Light-Intensity Physical Activities and Mortality in the United States General Population and CKD Subpopulation

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Abstract

Background and objectives Sedentary behavior is associated with increased mortality in the general population. Whether replacing sedentary behavior with low- or light-intensity activities confers a survival benefit in the general or CKD populations is unknown.

Design, setting, participants, & measurements This observational analysis of the 2003–2004 National Health and Nutrition Examination Survey examined the associations of low- and light-intensity activities with mortality. On the basis of the number of counts/min recorded by an accelerometer, durations of sedentary (<100/min), low (100–499/min), light (500–2019/min), and moderate/vigorous (≥2020/min) activity were defined and normalized to 60 minutes. The mortality associations of 2 min/hr less sedentary duration in conjunction with 2 min/hr more (tradeoff) spent in one of the low, light, or moderate/vigorous activity durations while controlling for the other two activity durations were examined in multivariable Cox regression models in the entire cohort and in the CKD subgroup.

Results Of the 3626 participants included, 383 had CKD. The mean sedentary duration was 34.4±7.9 min/hr in the entire cohort and 40.8±6.8 in the CKD subgroup. Tradeoff of sedentary duration with low activity duration was not associated with mortality in the entire cohort or the CKD subgroup. Tradeoff of sedentary duration with light activity duration was associated with a lower hazard of death in the entire cohort (hazard ratio, 0.67; 95% confidence interval, 0.48 to 0.93) and CKD subgroup (hazard ratio, 0.59; 95% confidence interval, 0.35 to 0.98). Tradeoff of sedentary duration with moderate/vigorous activity duration had a nonsignificant lower hazard in the entire cohort and CKD subgroup.

Conclusions Patients with CKD are sedentary nearly two thirds of the time. Interventions that replace sedentary duration with an increase in light activity duration might confer a survival benefit.

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Introduction

Physical function (1–3) and physical activity (PA) (4,5) are diminished in the CKD and ESRD populations. Compared with the non-CKD subgroup, those with CKD are more sedentary (4,6,7). Sedentary activities with low energy expenditure (approximately 1.0–1.3 metabolic equivalents [METs]) have emerged as an important risk factor for obesity (8), insulin resistance (9), diabetes (10), and increased mortality (11–13) in the general population. The term exercise is typically applied to moderate (3–6 METs of energy expenditure) or vigorous (>6 METs) physical activities (14). The Physical Activity Guidelines for Americans recommends at least 150 minutes of moderate-intensity activity (3–6 METs) per week or 75 minutes of vigorous-intensity activity (>6 METs) per week (14). In LOOK-AHEAD, a large randomized controlled trial, an intensive lifestyle intervention of increasing moderate activity to 175 min/wk did not reduce the rate of cardiovascular events in overweight or obese patients with type 2 diabetes mellitus (15). This raises the question of whether interventions that focus on sedentary behavior—the other extreme of the PA spectrum—might confer a survival benefit.

There is a general consensus that sedentary behavior must be decreased, but as noted in the United Kingdom guidelines on this topic (16), the critical unresolved questions are how much of the sedentary activities must be replaced and by which kind of activity. It is unlikely that moderate/vigorous physical activities (MVPAs) could be an effective replacement for sedentary activities because most Americans do not even reach the current goals for MVPA (17,18). Furthermore, assuming 16 awake hours per day, achieving the currently recommended duration of MVPA would account for only 2% of the total awake time (2.5 hours out of 112 awake hours per week). Therefore, decreasing sedentary activities must involve an increase in activities that are less intensive than MVPAs. These are low- or light-intensity activities (Table 1). Because standing, a low-intensity activity, is by definition nonsedentary (*i.e.*, not sitting or lying down), one might consider replacing sitting duration with standing duration in order to decrease sedentary behavior. However, to our knowledge, the relative importance of low- and light-intensity activities for reducing sedentary behavior has not been established in the general or CKD populations.

Because sedentary PA, low- and light-intensity PA, and MVPAs are mutually exclusive, decreasing sedentary behavior involves a tradeoff of sedentary duration with the duration of one of the other three activities. Therefore, we examined the mortality associations of 2 min/hr less sedentary duration in conjunction with 2 min/hr more time (tradeoff) spent in one of the low- or light-intensity PAs or MVPAs while controlling for the durations of the other two activities. We used objective PA data obtained with an accelerometer in the 2003–2004 National Health and Nutrition Examination Survey (NHANES). We also used theoretical calculations to estimate the energy expenditure for tradeoff of 1–5 min/hr of sedentary duration with equal durations of low- or light-intensity activities.

