

Adherence to the 2008 Adult Physical Activity Guidelines and Mortality Risk

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Background: Mortality differentials by level and intensity of physical activity have been widely documented. A comprehensive review of scientific evidence of the health benefits of physical activity led the USDHHS to issue new Federal Guidelines for physical activity in 2008. Reductions in mortality risk associated with adherence to these Guidelines among the general U.S. adult population have not yet been studied.

Purpose: This study compared the relative mortality risks of U.S. adults who met the 2008 Guidelines with adults who did not meet the recommendations.

Methods: Cox proportional hazards models were used to examine the relative mortality risks of U.S. adults aged ≥ 18 years, using data from the 1997–2004 National Health Interview Survey and linked mortality records for deaths occurring in 1997–2006 (analyzed in 2010). Risks for adults with and without chronic health conditions were examined separately.

Results: Meeting the recommendations for aerobic activity was associated with substantial survival benefits, especially among the population having chronic conditions, with estimated hazard ratios ranging from 0.65 to 0.75 ($p < 0.05$). While strengthening activities by themselves did not appear to reduce mortality risks, they may provide added survival benefits to those already engaged in aerobic activities. The relative benefits of physical activity were greatest among adults who had at least one chronic condition.

Conclusions: Adherence to the 2008 *Physical Activity Guidelines* was associated with reduced all-cause mortality risks among U.S. adults, after controlling for sociodemographic characteristics, BMI, smoking, and alcohol use.

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Background

Physical activity is associated with reduced risks of mortality as well as of serious chronic health conditions, such as cardiovascular disease, cancer, diabetes, depression, and functional limitations.^{1–4} Early studies of the health benefits of physical activity suggested that only vigorous activity provided sufficient protection against many adverse health events.⁵ Vigorous activity remained the focus of health promotion efforts until 1995 when recommendations of the CDC and the American College of Sports Medicine (ACSM) called for adults to accumulate ≥ 30 minutes of moderate-intensity physical activity on most days of the week.⁶ The 1996 U.S. Surgeon

General's Report on Physical Activity and Health described these recommendations and served as the foundation for the Healthy People 2010 (HP 2010) objectives for physical activity that guided public policy and programs over the course of the following decade.⁷ The HP 2010 objectives specified that adults should engage in vigorous leisure-time physical activity (LTPA) at least three times per week for at least 20 minutes or moderate LTPA at least five times per week for at least 30 minutes.⁸ For purposes of HP 2010, lesser amounts of vigorous and moderate activities could not be combined. The 1995 CDC/ACSM recommendations were updated and clarified in 2007, with emphasis on the potential health benefits of combinations of vigorous and moderate-intensity activities and of muscle-strengthening activities.⁹

In the fall of 2008, the USDHHS issued the 2008 *Physical Activity Guidelines for Americans*.¹⁰ These Guidelines established targets for total amounts of physical activity: to be "sufficiently active," adults should engage in moderate-intensity aerobic physical activity of at least 150 minutes

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per week or vigorous-intensity aerobic activity of at least 75 minutes per week or an equivalent combination; to be “highly active,” adults should engage in double these amounts. The 2008 Guidelines further urged adults to engage in activities to strengthen seven large muscle groups on at least 2 days per week. Compared with HP 2010 physical activity indicator, the greater flexibility offered by the 2008 Guidelines resulted in more than a 10 percentage point increase in prevalence of U.S. residents meeting national physical activity goals—an increase exclusively due to changes in the definition, not in physical activity.^{11,12}

The 2008 Guidelines grew out of comprehensive review of the scientific evidence concerning the health benefits of physical activity and the consequences of inactivity. Mortality differentials by level and intensity of physical activity have been widely documented.¹³ However, the mortality risks associated with the specific levels and types of activity outlined in the 2008 Guidelines have not been studied in the general U.S. population. This paper examines the all-cause mortality risks associated specifically with the levels of aerobic and muscle-strengthening activities outlined in the 2008 Guidelines for Adults, using leisure-time physical activities as the indicators.

