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Dose-Response Association of Moderate-to-Vigorous Physical Activity with Cardiovascular Biomarkers and All-Cause Mortality: Considerations by Individual Sports, Exercise and Recreational Physical Activities

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Abstract

Background: Previous research demonstrates that moderate-to-vigorous physical activity (MVPA) is associated with reduced all-cause mortality risk. Our understanding of whether individual physical activities are associated with all-cause mortality is less understood. Methods: Data from the 1999-2006 NHANES were employed, with follow-up through 2011. 48 different individual physical activities (e.g., swimming, running, bicycling) were assessed, and total MVPA MET-min-month was calculated based on their responses to these 48 individual physical activities. Results: Greater engagement in MVPA was associated with more favorable cardiovascular biomarkers, particularly for men. Even after adjustment for total MVPA, different individual physical activities were associated with cardiovascular biomarkers across gender. When compared to those not meeting guidelines (0-1999 MVPA MET-min-month), a dose-response association between MVPA and mortality was observed, with those engaging in 5 times the guideline level having the lowest risk of all-cause mortality (45% reduced risk). There was no evidence of a harmful effect of very high MVPA (e.g., 20,000+ MVPA MET-min-month). Conclusions: Engaging in MVPA even below the minimum recommendation was associated with survival benefits, and the greatest survival effects occurred at a dose of approximately 5 times the minimum recommendation. Although very high levels (e.g., 10 times the minimum recommendation) of self-reported MVPA did not demonstrate the greatest survival effects, high levels of physical activity did not appear to have harmful effects.

Keywords: Cardiovascular biomarkers; epidemiology; mortality; survival
Introduction

Regular participation in physical activity is associated with numerous health benefits. In a meta-analysis (N=33 studies evaluated) by Sattelmair et al., results showed that adults who met moderate-to-vigorous physical activity (MVPA) guidelines (minimum of 150 min/wk of MVPA) had a 14% lower coronary artery heart disease risk compared to those reporting no leisure time physical activity. Those engaging in twice the guideline amount (300 min/wk) had a 20% reduced risk, with higher levels only modestly reducing risk (e.g., men reaching 5 times the guidelines had a 21% reduced risk).

In the National Walkers’ Health Study (8,436 men and 33,586 women), a dose-response association of walking energy expenditure and total mortality was observed; when compared to those walking ≤ 1.07 MET-hrs/day, those walking 1.07-1.8 MET-hrs/day, between 1.8-3.6 MET-hrs/day, and above 3.6 MET-hrs/day, respectively, had 11.2%, 32.4% and 32.9% reduced risk of premature all-cause mortality. Meta-analyses have also been conducted to examine the dose-response association between MVPA and all-cause mortality. In 2001, Lee and Skerrett examined 44 studies, and from these, a 20-30% reduced risk of all-cause mortality was observed among those meeting MVPA guidelines. Most recently in 2015, Arem et al. quantified the dose-response association between leisure-time physical activity mortality among 6 studies (N_total=661,137). Their findings showed that, compared with those reporting no leisure time physical activity, those engaging in physical activity below the guidelines had a 20% reduced mortality risk. A 31%, 37% and 39% reduced mortality risk, respectively, was observed for those achieving 1-2 times, 2-3 times and 3-5 times the recommended minimum. Notably, there was no evidence of harm at 10 or more times the recommended minimum (31% reduced mortality risk).
Taken together, these findings suggest a dose-response relationship between MVPA and mortality risk, but the survival benefits appear to be only modestly different when comparing high exercises (e.g., those achieving 3-5 times the recommended minimum) to those achieving the minimum MVPA recommendation. In addition to overall energy expenditure, and although less investigated, there is some evidence to suggest that individual physical activities (e.g., bicycling, running, and swimming) may have specific survival benefits.6-8

To improve our understanding of the relationship between MVPA with health and all-cause mortality risk, the purposes of this study were to 1) examine the cross-sectional dose-response association between self-reported MVPA and cardiovascular biomarkers (e.g., HDL-cholesterol) and to also examine the association between individual physical activities (sports, exercise and recreational activities) on the evaluated biomarkers; and 2) examine the prospective dose-response association between self-reported MVPA and all-cause mortality and to also examine the prospective association between individual physical activities on all-cause mortality.