Materials and Methods

Study Population

The National Center for Health Statistics is conducting NHANES to obtain a sample of a representative population of the noninstitutionalized United States population. Of the 5041 individuals aged ≥20 years in the 2003–2004 NHANES dataset, 4070 had accelerometry performed and 3786 were deemed to have reliable accelerometry data. The final cohort included 3626 individuals (3243 without CKD and 383 with CKD) who wore an accelerometer for at least 10 hours a day and for at least 4 days for whom follow-up mortality data were available.

Baseline Data

NHANES data collection details have been published elsewhere (17). In brief, physician-diagnosed history of comorbid conditions and mobility limitations were per self-report. Mobility limitation was defined as special equipment needed to walk or inability to walk up 10 steps of stairs. PA was objectively assessed with an ActiGraph Model 7164 accelerometer (ActiGraph, Ft. Walton Beach, FL) (19). Participants were asked to wear the device while they were awake and to take it off for swimming or bathing (20). The uniaxial ActiGraph measures and records vertical acceleration as counts, indicating the intensity of PA associated with locomotion. Data were recorded in 1-minute epochs. PA intensity during awake time that the device was worn was categorized as sedentary, low intensity, light intensity, and moderate/vigorous according to the accelerometer counts (Table 1). Further technical details of PA intensity definitions are provided in the Supplemental Material.

Definition of CKD

The most recent CKD-Epidemiology Collaboration equation was used to estimate GFR (21). CKD was defined as eGFR<60 ml/min per 1.73 m^2.

Mortality Data

A Linked Mortality File through December 31, 2006, was created by the National Center for Health Statistics using a probabilistic match between NHANES and death certificate records from the National Death Index (22).

Statistical Analyses

NHANES is based on a complex probability sample design. We used the svy suite of commands in Stata software, version 12 (Stata Corp., College Station, TX) and followed the NHANES analytical guidelines (23). Hence, all reported results (including linear and Cox regression models) take survey weights into account.

Univariate descriptive statistics, including means and SDs, and designated quantiles, including medians and 25th, 75th percentiles, were obtained for such numeric variables as PA intensity durations; proportions and their associated 95% confidence intervals (95% CIs) were obtained to describe distributions of categorical variables. MVPA duration was positively skewed; therefore, it was square root transformed for subsequent statistical analyses. Numeric and categorical factors were compared between the tertiles of light-activity duration using an ANOVA test with 3 degrees of freedom for numeric factors and chi-squared tests for categorical factors.

Multiple linear regression was used to estimate the mean differences in durations of low-intensity and light-intensity PA and MVPA in conjunction with sedentary activity duration of 2 min/hr more; we adjusted for age, sex, race, education, smoking, alcohol use, lung disease, and an indicator variable for the presence of mobility limitations. Similar multiple linear regression analyses were used to estimate mean differences in the remaining activity durations in conjunction with 2 min/hr more in durations of low-intensity or light-intensity PA and MVPA.

Separate Cox regression analyses were performed to relate mortality individually to each PA intensity duration, with covariate adjustment for factors that are unlikely in the causal pathway between sedentary behavior and mortality (age, sex, race, education, smoking, alcohol use, lung disease, and an indicator variable for the presence

Table 1. Definition and examples of physical activity intensity levels

Physical Activity Level	Accelerometer Counts	Examples
Sedentary	<100	Sitting quietly, watching television, lying down
Low intensity	100–499	Sitting in class, studying, note taking, standing, making bed
Light intensity	500–2019	Casual walking, light gardening, cleaning (sink/toilet)
Moderate or vigorous intensity	≥2200	Brisk walking or running, lifting heavy weights

of mobility limitations). A subsequent multivariable Cox regression model was used to jointly relate to durations of the low and light PAs and MVPAs with the same covariates, with sedentary duration treated as the reference category. Because the durations of the four activity intensity levels (sedentary, low, light, and moderate/vigorous) were normalized to add to 60 min/hr, exponentiation of appropriately defined linear contrasts of the Cox regression coefficients provided estimates of the hazard ratios (HRs) associated with 2 minutes more and 2 minutes less of the durations for each pair of the four activity levels; the analysis controlled for the remaining two activity levels and the remaining covariates.

