logistic models predicting mortality of U.S. adults from individual types or categories of exercise in the 1998 NHIS (N = 26,727).

	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
Individual exercise type				
Walking	1.10 (1.04–1.16)**	0.87 (0.82–0.92)***	0.91 (0.86–0.96)**	0.93 (0.88–0.98)*
Running	0.30 (0.25–0.34)***	0.69 (0.59–0.81)***	0.75 (0.64–0.87)***	0.85 (0.73–1.00)*
Aerobics	0.39 (0.33–0.47)***	0.68 (0.57–0.81)***	0.73 (0.61–0.86)***	0.78 (0.65–0.92)**
Stretching	0.70 (0.65–0.75)***	0.80 (0.74–0.86)***	0.85 (0.79–0.91)***	0.87 (0.81–0.93)***
Weight lifting	0.51 (0.46–0.57)***	0.78 (0.70–0.86)***	0.83 (0.75–0.93)**	0.89 (0.80–0.98)*
Cycling	0.79 (0.72–0.87)***	0.88 (0.80–0.97)**	0.92 (0.83–1.01)	0.92 (0.83–1.01)
Stair climbing	0.68 (0.59–0.78)***	0.78 (0.68–0.89)***	0.82 (0.71–0.93)**	0.87 (0.76–0.99)*
Baseball	0.51 (0.40–0.65)***	1.42 (1.11–1.82)**	1.41 (1.10–1.81)**	1.48 (1.15–1.90)**
Basketball	0.31 (0.25–0.39)***	0.98 (0.79–1.22)	0.98 (0.78–1.22)	1.06 (0.85–1.32)
Volleyball	0.17 (0.10–0.29)***	0.56 (0.32–0.97)*	0.55 (0.32–0.96)*	0.59 (0.34–1.02)
Soccer	0.31 (0.20–0.48)***	1.06 (0.68–1.65)	1.03 (0.66–1.60)	1.13 (0.72–1.77)
Football	0.37 (0.24–0.58)***	1.06 (0.68–1.66)	0.98 (0.63–1.53)	1.07 (0.69–1.67)
Swimming	0.75 (0.65–0.86)***	0.89 (0.77–1.03)	0.98 (0.85–1.13)	1.00 (0.86–1.15)
Tennis	0.66 (0.49–0.88)**	0.80 (0.60–1.08)	0.98 (0.73–1.32)	1.02 (0.76–1.37)
Golf	0.96 (0.83–1.10)	0.79 (0.69–0.91)**	0.90 (0.78–1.04)	0.91 (0.79–1.05)
Individual exercise category				
Fitness	0.89 (0.84–0.94)***	0.84 (0.79–0.89)***	0.89 (0.84–0.94)***	0.89 (0.84–0.94)***
Team	0.30 (0.26–0.35)***	1.01 (0.85–1.20)	1.01 (0.85–1.20)	1.10 (0.93–1.30)
Facilities	0.80 (0.72–0.88)***	0.82 (0.74–0.91)***	0.93 (0.84–1.04)	0.95 (0.86–1.06)
Any exercise	0.80 (0.76–0.85)***	0.83 (0.78–0.88)***	0.89 (0.84–0.94)***	0.89 (0.84–0.95)***

Each exercise modeled individually. Model 1 controlled for total volume of exercises (MET-hours per week excluding the volume of the type or category of exercise that was included in the corresponding model). Model 2 controlled for total volume of exercises and demographic information (time-varying age, sex, nativity status, census region of residence, marital status, and race/ethnicity). Model 3 controlled for total volume of exercises, demographic information, and socioeconomic measures (educational attainment, household income, and home ownership). Model 4 controlled for total volume of exercises, demographic information, socioeconomic measures, and health behaviors and status (smoking, drinking alcohol, body mass index, self-reported health status, physical handicap, and health condition).

*P < 0.05.

**P < 0.01.

***P < 0.001.

measures were additionally added to the model. Fitness exercises were consistently related to lower risk of mortality even when all the covariates were modeled.

Volumes of exercise types and mortality risk. The categorically coded volumes of exercise types were included in the same model to examine whether volumes of specific exercises were related to the risk of mortality (Table 4). Compared with results with dummy-coded exercises in Tables 2 and 3, there were minimal substantive changes in associations with mortality. However, two notable exceptions were the association between low volume of tennis and higher risk of mortality and the association between high volume of tennis and lower risk of mortality after adjustments for volumes of other exercises and all covariates.

DISCUSSION

This study analyzed the associations between engaging in 15 different types of exercise and their volumes with mortality while adjusting for important covariates, using a nationally

TABLE 3. OR from discrete time logistic models predicting mortality of U.S. adults from 15 types or three categories of exercise in the 1998 NHIS (N = 26,727).