Mortality risks are associated with many variables other than lack of physical activity. In addition to varying by age and gender, mortality risks differ by race and ethnicity,^{14–16} education, income and health insurance coverage,¹⁷ obesity,^{18,19} and behaviors such as smoking and excessive alcohol consumption.^{20,21} Chronic health conditions, such as heart disease, stroke, or diabetes also increase mortality risks.²² Such conditions are often considered barriers to physical activity by the individuals who have the conditions, even though most of these individuals would benefit from physical activity.^{23,24} Mortality risks associated with different levels of physical activity may also be modified by the presence of various chronic conditions; however, although many studies have demonstrated the survival benefits of physical activity in the general population, as well as in specific disease groups,^{25–27} there is little evidence to compare the relative benefits of physical activity in people with or without chronic comorbid conditions.

An examination of the mortality risks associated with physical activity requires large study samples to control for the various limitations and conditions under which individuals manage to engage in physical activity. In addition, of particular interest are the mortality outcomes for individuals who, despite their limitations, manage to engage in this health-promoting behavior. This paper uses data from a multi-year nationally representative sample of U.S. adults to examine two questions: (1) Do adults who, at the time of their interview, report leisure-

time physical activity (LTPA) levels consistent with the 2008 Guidelines have lower mortality risks than those who do not meet the guidelines? (2) Does the presence of chronic health conditions modify these mortality risks?

Methods

Study Design and Population

The current analysis, conducted in 2010, is based on data from the 1997–2004 NHIS, which were linked to the National Death Index (NDI), with mortality information available from January 1, 1997, through December 31, 2006. The NHIS is an ongoing multipurpose, in-person, health survey of the civilian, non-institutionalized U.S. population conducted by the National Center for Health Statistics, CDC.²⁸ The NHIS uses a multistage probability sample design, sampling households throughout the 50 states and the District of Columbia. The basic annual NHIS consists of (1) a family component in which health and demographic information is collected on all family members; (2) an adult component, administered to one randomly selected adult (the “sample adult”) from each family; and (3) a child component (not used here). Final annual (unconditional) response rates over this 8-year period ranged from 86.1% to 90.3% for the family component (taking into account household nonresponse) and from 69.6% to 74.3% for the Sample Adult component (taking into account both the household and family nonresponse).

The NDI is a centralized database at NCHS containing information on all U.S. deaths in the 50 states and the District of Columbia. During the study period, NHIS interviews were completed by 258,279 sample adult respondents (Table 1). Of these, 242,397 (93.9%) were “eligible for linkage,” having provided sufficient information in the interviews for matching with NDI records. (Details of the matching methodology are available.²⁹) Through December 31, 2006, a total of 17,139 deaths were identified among “eligible” NHIS sample adults. Respondents not linked to death records were considered “censored,” meaning they were presumed to be alive as of December 31, 2006. Estimates for all analyses were weighted using poststratification to adjust for missing cases due to eligibility status.³⁰

Physical Activity Measures

Sample adults were asked five questions about their leisure-time physical activity (LTPA), introduced by the phrase *The next questions are about physical activities (exercise, sports, physically active hobbies. . .) that you may do in your LEISURE time.* The concept of “leisure-time physical activities,” which was implied for the questions between 1997 and 2003 by virtue of this introductory phrase, was made explicit in each question beginning in 2004: (1) *How often do you do VIGOROUS leisure-time physical activities for AT LEAST 10 MINUTES that cause HEAVY sweating or LARGE increases in breathing or heart rate?* (2) *About how long do you do these vigorous leisure-time physical activities each time?* (3) *How often do you do LIGHT OR MODERATE LEISURE-TIME physical activities for AT LEAST 10 MINUTES that cause ONLY LIGHT sweating or SLIGHT to MODERATE increases in breathing or heart rate?* (4) *About how long do you do these light or moderate leisure-time physical activities each time?* and (5) *How often do you do LEISURE-TIME physical activities specifically designed to STRENGTHEN your muscles such as lifting weights or doing calis-*

Table 1. Number of NHIS interviews and number of deaths based on NDI linkage^a

NHIS interview year	Sample adult respondents (aged ≥18 years)	Met eligibility criteria for linkage to NDI	Deaths from interview through December 31, 2006	Deaths from 2 years after interview through December 31, 2006 ^b
1997	36,116	34,393	3,956	3,267
1998	32,440	30,577	3,226	2,558
1999	30,801	29,076	2,542	1,966
2000	32,374	30,595	2,231	1,634
2001	33,326	31,358	1,937	1,296
2002	31,044	28,995	1,413	831
2003	30,852	28,210	1,095	494
2004	31,326	29,193	739	146
Total	258,279	242,397	17,139	12,192

^aInterviews with adults aged ≥18 years selected for the Sample Adult component of the NHIS. Deaths were identified through linkage of the interview data with the NDI for deaths through December 31, 2006.