Methods

Study Design with Assessment of Mortality Status

Data were extracted from the 1999-2006 National Health and Nutrition Examination Survey. Data from participants in these cycles were linked to death certificate data from the National Death Index. Person-months of follow-up were calculated from the date of the interview until date of death or censoring on December 31, 2011, whichever came first. Analyses are based on data from 16,049 adults (18-85 yrs) who provided complete data for the study variables; these
16,049 adults were free of congestive heart failure, coronary artery disease, heart attack, stroke, emphysema or bronchitis, as individuals with these self-reported physician-diagnosed conditions were excluded from the analyses.

Procedures were approved by the National Center for Health Statistics review board. Consent was obtained from all participants prior to data collection. Further information on NHANES methodology and data collection is available on the NHANES website (http://www.cdc.gov/nchs/nhanes.htm).

**Physical Activity**

Participants were asked open-ended questions about participation in leisure-time physical activity over the past 30 days. Data was coded into 48 activities, including 16 sports-related activities, 14 exercise-related activities, and 18 recreational-related activities; these individual physical activities are published elsewhere (http://wwwn.cdc.gov/Nchs/Nhanes/2005-2006/PAQIAF_D.htm#PADACTIV).

For each of the 48 activities where participants reported moderate or vigorous-intensity for the respective activity, they were asked to report the number of times they engaged in that activity over the past 30 days and the average duration they engaged in that activity.

**Cardiovascular Biomarkers**

Cardiovascular risk was determined using standard criteria for assessment of allostatic load based on guidelines addressed elsewhere. Cardiovascular biomarkers assessed included total
cholesterol, high-density lipoprotein (HDL) cholesterol, and C-reactive protein (CRP) obtained from a blood draw. In addition, blood pressure was assessed manually 3-4 times, which was done after resting quietly in a sitting position for 5 minutes and determining the maximum inflation level. Other cardiometabolic risk factors (e.g., fasting triglycerides, fasting glucose and fasting low-density lipoprotein (LDL) cholesterol) were considered, but not included as they were only available for a limited subsample of fasting participants. Further details on the assessment of these specific cardiovascular biomarkers are reported elsewhere.\textsuperscript{11,12}

**Covariates**

Covariates included age, gender, race-ethnicity and weight status. As demonstrated in the results section, other covariates (which reduced the sample due to missing data) were considered, but their inclusion did not appreciably alter the results.

**Data Treatment**

Body mass index (BMI) was calculated from measured mass in kg divided by squared height in meters. Weight status was defined as BMI-determined underweight (<18.5 kg/m\(^2\)), normal weight (18.5-24.9 kg/m\(^2\)), overweight (25-29.9 kg/m\(^2\)) or obese (30+ kg/m\(^2\)).

Using the average of the manually assessed blood pressure measurements, mean arterial pressure was calculated using the following formula: \((\text{[diastolic blood pressure x 2] + systolic blood pressure}] / 3)\).
For each of the 48 physical activities, Metabolic Equivalent of Task (MET)-min-month was calculated by multiplying the number of days, by the mean duration, by the respective MET level (MET-min-month = days*duration*MET level). The MET levels for each activity are provided elsewhere.  

A six-level dose-response physical activity variable was created, with participations classified into one of the following six mutually exclusive categories: 1) <2000 MVPA MET-min-month (consistent with current government MVPA guidelines; 2) 2000-3999 MVPA MET-min-month; 3) 4000-5999 MVPA MET-min-month; 4) 6000-7999 MVPA MET-min-month; 5) 8000-9999 MVPA MET-min-month; and 6) 10000+ MVPA MET-min-month).

