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Moderate-to-Vigorous Physical Activity and All-Cause Mortality: Do Bouts Matter?

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Abstract

Background The 2008 Physical Activity Guidelines for Americans recommends that adults accumulate moderate-to-vigorous physical activity (MVPA) in bouts of ≥ 10 minutes for substantial health benefits. To what extent the same amount of MVPA accumulated in bouts versus sporadically reduces mortality risk remains unclear.

This Issue

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Methods and Results We analyzed data from the National Health and Nutrition Examination Survey 2003–2006 and death records available through 2011 (follow-up period of \approx 6.6 years; 700 deaths) to examine the associations between objectively measured physical activity accumulated with and without a bout criteria and all-cause mortality in a representative sample of US adults 40 years and older ($n=4840$). Physical activity data were processed to generate minutes per day of total and bouts MVPA. Bouted MVPA was defined as MVPA accumulated in bouts of a minimum duration of either 5 or 10 minutes allowing for 1- to 2-minute interruptions. Hazard ratios for all-cause mortality associated with total and bouts MVPA were similar and ranged from 0.24 for the third quartile of total to 0.44 for the second quartile of 10-minute bouts. The examination of jointly classified quartiles of total MVPA and tertiles of proportion of bouts activity revealed that greater amounts of bouts MVPA did not result in additional risk reductions for mortality.

Conclusions These results provide evidence that mortality risk reductions associated with MVPA are independent of how activity is accumulated and can impact the development of physical activity guidelines and inform clinical practice.

accelerometer activity bouts adults
epidemiology exercise

National Health and Nutrition Examination
Survey

Clinical Perspective

What Is New?

- This study examines whether moderate-to-vigorous physical activity needs to be accumulated in bouts to provide mortality benefits.

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- Accelerometer-measured physical activity data collected in 2003–2006 from a representative sample of US adults (n=4840) were classified as being accumulated sporadically or in bouts and linked to mortality records available through 2011.
- Sporadic and bouted moderate-to-vigorous physical activity was similarly and strongly associated with mortality risk.
- Mortality risk reductions associated with moderate-to-vigorous physical activity are independent of how activity is accumulated.

What Are the Clinical Implications?

- This finding can inform future physical activity guidelines and guide clinical practice when advising individuals about the benefits of physical activity.
- The key message based on the results presented is that total physical activity (ie, of any bout duration) provides important health benefits.
- Practitioners can promote either long single or multiple shorter bouts of activity in advising adults how to progress toward 150 min/wk of moderate-to-vigorous physical activity.
- This flexibility may be particularly valuable for individuals who are among the least active and likely at greater risk for developing chronic conditions.

The 2008 Physical Activity Guidelines for Americans recommends that adults accumulate at least 150 min/wk of moderate or 75 min/wk of vigorous-intensity physical activity for substantial health benefits.¹ The guidelines also direct that activity be performed in bouts of at least 10 minutes. The 10-minute bout criterion originated in 1995 and was intended to provide flexibility in achieving the recommended dose.² This messaging shift emphasized the importance of accumulating a total volume of moderate-to-vigorous physical activity (MVPA) and has remained a central feature of guidelines as they

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evolved. Surprisingly, evidence supporting a minimum bout of 10 minutes is limited.³ Recent studies comparing MVPA accumulated in bouts to total minutes regardless of bouts suggest that bouts provide no additional benefit regarding metabolic syndrome, waist circumference, and body mass index.^{4, 5, 6, 7, 8} However, these studies are limited to cross-sectional designs that evaluated risk factors, making it difficult to understand the temporal sequence for the observed associations or the influence of MVPA bouts on end points, such as all-cause mortality. Thus, whether only bouts or total accumulated MVPA is more beneficial to mortality remains uncertain.

Methods

Study Population

The data, analytic methods, and study materials will not be made available to other researchers for purposes of reproducing the results or replicating the procedure. Study data are from NHANES (National Health and Nutrition Examination Survey) 2003–2006 cycles. NHANES samples noninstitutionalized US civilians using a multistage probability sampling design that considers geographical area and minority representation. Sample weights are generated to create nationally representative estimates for the US population and subgroups defined by age, sex, and race/ethnicity. See

https://www.cdc.gov/nchs/nhanes/about_nhanes.htm

for more details on NHANES sampling procedures.

NHANES collects data on various health and behavior indicators, including physical activity and self-reported diagnosis of prevalent health conditions such as diabetes mellitus, coronary artery disease, stroke, and cancer.

These data were merged with mortality records from the National Death Index, available through December 2011.