In additional analyses, the above models were adjusted for variables that might be in the causal pathway of the associations of PA intensity with mortality. These included comorbid conditions (history of congestive heart failure, coronary heart disease, stroke, diabetes, hypertension, and cancer), waist circumference, serum high-sensitivity C-reactive protein, and urine albumin-to-creatinine ratio.

We also examined the mortality associations of tradeoff of 1–5 min/hr of low- and light-intensity PA durations with sedentary duration. We also estimated the energy expenditure associated with tradeoff of 1–5 min/hr of low- and light-intensity PA durations with sedentary duration, as described in the Supplemental Material.

All analyses were repeated in the CKD subgroup.

Results

The mean accelerometer wear time was 14.0±1.4 hr/d. Figure 1 describes the distribution of the duration of the PA intensity levels in the entire cohort and CKD subgroup. Those with CKD were more sedentary and spent nearly two thirds of their time in sedentary activities.

Mean baseline eGFR was 93.5±17.1 and 48.5± 12.9 ml/min per 1.73 m^2 in the entire cohort and CKD subgroup, respectively. Baseline clinical characteristics by tertiles of duration of light-intensity activity in the entire cohort and CKD subgroup are summarized in Table 2. In general, longer duration of light-intensity activity was associated with younger age; male sex; and lower prevalence of diabetes, hypertension, and cardiovascular conditions.

The mean follow-up duration was 2.86±0.64 years. There were 137 deaths over 10,390 person-years of follow-up (mortality rate of 1.32 deaths/100 person-years) in the entire cohort and 50 deaths over 1048 person-years of follow-up (mortality rate of 4.77 deaths/100 person-years) in CKD subgroup. As shown in Figure 2, longer sedentary duration was associated with higher mortality risk in the entire cohort (HR, 1.18; 95% CI, 1.09 to 1.28) and the CKD subgroup (HR, 1.16; 95% CI, 1.04 to 1.31) subgroup. On the other hand, there appeared to be a graded lower mortality risk with greater intensity of physical activity in the entire cohort and CKD subgroup (Figure 2).

Table 3 summarizes the differences in the other three activity levels associated with 2 min/hr more in durations of sedentary activity, low- or light-intensity activity, or MVPA. For instance, each 2 min/hr more in sedentary duration was associated with shorter durations for other activities (1.02 min/hr for low-intensity activity, 0.92 min/hr for light-intensity activity, and 0.06 min/hr for MVPA) in the CKD subgroup. Thus, the association of higher mortality risk with longer sedentary duration described in Figure 2 could reflect less of any of the low-intensity or light-intensity activity or MVPA durations.

Table 4 summarizes mortality risk associated with each 2 min/hr shorter duration of a lower-intensity activity with a corresponding 2 min/hr greater duration of a