^bAll survival models are based on interview respondents who survived at least 2 years after the interview.

NDI, National Death Index; NHIS, National Health Interview Survey

thenics? Although recommendations set forth in the 2008 *Physical Activity Guidelines for Adults* may be met by non-leisure-time activities, for this analysis adherence to recommended activity levels is assessed exclusively in terms of LTPA and entails (1) ≥150 minutes of moderate or ≥75 minutes of vigorous aerobic LTPA per week or an equivalent combination and (2) muscle-strengthening activities ≥2 times per week.

This analysis compares the mortality risks of adults who met the 2008 *Guidelines* with respect to aerobic activity only, muscle-strengthening activities only, and both types of activities to the mortality risks of adults who met neither recommendation. Mortality risks of adults who engaged in higher levels of aerobic LTPA (i.e., >300 minutes of moderate or >150 minutes of vigorous activity per week) also were examined. The *Guidelines* equate 1 minute of vigorous activity to 2 minutes of moderate activity; total minutes of aerobic activity were summed using this conversion factor.

Sociodemographic and Health Measures

Sociodemographic information (gender, age, race/Hispanic ethnicity, education, poverty status, and health insurance coverage) was obtained during the family portion of the NHIS interview. Health-related behaviors (cigarette smoking and alcohol consumption) and height and weight were based on self-reports in the sample adult interview. An adjusted measure of the BMI was used to take into account systematic biases in self-reported height and weight depending on the respondents' gender, age, and education.³¹ Self-reported information on chronic health conditions included the presence or absence of diabetes; cancer; circulatory diseases (i.e., myocardial infarction, angina, cardiovascular diseases, and stroke); respiratory diseases (i.e., emphysema, asthma, and chronic bronchitis); or functional limitations (i.e., any difficulty: walking, climbing steps, standing, sitting, stooping, reaching, grasping, and lifting, pushing, or pulling large objects). Except for functional limitations, the presence of these conditions was indicated if the respondent had ever been told by a healthcare profes-

sional that he or she had the condition. For this analysis, these conditions were combined into a dichotomous variable: having one or more versus none.

Statistical Analysis

Kaplan–Meier survival functions were used to plot associations between categories of LTPA and all-cause mortality for all adults, regardless of chronic condition status. The Cox proportional hazards Model was used to examine the mortality risk of adults who engaged in various amounts of LTPA specified in the 2008 *Guidelines* compared with adults who did not meet the guidelines, controlling for sociodemographic characteristics and health-related behaviors. Deaths were limited to those that occurred at least 2 years after the NHIS interview.³² To allow for differential effects of physical activity on mortality, interactions between physical activity and the dichotomous conditions variable were examined. Age-specific models were run using age groups 18–44, 45–64, and ≥65 years to test for interactions between age and physical activity. However, because of the importance of age as a predictor of mortality, a continuous age variable was retained in all models. Analyses were carried out using Stata, version 10.1, employing the “svy” commands to provide correct variance estimates that account for the complex NHIS sample design.

Results

Among adults aged ≥18 years, nearly half (45.9%) had at least one chronic health condition (i.e., diabetes, cancer, circulatory conditions, respiratory conditions, or any functional limitation; see Appendix A, available online at www.ajpm-online.net). Demographic characteristics of adults with and without chronic conditions followed predictable patterns, with conditions more prevalent among women; older adults; non-Hispanic whites; adults with less education and lower incomes; those without private

Table 2. Adherence to the 2008 Physical Activity Guidelines for Adults, by chronic condition status: 1997–2004