**Statistical Analysis**

Statistical analyses were performed via procedures from survey data using Stata (v.12). Briefly, and prior to any analyses, the following Stata command was used to define the survey design: `svyset [w = weight, psu(psu variable) strara (strata variable)]`. Then, “svy” commands were used for each analysis to ensure the complex survey design of NHANES is accounted for when determining variance estimates. To account for oversampling, non-response, non-coverage, and to provide nationally representative estimates, all analyses included the use of survey sample weights, clustering and primary sampling units.

Weighted multivariable linear regression analyses were used to examine the association between MVPA MET-min-month and each of the evaluated cardiovascular biomarkers. Weighted Cox proportional hazard models were used to examine the association between MVPA MET-min-
month and all-cause mortality. Schoenfeld’s residuals were used to verify the proportional hazards assumption.

**Results**

**Study Variable Characteristics**

Weighted characteristics of the study variables are shown in Table 1. Among the 16,049 participants, 1,290 died during the weighted mean follow-up of 103.8 months (8.65 yrs). Participants, on average, were 43.0 years of age with an equal distribution across gender. Approximately 47% of the sample self-reported at least 2,000 MVPA MET-min-month. In an attempt to examine potential evidence of convergent validity for the self-reported MVPA MET-min-month variable, we calculated accelerometer-assessed MVPA estimates across the 6 doses of MET-min-month. Notably, and unlike in the present sample of 1999-2006 NHANES participants, only those in the 2003-2006 NHANES cycles had accelerometry data. As a result, the following accelerometer-assessed MVPA estimates across the 6 doses of MVPA MET-min-month are for 5,134 adults in the 2003-2006 NHANES cycles. Across the 6 doses of self-reported MVPA MET-min-month of MVPA, from least to most MVPA, the unweighted mean accelerometer-assessed MVPA (using the 2020 counts/min cut-point and only among those with 4+ days of 10+ hours/day of monitoring) estimates, respectively, were 19.5, 25.2, 28.3, 30.4, 32.3, and 37.6 (P\textsubscript{trend}<0.001).

**Cross-Sectional Dose-Response Association Between MVPA and Cardiovascular Biomarkers**

Table 2 displays the gender-stratified weighted multivariable linear regression results examining the dose-response association between MVPA MET-min-month and the 4 evaluated
cardiovascular biomarkers. For men, those engaging in higher levels of self-reported MVPA had higher HDL cholesterol, and lower levels of total cholesterol, mean arterial pressure and CRP. The results were less pronounced for women, but generally, women with higher self-reported MVPA and higher HDL cholesterol and lower CRP levels. Interestingly, even the highest MVPA MET-min-month group (≥ 10,000 MVPA MET-min-month) was favorably associated with the cardiovascular biomarkers, particularly among men.

**Cross-Sectional Association of Individual Physical Activities on Cardiovascular Biomarkers**

Among the 48 evaluated physical activities, we examined the association between meeting MVPA guidelines (2000+ MET-min-month) and the cardiovascular biomarkers among 10 of out of the 48 different individual physical activities. These 10 physical activities were evaluated because they had the highest prevalence of meeting MVPA guidelines, and included *aerobics* (weighted percent meeting guidelines: 4.1%; n=593), *basketball* (3.0%; n=653), *bicycling* (4.9%; n=640), *dance* (2.6%; n=502), *jogging* (2.4%; n=358), *running* (4.5%; n=698), *stair climbing* (2.1%, n=302), *swimming* (2.6%, n=329), *walking* (13.8%; n=2,037), and *weight lifting* (3.1%; n=466).