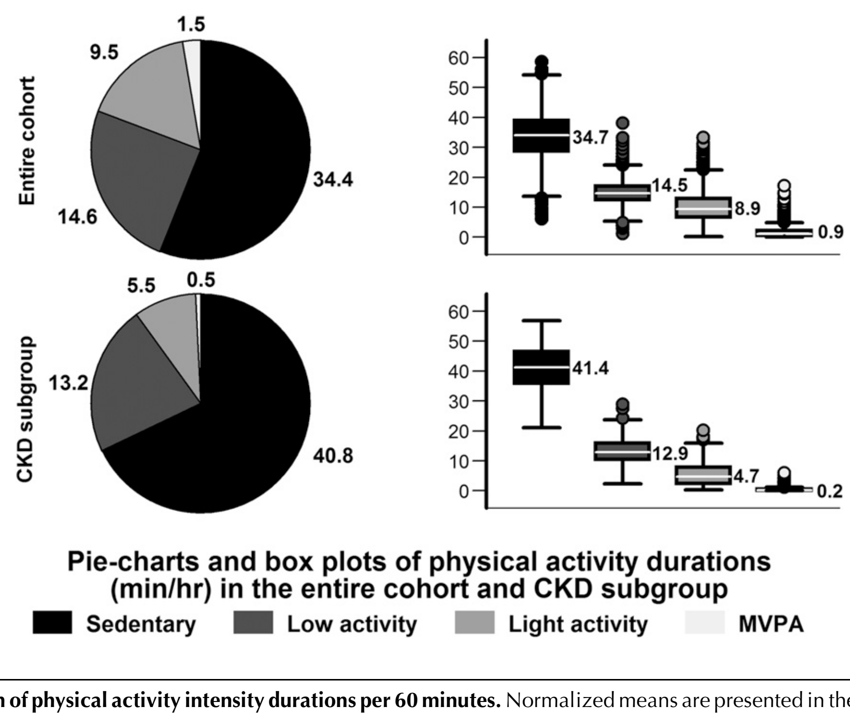

Figure 1. | **Distribution of physical activity intensity durations per 60 minutes.** Normalized means are presented in the pie charts. Normalized medians and 25th and 75th percentiles are presented in box plots, and whiskers represent the 10th and 90th percentiles. MVPA, moderate/vigorous-intensity physical activity.

Table 2. Baseline clinical characteristics by tertiles of duration of light-intensity activity in the entire cohort and CKD subgroup

Characteristic	Light-Intensity Activity Duration					
	Entire Cohort (n=3626)			CKD Subgroup (n=383)		
	Lowest Tertile (<7.1 min/hr) (n=1209 [28.%])	Middle Tertile (7.1–11.1 min/hr) (n=1209 [35.6%])	Highest Tertile (>11.1 min/hr) (n=1208 [36.4%])	Lowest Tertile (<3.3 min/hr) (n=128 [28.0])	Middle Tertile (3.4–7.0 min/hr (n=128 [32.7%])	Highest Tertile (>7.0 min/hr) (n=127 [39.3%])
Demographic						
Age (yr)[a,b]	55±16	46±12	41±10	76±14	73±11	66±14
Male (%)[a]	44	42	57	37	40	41
Black race (%)	9	11	9	5	7	7
High school education or more (%)[c]	80	88	81	68	69	76
Clinical						
Diabetes (%)[a]	17	7	5	32	31	19
Hypertension (%)[a]	51	38	27	80	79	75
Coronary heart disease (%)[a]	7	3	1	15	13	10
Congestive heart failure (%)[a,d]	6	2	1	20	14	8
Stroke (%)[a]	6	2	1	18	11	9
Cancer (%)[a]	15	8	5	30	25	20
Chronic bronchitis or emphysema (%)[a]	12	7	5	12	18	11
Smoking (%)[a]	24	25	31	8	15	13
Alcohol use (%)[a]	61	68	72	46	44	51
Waist circumference (cm)[d,e]	99.6±13.6	96.8±11.9	96.5±10.8	103.5±17.4	100.6±17.9	98.4±14.8
High-sensitivity C-reactive protein (mg/dl)[e,a]	2.4 (1.1, 5.3)	2.0 (0.8, 4.7)	1.6 (0.7, 3.7)	3.0 (1.5, 6.2)	2.3 (1.2, 4.4)	2.0 (1.0, 5.0)
Urine albumin-to-creatinine ratio (μg/mg)[c,d,e]	6.8 (4.3, 14.6)	5.8 (4.0, 9.7)	5.4 (3.8, 9.1)	11.5 (5.6, 53.9)	11.2(5.9, 28.5)	7.2 (5.4, 22.9)
eGFR (ml/min per 1.73 m^2)[a,d]	84.3±20.7	94.0±15.6	99.9±13.7	45.3±15.2	48.7±13.3	50.7±10.0
Special equipment needed to walk or unable to walk up 10 steps of stairs (%)[a,b]	27	10	7	64	33	21
Physical activity duration (min/hr)						
Sedentary duration[a,b]	42±4	35±3	27±4	47±5	41±4	34±5
Low-intensity activity duration[a,b]	13±3	15±2	16±3	11±4	14±4	15±4
Light-intensity activity duration[a,b]	5±1	9±1	15±3	2±1	5±1	10±3
Moderate- to vigorous-intensity activity duration[a,b]	0.4 (0.1,1.1)	1.1 (0.6,1.8)	2.0 (1.1,3.2)	0.1 (0.0,0.2)	0.2 (0.1,0.4)	0.5 (0.3,0.8)

Survey weight-adjusted means ± SDs, medians (interquartile range), or proportions are presented.
[a]$P<0.001$ for the entire cohort.
[b]P<0.001 for CKD subgroup.
[c]$P<0.05$ for the entire cohort.
[d]$P<0.05$ for CKD subgroup.
[e]Waist circumference missing in 108 patients in the entire cohort and 16 in the CKD subgroup, urine albumin-to-creatinine ratio missing in 32 and 10, and C-reactive protein missing in 2 and 0, respectively.