Characteristic	Total		No conditions ^a		≥1 conditions ^a	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
Physical activity guidelines met		100.0		100.0		100.0
Neither	132,613	52.5 (52.0, 53.0)	63,170	48.1 (47.5, 48.7)	69,443	57.7 (57.2, 58.2)
Strength only	8,173	3.4 (3.3, 3.5)	3947	3.2 (3.1, 3.3)	4,226	3.7 (3.6, 3.8)
Aerobic only	60,144	25.8 (25.5, 26.1)	33,842	27.4 (27.0, 27.8)	26,302	24.0 (23.6, 24.3)
Both	35,576	15.7 (15.4, 16.0)	22,776	18.7 (18.3, 19.1)	12,800	12.1 (11.8, 12.4)
Unknown	5,891	2.6 (2.4, 2.8)	3,128	2.6 (2.4, 2.8)	2,763	2.6 (2.3, 2.8)
Aerobic activity (minutes/week)						
0	96,416	37.2 (36.6, 37.7)	45,337	33.7 (33.1, 34.2)	51,079	41.3 (40.7, 41.9)
<150	44,502	18.8 (18.5, 19.1)	21,832	17.6 (17.3, 18.0)	22,670	20.2 (19.8, 20.5)
150–300	33,029	14.2 (14.0, 14.4)	18,558	15.1 (14.8, 15.4)	14,471	13.1 (12.8, 13.3)
>300	62,211	27.1 (26.7, 27.5)	37,794	30.8 (30.3, 31.3)	24,417	22.7 (22.4, 23.1)
Unknown	6,239	2.8 (2.6, 3.0)	3,342	2.8 (2.6, 3.0)	2,897	2.7 (2.5, 3.0)
Total	242,397		126,863		115,534	

Note: Table represents the civilian, non-institutionalized population aged ≥18 years. n, number of sample adult respondents; %, weighted percentage

^aChronic conditions include diabetes, hypertension, circulatory, respiratory (including chronic bronchitis), and one or more functional limitations.

health insurance (except the uninsured, who were less likely to have a *diagnosed* chronic condition but were also less likely to have seen a physician); and adults who reported health risks such as current obesity or past drinking or smoking. Table 2 shows that adults who had at least one chronic condition were more likely (3.7%) than those with none (3.2%) to meet the recommendations for strengthening activity ($p < 0.01$) but were less likely to meet the aerobic activity guideline. Among adults with at least one chronic condition, 24.0% met the aerobic guidelines compared with 27.4% of adults who had none of these conditions ($p < 0.01$). Similarly, 12.1% of adults with chronic conditions met the aerobic and strengthening guidelines versus 18.7% of adults without chronic conditions.

Figure 1 shows the (weighted) Kaplan–Meier survival curves associated with four levels of adherence to the 2008 Guidelines for all adults: meeting both the aerobic and muscle-strengthening guidelines, the aerobic guidelines only, the muscle-strengthening guidelines only, and neither of the minimum recommendations. This graph suggests that meeting the 2008 Guidelines is associated with survival benefits, with aerobic activity alone showing generally stronger benefits than muscle strengthening alone. Figure 2 illustrates that the greatest increase in survival probabilities occurs among adults who engage in at least some LTPA compared with those who en-

gage in none. Additional survival benefits are associated with higher levels of aerobic LTPA.

Table 3 presents results from four proportional hazards models. Because existing chronic diseases could both increase near-term mortality and unduly limit LTPA, the

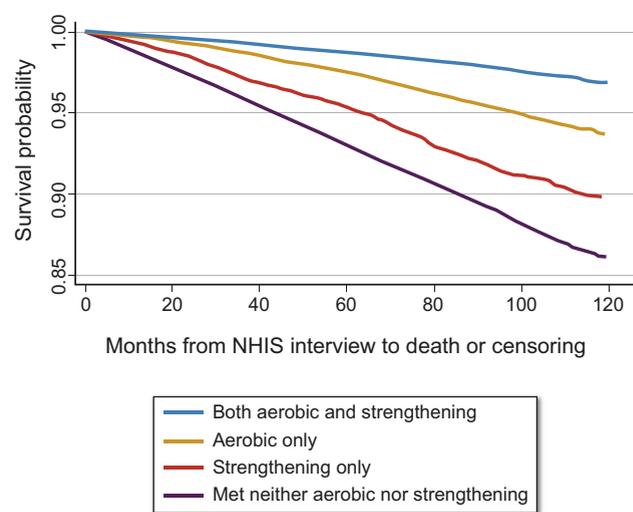


Figure 1. Survival probabilities by levels of adherence to 2008 Physical Activity Guidelines

Note: U.S. adults aged ≥18 years (weighted); respondents not linked to death records were considered “censored,” meaning they were presumed to be alive as of December 31, 2006.