The National Center for Health Statistics links mortality records available through the National Death Index with individuals in the respective NHANES database using various individual information such as social security number, first name, month of birth, sex, race, and others.⁹

The matching process/linkage provides vital status for

each individual that has been shown to accurately identify 87% to 97% of the true death records and is fairly accurate across race/ethnicities.**10, 11, 12** Our study used linked mortality NHANES data released to the public by the National Center for Health Statistics and restricted the analytical sample to adults aged 40 years and older with complete data on all variables of interest (N=4840 respondents). Details of this cohort have been reported elsewhere.**13** The NHANES study was reviewed and approved by the National Center for Health Statistics Research Ethics Review Board and all participants provided signed consent for participation.

Assessment of Physical Activity

Physical activity was measured with a waist-worn uniaxial accelerometer (AM-7164; ActiGraph) for up to 7 days using a standardized protocol.**14** Data were initially screened for nonwear time using a previously developed algorithm for NHANES accelerometer data.**14** Days with fewer than 10 hours of wear time were excluded and participants with at least 1 valid day of accelerometer data were included in the analysis. A threshold of 760 counts per minute defined MVPA. This threshold was defined to capture a broader range of lifestyle and ambulatory activities and has been demonstrated to provide accurate estimates of time spent in MVPA.**15, 16, 17** Minutes of activity were computed for 3 measures of MVPA: total with no bout restriction, accumulated in ≥ 5 -minute bouts, and accumulated in ≥ 10 -minute bouts. MVPA accumulated in bouts of 5 or 10 minutes allowed for 1 and 2 minutes, respectively, of activity counts < 760 counts per minute to accommodate real-life activity patterns (eg, stopping at a crosswalk while walking).

Statistical Analysis

All analyses were conducted with Cox proportional hazard models using established covariates of the physical activity–mortality association**13**: age (years), sex, race-ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, other), education (less than high school, high

school diploma, high school or more), alcohol consumption (never, former, current), smoking status (never, former, current), body mass index (<25, 25–29.9, ≥30 kg/m²), and self-reported diagnosis (yes/no) of diabetes mellitus, coronary artery disease, stroke, cancer, and mobility limitation.

First, we examined mortality associations by quartiles for each of the 3 MVPA measures: total, ≥5-minute, and ≥10-minute bouts, not accounting for differences in activity volume. Total MVPA was similar across the 3 measures and strongly correlated ($r=0.7-0.9$) (Table **S1**), suggesting that the measures were not independent and that individuals who accumulated the most total MVPA also accumulated high amounts of MVPA in 5- or 10-minute bouts.

To account for the dependence between total and bouted activity, we jointly classified quartiles of total MVPA by bouted activity, based on tertiles of the proportion of total MVPA accumulated in bouts of ≥5 or ≥10 minutes. This resulted in 12 categories of total MVPA and relative contribution of bouted MVPA. Many participants, particularly in the lower quartiles of total MVPA, had 0 bouts of ≥10 minutes. This led to unstable estimates, so analyses focused on bouts of ≥5 minutes. In these analyses, evidence of greater benefit for bouted activity would be demonstrated by lower hazard ratios (HRs) as contribution of bouts to total MVPA increased. To further describe the relationship between these exposures we plotted the risk estimates for each of the 12 categories against total MVPA. The assumption of proportional hazards was tested and held true for our MVPA exposure. All analyses accounted for the complex survey design in NHANES and were conducted using the SAS version 9.3 (SAS Institute Inc) and SUDAAN (RTI International) statistical packages.

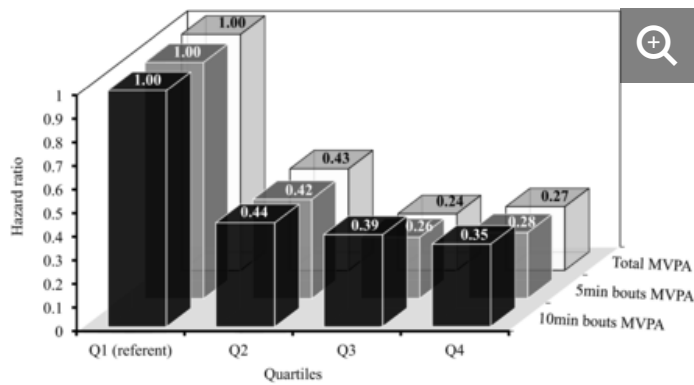
Results

Over a mean follow-up of 6.6 years, 700 deaths were recorded. Participants were 46.7% male and 77.4% non-Hispanic white, 17.4% had less than a high school education, 21.1% were current smokers, and 62.0% reported drinking alcohol.