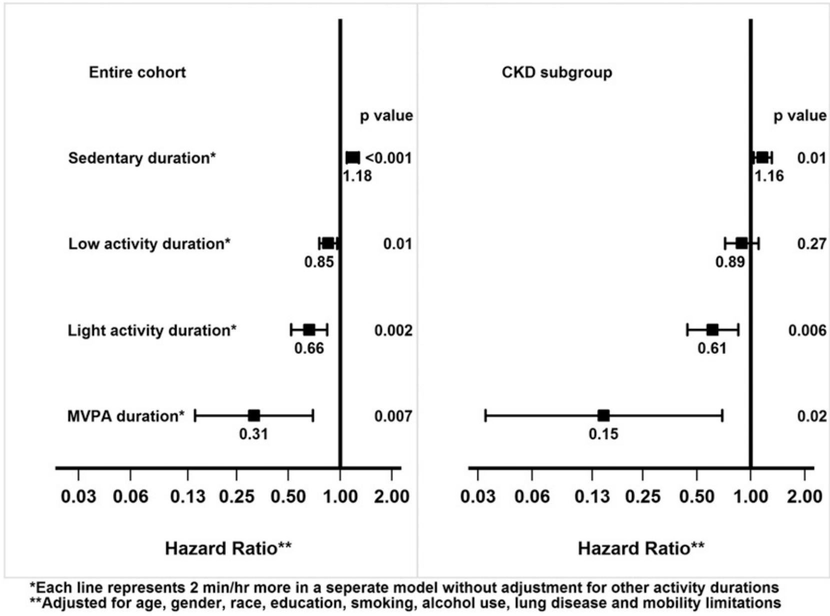

Figure 2. | **Mortality associations with individual activity durations, without adjustment for other activities.** Hazard ratios and 95% confidence intervals are presented. MVPA, moderate/vigorous-intensity physical activity.

higher-intensity activity while controlling for the other two activity durations. A tradeoff of sedentary duration with low-intensity PA duration was not associated with survival in the entire cohort or CKD subgroup. On the other hand, 2 min/hr shorter sedentary duration with 2 min/hr greater duration of light-intensity activity duration was significantly associated with lower mortality risk in the entire cohort (HR, 0.67; 95% CI, 0.48 to 0.93) and CKD subgroup (HR, 0.59; 95% CI, 0.35 to 0.98).

With additional adjustment for factors (listed in the Materials and Methods section) that may be in the causal pathway between physical activity intensity and mortality, tradeoff of each 2 min/hr of sedentary duration with light-intensity activity duration was associated with lower hazard of death in the entire cohort (HR, 0.71; 95% CI, 0.52 to 0.97) and the CKD subgroup (HR, 0.57; 95% CI, 0.35 to 0.95) (Supplemental Table 1).

HRs consistent with reduced risk were observed in the CKD subgroup for 2 min/hr less in sedentary duration with 2 min/hr more in MVPA duration (HR, 0.46; 95% CI, 0.09 to 2.45) and for 2 min/hr less in low-intensity activity duration in conjunction with 2 min/hr more in either light-intensity activity duration (HR, 0.54; 95% CI, 0.26 to 1.11) or MVPA duration (HR, 0.42; 95% CI, 0.08 to 2.15). However, none of the latter three comparisons reached statistical significance (Table 4).

Tradeoff of 1–5 min/hr of sedentary duration with low-intensity activity duration is expected to result in additional weekly expenditure of 30–150 kcal only (Supplemental Figure 1) without any mortality associations (Figure 3). On the other hand, similar tradeoff of sedentary duration with light-intensity activity duration is expected to result in approximately 200–1000 kcal/wk of additional energy expenditure (Supplemental Figure 1) and significantly lower risk of death (Figure 3).