NHIS, National Health Interview Survey, 1997–2004

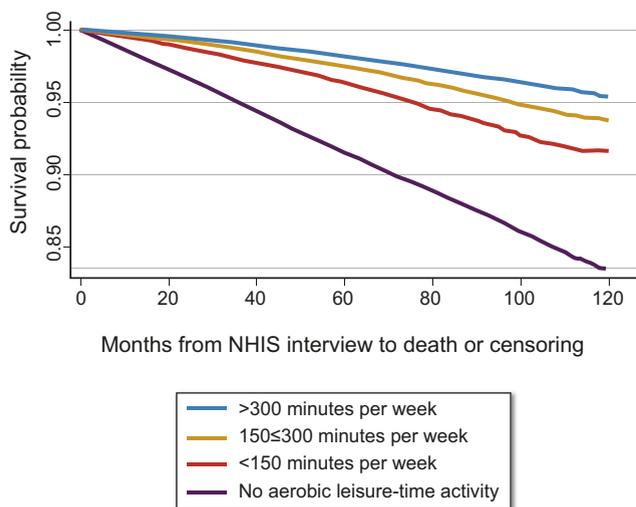


Figure 2. Survival probabilities by levels of adherence to 2008 aerobic physical activity guidelines

Note: Respondents not linked to death records were considered “censored,” meaning they were presumed to be alive as of December 31, 2006.

NHIS, National Health Interview Survey, 1997–2004

multivariate analysis was restricted to interview respondents who survived for at least 2 years after participating in the NHIS. The mortality hazard ratios shown are those associated with meeting the 2008 Guidelines among adults with and without chronic conditions—for all adults and for three age groups. Based on an examination of the parallel shape of the estimated hazard graphs of the LTPA groups (not shown), the proportional hazard assumption of the Cox models was met. The hazard ratios displayed in Table 3 are only those associated with meeting the recommendations for physical activity in the 2008 Guidelines. Hazard ratios associated with the confounding variables have been omitted.

The hazard ratios in Table 3 suggest the benefits associated with meeting the 2008 Guidelines relative to meeting neither aerobic nor muscle-strengthening guidelines. The results show no association between meeting the muscle-strengthening recommendations alone and survival benefits. By contrast, meeting the recommendations for aerobic activity is associated with substantial survival benefits, especially among the population with at least one chronic condition, where estimated hazard ratios (HRs) range from 0.65 to 0.75 ($p < 0.001$). Benefits of aerobic activity among adults without a chronic condition are apparent for ages ≥ 65 years ($HR = 0.73$, $p < 0.001$). The hazard ratios reveal a third consistent pattern: the relative strength of the association between meeting the recommendations for aerobic activity and survival benefits is larger among adults with ($HR = 0.66$, $p < 0.001$) than without chronic conditions ($HR = 0.88$, $p < 0.05$): all aerobic LTPA–chronic condition interac-

tions are significant for adults aged < 65 years. Finally, although muscle strengthening alone is not associated with survival benefits, adding muscle strengthening to the recommended levels of aerobic activity may offer additional survival benefits for adults aged ≥ 45 years.

Table 4 focuses on the mortality hazards associated with levels of aerobic activity only. Again, there is a clear pattern of relatively greater survival benefits associated with aerobic activity among people with one or more chronic conditions. Compared to people who do not engage in aerobic activity, mortality hazards associated particularly with extensive aerobic activity (> 300 minutes per week) showed greater reductions for people with chronic conditions ($HR = 0.54$, $p < 0.001$) than those without ($HR = 0.77$, $p < 0.001$) (all PA–chronic conditions interactions are significant).

Discussion

The assessment of physical activity in the U.S. population is an evolving field of study. Efforts to identify levels of activity that promote health, prevent disease, and postpone death have been hampered by the difficulty of accurately assessing physical activity. No single measure of activity perfectly captures the behavior of the population at large. Still, the goal of promoting physical activity remains a priority, as evidence from around the world continues to point to its health benefits.