	Model 1, OR (95% CI)	Model 2, OR (95% CI)	Model 3, OR (95% CI)	Model 4, OR (95% CI)
15 exercise types				
Walking	1.21 (1.15–1.29)***	0.92 (0.87–0.97)**	0.94 (0.89–1.00)	0.96 (0.90–1.02)
Running	0.41 (0.35–0.48)***	0.78 (0.66–0.92)**	0.81 (0.68–0.95)*	0.89 (0.75–1.05)
Aerobics	0.50 (0.42–0.59)***	0.78 (0.66–0.93)**	0.81 (0.68–0.96)*	0.84 (0.70–1.00)*
Stretching	0.84 (0.78–0.91)***	0.87 (0.81–0.94)***	0.90 (0.83–0.97)**	0.90 (0.83–0.97)**
Weight lifting	0.74 (0.66–0.82)***	0.89 (0.79–0.99)*	0.92 (0.82–1.03)	0.95 (0.85–1.07)
Cycling	0.94 (0.86–1.04)	0.96 (0.87–1.05)	0.97 (0.88–1.07)	0.95 (0.86–1.05)
Stair climbing	0.86 (0.75–0.99)*	0.88 (0.77–1.01)	0.89 (0.77–1.02)	0.92 (0.80–1.06)
Baseball	0.72 (0.56–0.92)*	1.58 (1.22–2.05)**	1.56 (1.20–2.02)**	1.58 (1.21–2.05)**
Basketball	0.45 (0.36–0.56)***	1.03 (0.82–1.30)	1.02 (0.80–1.28)	1.06 (0.84–1.34)
Volleyball	0.24 (0.14–0.42)***	0.54 (0.31–0.94)*	0.53 (0.30–0.92)*	0.53 (0.31–0.93)*
Soccer	0.48 (0.31–0.75)**	1.12 (0.71–1.75)	1.08 (0.69–1.70)	1.14 (0.73–1.80)
Football	0.65 (0.42–1.02)	1.04 (0.65–1.65)	0.95 (0.60–1.51)	0.98 (0.62–1.57)
Swimming	0.87 (0.76–1.01)	0.97 (0.84–1.12)	1.03 (0.89–1.19)	1.03 (0.89–1.20)
Tennis	0.88 (0.66–1.18)	0.93 (0.69–1.25)	1.08 (0.80–1.46)	1.09 (0.81–1.47)
Golf	1.09 (0.95–1.25)	0.83 (0.72–0.95)**	0.91 (0.79–1.05)	0.92 (0.80–1.06)
3 exercise categories				
Fitness	0.92 (0.87–0.97)**	0.84 (0.79–0.89)***	0.89 (0.84–0.94)***	0.89 (0.84–0.94)***
Team	0.28 (0.24–0.33)***	1.02 (0.86–1.21)	1.00 (0.85–1.19)	1.10 (0.92–1.30)
Facilities	0.83 (0.75–0.92)***	0.83 (0.74–0.92)***	0.93 (0.84–1.04)	0.95 (0.85–1.05)

Exercises modeled jointly. 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 and status (smoking, drinking alcohol, body mass index, self-reported health status, physical handicap, and health condition).

*P < 0.05.

**P < 0.01.

***P < 0.001.

TABLE 4. OR from discrete time logistic models predicting mortality of U.S. adults from the volumes of 15 types of exercise in the 1998 NHIS (N = 26,727).