Discussion

In this study of noninstitutionalized, community-dwelling adults, the participants spent more than half their time in sedentary activities (Figure 1). Those with CKD were even more sedentary and spent more than two thirds of their time in sedentary activities. Furthermore, increase in sedentary duration was associated with increased hazard of death in the entire cohort and CKD subgroup (Figure 2), which is consistent with previous studies of sedentary behavior and mortality (11–13). However, because there are only a fixed number of minutes in an hour, an increase in the duration of any given activity must result in a decrease in at least one of the other three activities. Furthermore, people who are active are likely to have higher levels of not only MVPA but also light-intensity activities. These have important implications for interpretation of the data as discussed below.

We estimated the mortality HRs associated with 2 min/hr tradeoff of sedentary duration with each of the low- and light-intensity activities and MVPAs while controlling for the durations of the remaining two activities.

These data suggest that tradeoff of sedentary duration with low-intensity activity was not associated with a substantial difference in mortality risk in the entire cohort or the CKD subgroup (Table 4). On the other hand, 2 min/hr tradeoff of sedentary duration with an equal duration of light-intensity activity was associated with a lower mortality risk in the entire cohort and the CKD subgroup (Table 4).

According to the concept of nonexercise activity thermogenesis (24,25), the energy expenditure from nonexercise activities provides a biologic framework for the rationale for increasing low- or light-intensity activities. Trading off 1–5 min/hr of sedentary duration for a low-intensity activity (such as standing) will result in an additional energy expenditure of only approximately 30–150 kcal/wk. On

Table 3. Relationships among durations of each intensity of physical activity

Variable	Δ Sedentary Duration	Δ Low-Intensity Activity Duration	Δ Light-Intensity Activity Dureation	Δ Moderate- or Vigorous-Intensity Activity Duration
Entire cohort				
↑ 2 min/hr of sedentary duration	—	−0.72 (−0.77 to −0.68)	−1.11 (−1.15 to −1.07)	−0.17 (−0.19 to −0.15)
↑ 2 min/hr of low-intensity activity duration	−2.77 (−2.89 to −2.64)	—	0.86 (0.76 to 0.96)	−0.09 (−0.13 to −0.06)
↑ 2 min/hr of light-intensity activity duration	−2.83 (−2.94 to −2.72)	0.57 (0.48 to 0.67)	—	0.25 (0.22 to 0.29)
↑ 2 min/hr of moderate or vigorous-intensity activity duration	−6.88 (−7.41 to −6.35)	−0.64 (−0.96 to −0.33)	4.26 (3.80 to 4.72)	—
CKD subgroup				
↑ 2 min/hr of sedentary duration	—	−1.02 (−1.15 to −0.90)	−0.92 (−1.02 to −0.82)	−0.06 (−0.09 to −0.03)
↑ 2 min/hr of low-intensity activity duration	−2.77 (−2.92 to −2.61)	—	0.78 (0.63 to 0.93)	−0.02 (−0.04 to 0.01)
↑ 2 min/hr of light-intensity activity duration	−3.07 (−3.36 to −2.79)	0.96 (0.69 to 1.24)	—	0.11 (0.04 to 0.18)
↑ 2 min/hr of moderate or vigorous-intensity activity duration	−6.02 (−8.43 to −3.62)	0.13 (−0.72 to 0.98)	3.67 (1.80 to 5.55)	—

Values are expressed as coefficients (95% confidence intervals). The entries in each row of the table provide survey weight–adjusted estimated mean differences in the durations of each of the remaining three activity levels associated with 2 min/hr more of the activity indicated in the left column. The 2 min/hr more in moderate- or vigorous-intensity physical activity (MPVA) in the bottom row is based on a change from 0.07 min/hr to 2.07 min/hr, which corresponds roughly to an increase from the 25% and 95% percentiles of moderate- or vigorous-intensity in CKD subgroup and 5% and 75% percentiles of moderate- or vigorous-intensity in the entire cohort. Results are based on multiple linear regressions adjusted for age, sex, race, education, smoke, alcohol use, lung disease, and mobility limitations.