This study suggests that adherence to the levels of physical activity recommended in the 2008 Physical Activity Guidelines for Adults may have substantial survival benefits. All-cause mortality risks are lower by 27% among people without existing chronic comorbidities, and by almost half among people with chronic comorbidities. Such lower risks occur regardless of age and obesity levels. (However, an examination of interactions of PA with smoking and alcohol consumption suggests that relative survival benefits associated with PA are largest among current smokers and light-moderate drinkers.)

This analysis is subject to several limitations. (1) As always with non-experimental data, causal interpretations are hazardous. The associations between survival probabilities and LTPA could be attributable to reverse causation with physical inactivity being a consequence of the presence of advanced disease or disability at the time of the NHIS interview. However, by limiting the survival analysis to deaths occurring at least 2 years after the interview, the probability that reverse causation could account for the observed associations was reduced. (2) Some adults classified as having “no conditions,” may have had health conditions that were not captured in the survey, leading to a potential underestimate of the differences in the LTPA–mortality associations. (3) Severity of

Table 3. All-cause mortality hazards associated with meeting the 2008 adult physical activity guidelines by condition status^a

Age range (years) and guidelines met	Adults with at least one chronic condition		Adults without any chronic conditions	
	Population	HR (95% CI)	Population	HR (95% CI)
≥18	93,360,923		109,815,326	
Neither PA criterion (ref)	53,880,787	1.00	52,800,390	1.00
Strength only ^b	3,446,057	1.00 (0.89, 1.13)	3,511,957	1.06 (0.73, 1.55)
Aerobic only ^c	22,371,402	0.66 (0.61, 0.70***)	30,084,030	0.88 (0.79, 0.98*)
Both ^c	11,278,365	0.54 (0.48, 0.61***)	20,583,081	0.73 (0.60, 0.87**)
18–44	34,334,992		74,576,068	
Neither PA criterion (ref)	16,681,593	1.00	34,645,566	1.00
Strength only ^b	1,300,612	0.97 (0.49, 1.90)	2,533,830	1.19 (0.60, 2.37)
Aerobic only ^c	9,254,043	0.75 (0.56, 0.99*)	19,983,363	1.30 (1.00, 1.69*)
Both ^b	6,218,255	0.75 (0.52, 1.07)	15,554,582	1.21 (0.88, 1.66)
45–64	33,154,279		28,886,282	
Neither PA criterion (ref)	19,507,715	1.00	14,561,091	1.00
Strength only ^b	1,153,792	1.15 (0.88, 1.49)	814,292	1.00 (0.42, 2.40)
Aerobic only ^c	8,066,782	0.73 (0.62, 0.84**)	8,213,233	0.94 (0.77, 1.14)
Both ^b	3,561,829	0.57 (0.45, 0.74**)	4,473,630	0.59 (0.43, 0.80**)
≥65	26,162,965		6,858,656	
Neither PA criterion (ref)	17,855,608	1.00	3,833,541	1.00
Strength only ^b	996,976	0.96 (0.83, 1.10)	183,108	1.12 (0.74, 1.68)
Aerobic only ^b	5,125,712	0.65 (0.60, 0.70***)	2,015,001	0.73 (0.62, 0.86***)
Both ^b	1,533,557	0.52 (0.45, 0.61***)	634,659	0.59 (0.42, 0.82**)

^aCox proportional hazards models: All four models control for the same covariates: gender, continuous age, race/ethnicity, education, poverty status, health insurance status, BMI, smoking, and consumption of alcohol and were stratified by the presence/absence of selected chronic health conditions. Unknowns were included in the model but not shown separately. Interviews were conducted in 1997–2004. Mortality follow-up was from date of interview through December 31, 2006. Models were restricted to deaths occurring at least 2 years after interview.

^bNonsignificant interaction between PA level and presence of any chronic condition

^cSignificant ($p < 0.05$) interaction between PA level and presence of any chronic condition

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

HR, hazard ratio; PA, physical activity; population, weighted population estimate (average annual)

reported conditions could not be ascertained; some of the apparent additional survival benefits of LTPA among people with chronic conditions may reflect lower severity among those who were physically active. However, stratification by the presence or absence of any functional limitation (suggestive of more advanced illness and disability) revealed that adults both with and without existing functional limitations had lower mortality risk if they met the *Guidelines*. Further restricting the analysis to adults with at least one chronic condition but no functional limitations at the time of interview (i.e., excluding cases whose functional limitations may be the result of their closeness to death) revealed somewhat weaker hazard ratios, but adults who met the *Guidelines*

remained at lower risk of dying than those who did not (data not shown).