		Model A	Model B
	n (%)	**OR (95% CI)**	**OR (95% CI)**
Walking (MET-hours per week)			
None	13,952 (52.20)	1.00	1.00
Low (≤4.50)	6828 (25.55)	1.10 (1.02–1.18)*	0.97 (0.90–1.04)
High (>4.50)	5947 (22.25)	1.35 (1.26–1.45)***	0.95 (0.88–1.02)
Running (MET-hours per week)			
None	23,707 (88.7)	1.00	1.00
Low (≤9.00)	1547 (5.79)	0.45 (0.37–0.55)***	0.94 (0.76–1.16)
High (>9.00)	1473 (5.51)	0.36 (0.29–0.46)***	0.82 (0.64–1.04)
Aerobics (MET-hours per week)			
None	24,821 (92.87)	1.00	1.00
Low (≤6.67)	971 (3.63)	0.54 (0.43–0.68)***	0.87 (0.69–1.10)
High (>6.67)	935 (3.50)	0.46 (0.35–0.58)***	0.79 (0.62–1.02)
Stretching (MET-hours per week)			
None	18,732 (70.09)	1.00	1.00
Low (≤1.00)	4565 (17.08)	0.72 (0.66–0.80)***	0.88 (0.80–0.97)*
High (>1.00)	3430 (12.83)	1.01 (0.92–1.12)	0.92 (0.83–1.02)
Weight lifting (MET-hours per week)			
None	22,290 (83.40)	1.00	1.00
Low (≤4.50)	2282 (8.54)	0.76 (0.66–0.87)***	0.89 (0.78–1.02)
High (>4.50)	2155 (8.06)	0.70 (0.60–0.82)***	1.03 (0.88–1.22)
Cycling (MET-hours per week)			
None	23,067 (86.31)	1.00	1.00
Low (≤3.75)	1898 (7.10)	0.94 (0.83–1.07)	0.98 (0.86–1.11)
High (>3.75)	1762 (6.59)	0.93 (0.82–1.07)	0.91 (0.80–1.05)
Stair climbing (MET-hours per week)			
None	24,702 (92.42)	1.00	1.00
Low (≤2.33)	1038 (3.88)	1.02 (0.86–1.21)	0.95 (0.80–1.13)
High (>2.33)	987 (3.69)	0.70 (0.57–0.86)**	0.89 (0.72–1.10)
Baseball (MET-hours per week)			
None	25,941 (97.06)	1.00	1.00
Low (≤3.75)	414 (1.55)	0.91 (0.67–1.24)	1.89 (1.36–2.63)***
High (>3.75)	372 (1.39)	0.54 (0.36–0.81)**	1.19 (0.79–1.80)
Basketball (MET-hours per week)			
None	25,187 (94.24)	1.00	1.00
Low (≤8.00)	833 (3.12)	0.48 (0.36–0.64)***	0.97 (0.72–1.31)
High (>8.00)	707 (2.65)	0.43 (0.31–0.60)***	1.15 (0.81–1.63)
Volleyball (MET-hours per week)			
None	26,251 (98.22)	1.00	1.00
Low (≤5.00)	268 (1.00)	0.23 (0.11–0.49)***	0.47 (0.22–0.99)*
High (>5.00)	208 (0.78)	0.25 (0.11–0.57)**	0.63 (0.28–1.43)
Soccer (MET-hours per week)			
None	26,327 (98.50)	1.00	1.00
Low (≤5.50)	206 (0.77)	0.44 (0.23–0.85)*	0.92 (0.47–1.79)
High (>5.50)	194 (0.73)	0.53 (0.29–0.95)*	1.40 (0.76–2.56)
Football (MET-hours per week)			
None	26,356 (98.61)	1.00	1.00
Low (≤3.75)	193 (0.72)	0.71 (0.39–1.29)	0.94 (0.51–1.75)
High (>3.75)	178 (0.67)	0.60 (0.31–1.15)	0.92 (0.47–1.81)
Swimming (MET-hours per week)			
None	25,128 (94.02)	1.00	1.00
Low (≤3.00)	898 (3.36)	0.90 (0.74–1.09)	1.17 (0.96–1.42)
High (>3.00)	701 (2.62)	0.84 (0.68–1.03)	0.91 (0.73–1.12)
Tennis (MET-hours per week)			
None	26,291 (98.37)	1.00	1.00
Low (≤6.00)	236 (0.88)	1.06 (0.73–1.54)	2.07 (1.41–3.04)***
High (>6.00)	200 (0.75)	0.70 (0.44–1.12)	0.60 (0.38–0.97)*
Golf (MET-hours per week)			
None	25,402 (95.04)	1.00	1.00
High (=6.00)	1325 (4.96)	1.10 (0.96–1.26)	0.92 (0.80–1.06)

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), and health behaviors and status (smoking, drinking alcohol, body mass index, self-reported health status, physical handicap, and health condition).

*$P < 0.05$.

**$P < 0.01$.

***$P < 0.001$.

representative sample of American adults and their mortality information over a 17-yr follow-up period. As such, this study contributes to previous research by, to our knowledge, using the most comprehensive list of exercise heretofore investigated while also controlling for extensive potential sociodemographic and health confounders as well as total volume of exercises or individual exercises participated in. Still our results replicated previous findings, specifically that those who participated in any exercise had significantly lower risk of mortality (OR = 0.89, 95% CI = 0.84–0.95) than those who did not exercise (3,8–10).

These findings are consistent with the 2018 Physical Activity Guidelines (11) and stress that engaging in any exercise is better than none for longevity. Given the magnitude of our findings regardless of controls, our results stress the importance of making exercise foundational to preventative health programs.