Table 4. Hazard ratios of death per 2 min/hr tradeoff of lower-level activity duration with higher-level activity duration

Variable	↑ 2 min/hr of Low-Intensity Activity Duration: HR (95% CI, *P* Value)	↑ 2 min/hr of Light-Intensity Activity Duration: HR (95% CI, *P* Value)	↑ 2 min/hr of Moderate- or Vigorous-Intensity Activity Duration: HR (95% CI, *P* Value)
Entire cohort[a]			
↓2 min/hr of sedentary duration	1.01 (0.86 to 1.19; *P*=0.87)	0.67 (0.48 to 0.93; *P*=0.02)	0.80 (0.42 to 1.51; *P*=0.46)
↓2 min/hr of low-intensity activity duration		0.66 (0.42 to 1.05; *P*=0.08)	0.79 (0.44 to 1.40; *P*=0.39)
↓2 min/hr of light-intensity activity duration			1.19 (0.52 to 2.73; *P*=0.66)
CKD subgroup[a]			
↓2 min/hr of sedentary duration	1.09 (0.82 to 1.44; *P*=0.54)	0.59 (0.35 to 0.98; *P*=0.04)	0.46 (0.09 to 2.45; *P*=0.34)
↓2 min/hr of low-intensity activity duration		0.54 (0.26 to 1.13; *P*=0.10)	0.42 (0.08 to 2.15; *P*=0.28)
↓2 min/hr of light-intensity activity duration			0.79 (0.12 to 5.50; *P*=0.80)

Hazard ratios from Cox regression models that took survey design into account. For tradeoff: mortality risk associated with each 2 min/hr shorter lower-intensity activity duration with a corresponding 2 min/hr greater higher-intensity activity duration while controlling for the other two activity durations. Adjusted for age, sex, race, education, smoke, alcohol use, lung disease, mobility limitations. HR, hazard ratio; 95% CI, 95% confidence interval.
[a]No missing variables for these main models.

the other hand, a 1–5 min/hr tradeoff of sedentary duration with 2.5 METs of light-intensity activities (such as casual walking) is expected to increase energy expenditure by about 200–1000 kcal/wk (Supplemental Figure 1). In comparison, achieving the weekly recommended MVPA duration of 2.5 hr/wk with brisk walking (4 METs) will result in approximately 600 kcal of additional energy expenditure per week. Therefore, increasing light activities has the potential to double the weekly energy expenditure resulting from achieving the MVPA goal alone.

A few pilot studies have examined interventions to decrease sedentary duration (26–28). However, because low-intensity activity does not appear to confer a survival benefit (Table 4) or increase energy expenditure (Supplemental Figure 1), merely replacing sedentary duration by low-intensity activities duration is unlikely to be beneficial. Instead, our analyses suggest that interventions targeting sedentary duration should seek to increase light-intensity activity duration. Randomized, controlled trials are needed to determine whether such interventions will reduce morbidity and mortality.

Each 2 min/hr increment in MVPA duration was associated with the lowest mortality risk (Figure 2). Indeed, the net increase in the physical activity dose was the highest for each 2 min/hr increase in MVPA duration; a net decrease of approximately 7.5 min/hr in duration of sedentary and low-intensity activity with a concomitant increase in duration of light-intensity activities of 4.3 min/hr (Table 3). In comparison, the net increase in the physical activities dose was lower for each 2 min/hr increase in duration of low- or light-intensity activity (Table 3). Thus, these results suggest that the tradeoff of sedentary duration with longer duration of higher-intensity physical activities provides a dose-dependent survival benefit.

Nonetheless, tradeoff of sedentary activity duration with MVPA duration while holding duration of low- and light-intensity activities constant was not associated with statistically significant lower mortality risk (Table 4). This might be because duration of MVPA was too short in this study population.

It may be more realistic, however, to seek to replace sedentary duration with light-intensity activity duration rather than MVPA duration. We believe an optimal strategy should include decreasing sedentary duration by increasing the duration of light- (but not low-) intensity activities in combination with achieving weekly MVPA duration goals. Interventional trials are needed to test this strategy.

The strengths of this study include objective measurement of PA. The technological advances that made objectively measuring PA intensity and duration possible enabled a more comprehensive examination of the associations of duration of PA intensity with mortality in the current study.