For each of the 3 MVPA measures, greater MVPA was associated with lower mortality (P trend <0.01 ; Figure 1). HRs ranged from 0.24 to 0.44 and were nearly identical for each measure. For example, risk was similar in the upper quartiles for total MVPA (HR, 0.27; 95% confidence interval [CI], 0.16–0.45), 5-minute bouts (HR, 0.28; 95% CI, 0.17–0.45), and 10-minute bouts (HR, 0.35; 95% CI, 0.23–0.53) (Table S2). Among the categories jointly classified by quartiles of total MVPA and tertiles of bouts MVPA, greater total MVPA was associated with lower mortality, but greater proportions of bouts MVPA showed no additional risk reduction (Table). Specifically, within a given quartile of MVPA, HRs were similar across tertiles of bout proportion (Table, columns 2–4). For example, in the first MVPA quartile, higher contributions of bouts activity resulted in similar HRs for moderate (0.75; 95% CI, 0.60–0.95) and high amounts of bouts activity (0.77; 95% CI, 0.60–0.99). HRs across tertiles within each of the remaining quartiles were also similar. Analyses replicated with bouts of ≥ 10 minutes were unstable in the lowest 2 quartiles because $>30\%$ of the sample had no ≥ 10 -minute bouts, but showed the same pattern for quartiles 3 and 4 (data not shown). To visualize these relationships, we plotted the HRs for each of the 12 categories by total MVPA in each category (Figure 2). Overall, greater total MVPA was associated with lower mortality, reaching a plateau at about 100 min/d, with no appreciable additional benefit of greater relative contributions of bouts activity. It was also evident that accumulating greater total MVPA required continuous bouts of activity.

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Figure 1.

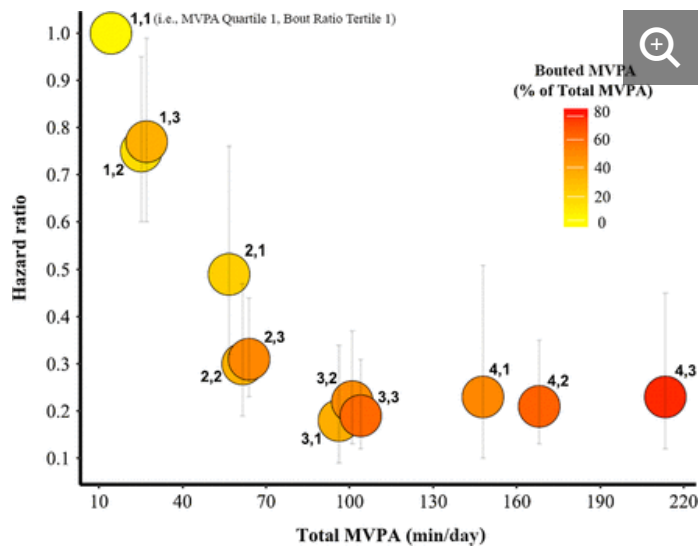
Main effects for quartile-specific distributions of total minutes per day of moderate-to-vigorous physical activity (MVPA), and both ≥ 5 - and ≥ 10 -minute bouts of accumulated minutes per day of MVPA. Quartiles: total MVPA (≤ 40.2 , 40.2–79.5, 79.5–123.4, and > 123.4 min/d); 5-minute bouts MVPA (≤ 10.7 , 10.7–34.3, 34.3–70.7, and > 70.7 min/d); 10-minute bouts MVPA (0.0, 0.0–5.1, 5.1–20.5, > 20.5 min/d). Hazard ratios are adjusted for age, sex, race-ethnicity, education, alcohol consumption, smoking status, body mass index, and self-reported diagnosis of diabetes mellitus, coronary artery disease, stroke, cancer, and mobility limitation.

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Table 1.

Mortality HRs for Joint Effects of Total MVPA and Proportions of Bouted (≥ 5 Minutes) MVPA

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Figure 2.

Distribution of hazard ratios provided in the **Table** by total duration of moderate-to-vigorous physical activity (MVPA) for jointly classified quartiles of total minutes and tertiles of relative contribution of bouts minutes. For example, 4,1 is equivalent to combined quartile 4 of total MVPA and tertile 1 (**Table**) of the relative contribution of bouts to total minutes. The relative contribution (%) of bouts MVPA minutes ranged from 3% (bright yellow) to 81% (dark red). The joint group 4,1 represents 150 minutes in total MVPA and \approx 50% of the total duration was accumulated in bouts of \geq 5 minutes. The remaining 50% was accumulated in sporadic activity. The grey error bars indicate the upper and lower 95% confidence intervals for respective hazard ratios. Hazard ratios are adjusted for age, sex, race-ethnicity, education, alcohol consumption, smoking status, body mass index, and self-reported diagnosis of diabetes mellitus, coronary artery disease, stroke, cancer, and mobility limitation.