In addition, our results were similar to previous studies (9,10) that found association between aerobics and a lower risk of all-cause mortality. However, running, cycling, swimming, and soccer, which were associated with lower risks of mortality in previous studies (9,10), were not linked to mortality risk when adjusting for various covariates, including total volume of other exercises, in this study. Extending these studies (9,10), we found that walking, stretching, weight lifting, and stair climbing, which were not included their analyses, were associated with lower risks of mortality after controlling for covariates and total volume of other exercises. One possible explanation for the difference in findings is that we analyzed a different country where these exercises had different engagement levels as well as meanings (e.g., soccer) or because we controlled for additional confounders, including measures of socioeconomic status. For instance, we found that golf was no longer related to the risk of mortality after adjusting for socioeconomic measures. This is not surprising, as golf requires relatively high socioeconomic resources for consistent engagement (13).

Another important contribution is that we analyzed the unique association between each exercise type and mortality, controlling for engagement in all of the individual exercises. Of those who exercised, most (59.4% in our sample) participated in more than one type of exercise, and different types of exercise may benefit health differently (9,10). Thus, it is important to control for participation in individual types of exercise rather than just the total volume. We found that after controlling for engagement in individual exercises, most exercise types were statistically indistinguishable in their associations with mortality, which differed from the results when adjusting for total volume of exercises. Generally, this emphasizes that researchers should consider the joint contribution of all exercise types in relation to mortality. However, our results did indicate that stretching, volleyball, and baseball were uniquely associated with the risk of mortality when controlling for both confounders and engagement in individual exercises. Notably, these associations are still also significant when the volume of each exercise rather than a mere binary measure of participation was specified. Stretching has substantial mental and physical benefits (29), including prolonging engagement in other exercises (30,31). Our findings in particular stress the importance of stretching for reducing the risk of mortality. Although we could not statistically explain the benefit of volleyball, volleyball generally requires social groups and social contact that combined with exercise is beneficial for health (32).

Playing baseball was related to a lower risk of mortality when only total volume of exercises or engagement in individual exercises was adjusted but to a higher risk of mortality after adjusting for demographic information. The suppression effect emerged when age was included, suggesting that among people of similar ages and participation in exercises, baseball players, particularly those who played in a low volume, were at 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 (33). The potential reasons for the higher mortality risk among baseball players may be that injuries from playing (34) and baseball players' high consumption of smokeless tobacco ("chewing tobacco") have important consequences for their health (35,36) and may outweigh the potential benefit of the exercise.

Given the distinct characteristics of the three major categories of exercise (e.g., number of participants, competitive levels, and demand for facilities) (13), it is not surprising to find that they displayed differential benefits for mortality. Only the fitness exercises were consistently related to lower risks of mortality (OR = 0.89, 95% CI = 0.84–0.94) after adjustment for multiple covariates. Exercises in the fitness category require minimal facilities and can be performed individually, so people from diverse backgrounds and socioeconomic levels can easily engage in them—a potential reason why the association between fitness exercises and mortality remained robust after progressive adjustment for sociodemographic confounders. The potential cardiorespiratory benefits of fitness exercises may also explain the lower risk of mortality for people who engaged in them. Thus, our findings support previous research, suggesting the importance of cardiovascular fitness for longevity (37).

The current study has several notable strengths. We analyzed a nationally representative sample that conducted a 17-yr prospective investigation 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 (6,7,10,38) but also extend previous research by emphasizing the unique contribution of each exercise, which is important given that of those who exercise most people engaged in multiple forms of exercise (9). We also paid considerable attention to the volume of each exercise, and our findings were largely supported by analyzing the volume of each exercise rather than analyzing self-reported participation (or not) in the activity.

There are important 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 and is missing other exercise types (e.g., ice hockey). Similarly, other forms of physical activity such as household work were not included in this study. Second, the self-reported exercise may be biased (likely over reports) because of recall error or social desirability bias (39). Third, one study of British men at midlife suggested that men changed their exercise profiles as they age (40). 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 and by age, although such studies will likely lack the generalizability to the entire adult population that studies such as this one can provide. The exercise landscape has likely changed dramatically since 1998 when the respondents were interviewed; thus, we urge future researchers to update this kind of research periodically.

This study found that participation in any type of exercise was better than none and was related to a lower mortality risk. We also found that most exercise types were indistinguishable in relation to morality when other exercises were controlled, suggesting that Americans should engage in whichever exercise they prefer, so long as it is an exercise they can do consistently. However, we found that, walking, aerobics, stretching, weight lifting, stair climbing, and volleyball were related to lower risks of mortality. These findings suggest that participation in any or some types of exercises is independently related to lower mortality risk and highlight the importance of considering engagement in or the joint contribution of multiple types of exercise when analyzing the effects of specific exercises on mortality.

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The results of this study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation. The results of the present study do not constitute endorsement by the American College of Sports Medicine.

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