Together, these findings provide some confidence that the established associations are not primarily the result of people approaching their death ceasing to be physically active. (4) The physical activity measure pertains only to leisure-time physical activity. On the assumption that people engaging in physically demanding work are less likely to engage in LTPA, the benefits from LTPA may well be understated in this analysis. (5) The reliance on self-reported LTPA may lead to an overestimate of actual physical activity because of socially desirable responses.³³ (6) The NHIS

Table 4. All-cause mortality hazards associated with meeting the 2008 aerobic activity guidelines by condition status^a

Age range (years) and activity level (minutes/week)	Adults with at least one chronic condition		Adults without any chronic conditions	
	Population	HR (95% CI)	Population	HR (95% CI)
≥18	93,360,922		109,815,325	
0 (ref)	38,542,189	1.00	36,964,146	1.00
<150 ^b	18,842,828	0.79 (0.74, 0.84***)	19,393,876	0.85 (0.74, 0.99*)
150–300 ^c	12,212,769	0.66 (0.60, 0.72***)	16,592,094	0.84 (0.72, 0.97*)
>300 ^c	21,212,438	0.54 (0.50, 0.59***)	33,807,754	0.77 (0.68, 0.87***)
18–44	34,202,479		74,200,003	
0 (ref)	10,715,674	1.00	23,975,583	1.00
<150 ^b	7,220,207	0.72 (0.54, 0.97*)	13,052,345	1.00 (0.71, 1.43)
150–300 ^b	5,085,890	0.82 (0.58, 1.17)	11,278,057	1.48 (1.07, 2.05*)
>300 ^c	10,225,260	0.62 (0.46, 0.85**)	23,916,296	1.14 (0.86, 1.51)
45–64	33,053,745		28,779,474	
0 (ref)	13,582,797	1.00	10,138,296	1.00
<150 ^b	7,038,620	0.85 (0.73, 0.99*)	5,188,581	0.95 (0.72, 1.25)
150–300 ^b	4,368,401	0.66 (0.54, 0.81***)	4,361,239	0.80 (0.59, 1.08)
>300 ^c	7,132,599	0.63 (0.54, 0.75***)	8,209,348	0.83 (0.67, 1.03)
≥65	26,104,698		6,835,849	
0 (ref)	14,243,717	1.00	2,850,267	1.00
<150 ^b	4,584,001	0.79 (0.73, 0.85***)	1,152,950	0.79 (0.65, 0.96*)
150–300 ^b	2,758,478	0.66 (0.59, 0.74***)	952,797	0.69 (0.56, 0.86**)
>300 ^c	3,854,579	0.53 (0.48, 0.58***)	1,682,110	0.63 (0.53, 0.76***)

^aCox proportional hazard models: All four models control for the same covariates: gender, continuous age, race/ethnicity, education, poverty status, health insurance status, BMI, smoking, and consumption of alcohol and were stratified by the presence/absence of selected chronic health conditions. Unknowns were included in the model but not shown separately. Interviews were conducted in 1997–2004. Mortality follow-up was through December 31, 2006. Models were restricted to deaths occurring at least 2 years after interview.

^bNonsignificant interaction between physical activity level and presence of any chronic condition

^cSignificant ($p < 0.05$) interaction between physical activity level and presence of any chronic condition

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

HR, hazard ratio; population, weighted population estimate (average annual)

question about moderate-intensity LTPA is phrased in terms of “light-moderate” activity, which may lead to an overestimate of moderate activity. (7) NHIS data do not permit assessment of how long respondents had performed the activities, nor if they continued them after the interview. The likely result is a downward bias of estimates of the association between LTPA and mortality risks.

Conclusion

Adherence to the 2008 Physical Activity Guidelines at the time of the baseline interview was associated with reduced all-cause mortality risks over the follow-up

period among a representative sample of U.S. adults, after controlling for sociodemographic characteristics, BMI, smoking, and alcohol use. Adults with comorbid conditions had greater reductions in relative mortality risks than adults without conditions. Longer follow-up is needed to confirm these findings, especially those related to the survival benefits of LTPA for adults with comorbid conditions.

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Appendix

Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.amepre.2010.12.029.