The major limitations of this study include those of all observational studies that use existing data. The observational nature of the study prohibits inference beyond associations as unmeasured residual confounding must be considered while interpreting the results and hence, this study should be considered exploratory. Furthermore, activities such as swimming and water aerobics were not recorded because the accelerometers were not waterproof. In addition, the device used in NHANES recorded uniaxial movement; hence, information on use of stationary bikes, elliptical trainers, or equipment that primarily involved upper body movement, such as rowing, may not have been recorded accurately. These might have resulted in underestimation of MVPA (29). However, these issues are unlikely to have led to underestimation of light-intensity activity. In addition, the CKD subgroup in this study is

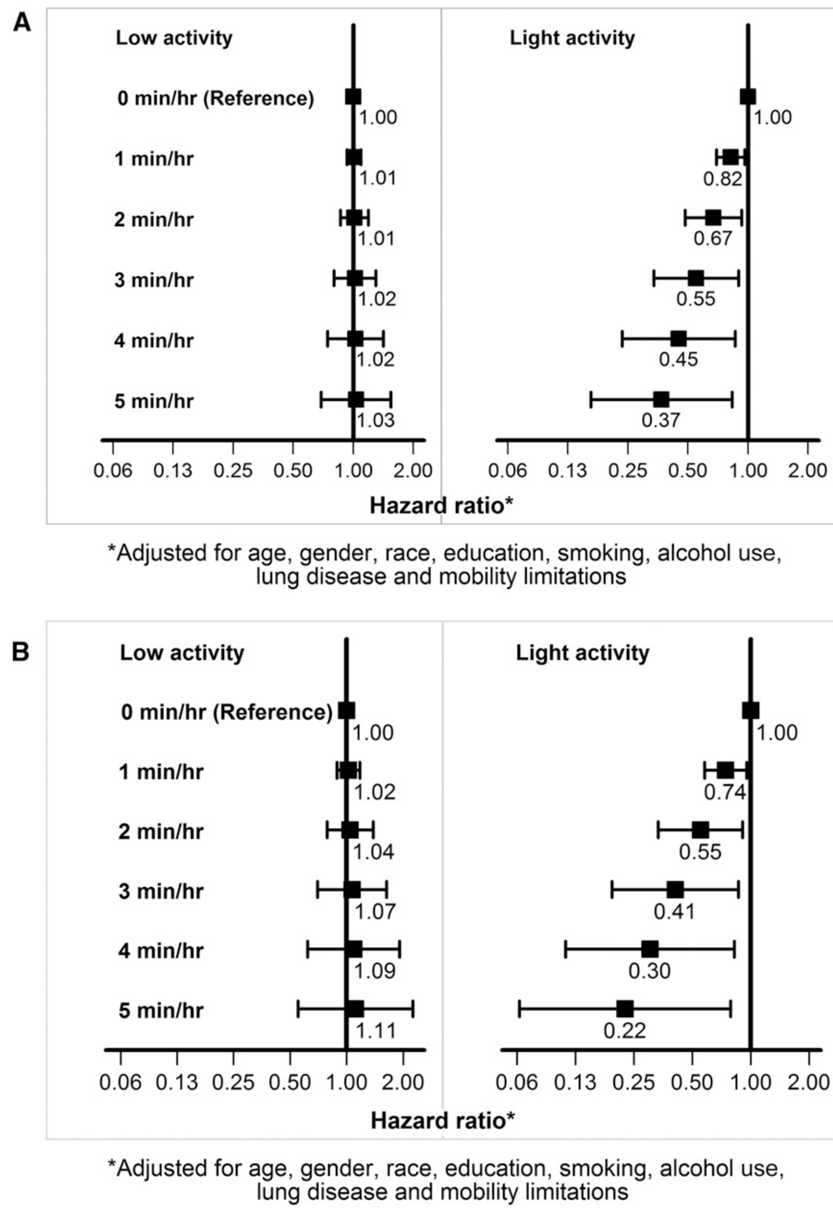

Figure 3. | **Mortality associations of tradeoff of 1–5 min/hr of sedentary duration with durations of low- or light-intensity activities.** (A) Entire cohort. (B) CKD subgroup.

mainly composed of stage III CKD. This study could not examine the associations of PA intensity levels with progression of CKD or incidence of ESRD. Finally, despite the association of light-intensity activity with lower mortality in multivariable models, caution is warranted in interpreting these results because of the relatively short duration of follow-up and low number of mortality events. Hence, longer-term studies are warranted to conclusively establish the relationship of light-intensity activity with mortality in non-CKD and CKD populations.

In summary, the importance of light activity has been underrecognized. Replacement of sedentary activity with light-intensity activity might confer a survival benefit. Survival benefits of interventions that increase light activities in combination with MVPAs need to be tested in both non-CKD and CKD populations.

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Disclosures

None.

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