Discussion

This prospective study examined the relative benefits of bouts versus sporadic MVPA on mortality in a representative sample of US adults, using an objective measure of physical activity. Greater total MVPA was strongly associated with lower mortality, and bouts activity conferred little additional benefit. Thus, these results provide evidence that mortality risk reductions associated with MVPA are independent of how activity is accumulated. These results can inform the development of the second edition of the Physical Activity Guidelines for Americans and other recommendations.

Several published studies have examined the associations between physical activity and mortality and were used to inform the current physical activity guidelines.³ However, most of these studies relied on data obtained from self-reports and only a few explored these associations using device-based measures of physical activity.^{13, 18, 19, 20, 21, 22, 23} Even though the current physical activity guidelines recommend that activity be accumulated in bouts of ≥ 10 minutes, most of these studies also examined the relative benefits of sporadic MVPA. The few studies specifically examining the value of bouts physical activity showed that sporadic versus bouts activity had similar associations with the metabolic syndrome, waist circumference, and body mass index.^{4, 5, 6, 7, 8} However, all of these studies employed cross-sectional designs and examined intermediate end points. Thus, these studies could not address the ancillary question of whether sporadic and bouts activity can provide similar health benefits. In our study, similar to earlier published NHANES studies, we found risk reductions for all-cause mortality to range from 60% to 80% across increased amounts of accumulated sporadic MVPA. However, the key finding of our study was that lowered risk for all-cause mortality associated with sporadic MVPA was no different than the lowered risk associated with activity accumulated in bouts of ≥ 5 minutes. This finding aligns with previous studies examining cross-sectional associations of sporadic versus bouts activity with various health risk

factors; however, it provides new evidence that benefits for mortality, a robust health end point, are independent of how activity is accumulated.

Our study is the first to use data from a representative sample of US adults with device-based estimates of physical activity to compare the benefits of sporadic with bouts activity. Our analyses provide a robust estimate of such benefits but include a few challenges that are worth mentioning. We found that total and bouts activity were highly correlated ($r=0.7-0.9$) and that few individuals in the United States accumulate activity in bouts of ≥ 10 minutes ($>30\%$ of the sample had no 10-minute bouts detected). These preliminary findings shaped our efforts in modeling the associations among sporadic versus bouts activity and mortality. To address these challenges, we jointly classified quartiles of total MVPA at various contributions of bouts activity of ≥ 5 minutes. We were unable to fully analyze the effects of MVPA accumulated in bouts of ≥ 10 minutes; however, where data were available, results for 5- and 10-minute bouts were similar. We also recognize that a variety of published cut points are available to define MVPA intensity.¹⁸ NHANES studies have commonly employed 2020 counts per minute, which is based on ambulatory calibration, to define MVPA; however, we chose to use a cut point calibrated to capture a greater variety of lifestyle activities in addition to ambulatory movement. Our selected cut point has been extensively evaluated and demonstrated to provide valuable insights when examining the associations between physical activity and mortality.^{13, 15, 16, 17, 23} We explored the use of the ambulatory MVPA threshold (ie, 2020 counts per minute) in our study but found limited utility as the majority of our sample did not accumulate any MVPA in bouts of 10 minutes with this threshold. We previously examined the associations of sporadic activity using either 760 or 2020 counts per minute and found similar associations with mortality (unpublished findings). Thus, we do not expect our conclusions to be dependent on our choice of the 760 cut point, and consider that the magnitude of our associations for both sporadic and bouts activity may be conservative.

Conclusions

Despite the historical notion that physical activity needs to be performed for a minimum duration to elicit meaningful health benefits, we provide novel evidence that sporadic and bouted MVPA are similarly associated with substantially reduced mortality. This finding can inform future physical activity guidelines and guide clinical practice when advising individuals about the benefits of physical activity. Practitioners can promote either long single or multiple shorter episodes of activity in advising adults on how to progress toward 150 min/wk of MVPA. This flexibility may be particularly valuable for individuals who are among the least active and likely at greater risk for developing chronic conditions.

Disclosures

None.

Supplementary Information

Table S1. Weighted US Adult Distributions of Total Time Per Day Spent in Sedentary, Light, and MVPA Across Quartiles of Total and Bouted MVPA

Table S2. HRs for Quartiles of Total and 5- and 10-Minute Bouted MVPA [[jah32997-sup-0001-TableS1-2.pdf](#)]

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