In a single weighted multivariable linear regression model that included these 10 binary variables (meets/does not meet MVPA guidelines) plus the covariates total MVPA MET-min-month, age, race-ethnicity and weight status, bicycling \(\beta=0.37; 95\%\ CI: 0.40-2.59; P=0.008\), dance \(\beta=3.28; 95\%\ CI: 0.94-5.63; P=0.007\) and running \(\beta=2.44; 95\%\ CI: 0.71-4.17; P=0.006\) were positively associated with HDL cholesterol among men. For women, bicycling \(\beta=3.61; 95\%\ CI:
1.35-5.88; P=0.002) and jogging (β=3.32; 95% CI: 0.27-6.38; P=0.03) were positively associated with HDL cholesterol.

For total cholesterol, only basketball (β=-9.3; 95% CI: -14.4- -4.2; P<0.001) was significant for men, with dance (β=-5.4; 95% CI: -10.7- -0.2; P=0.04) being the only individual physical activity significantly associated with total cholesterol for women.

For both men and women, none of the binary physical activity variables were independently associated with mean arterial pressure. For CRP, bicycling (β=-0.06; 95% CI: -0.10- -0.02; P=0.004) and weight lifting (β=-0.06; 95% CI: -0.11- -0.01; P=0.01) were significant for men, with aerobics (β=-0.07; 95% CI: -0.12 - -0.02; P=0.003) and basketball (β=-0.09; 95% CI: -0.18- -0.01; P=0.03) significant for women.

**Prospective Dose-Response Association Between MVPA and All-Cause Mortality**

The unadjusted (HR, 95% CI) dose-response association between leisure-time MVPA and all-cause mortality was as follows (<2000 MVPA MET-min-month as referent): 0.57 (0.46-0.70), 0.53 (0.39-0.73), 0.52 (0.39-0.70), 0.43 (0.26-0.71) and 0.39 (0.30-0.52). Table 3 displays the weighted adjusted prospective dose-response association between MVPA and all-cause mortality. For the entire sample, and after controlling for age, gender, race-ethnicity and weight status, a dose-response relationship was observable (HRs were 0.69, 0.65, 0.59, 0.61 and 0.55, respectively), with those engaging in the highest MVPA (10,000+ MVPA MET-min-month, equivalent to 5 times the government MVPA guidelines) having the lowest hazard ratio: a 45% reduced risk of all-cause mortality (HR=0.55; 95% CI: 0.41-0.74; Table 3). Notably, when
adding mean arterial pressure, HDL-cholesterol, total cholesterol and CRP as covariates, the results were similar: compared to those self-reporting < 2,000 MVPA MET-min-month, the hazard ratios (95% CI) for the respective groups were as follows: 0.68 (0.54-0.85), 0.66 (0.48-0.92), 0.60 (0.45-0.80), 0.65 (0.38-1.11) and 0.57 (0.42-0.76). Similarly, when adding self-reported smoking status (this reduced the total sample size from 16049 to 14076) to this last model that included the cardiovascular and demographic covariates, the respective hazard ratios (95% CI) were: 0.74 (0.58-0.93), 0.74 (0.53-1.03), 0.68 (0.51-0.91), 0.70 (0.41-1.20) and 0.61 (0.46-0.80). Similarly, when excluding individuals who died within the first year of follow-up (n=75), results were unchanged: 0.73 (0.58), 0.67 (0.48-0.93), 0.56 (0.42-0.75), 0.62 (0.36-1.06) and 0.58 (0.43-0.77).

Given the less frequent investigation of whether MVPA below the guideline threshold is associated with mortality, analyses were re-computed by creating a 7-category variable: 1) 0 leisure MVPA in the past 30 days (n=6257); 2) 1-1999 MVPA MET-min-month (n=2959); 3) 2000-3999 MVPA MET-min-month (n=1893); 4) 4000-5999 MVPA MET-min-month (n=1190); 5) 6000-7999 MVPA MET-min-month (n=888); 6) 8000-9999 MVPA MET-min-month (n=621); and 7) 10000+ MVPA MET-min-month (n=2241). Compared to those reporting 0 leisure-time MVPA MET-min-month, the adjusted (age, gender, race-ethnicity and weight status) hazard ratios (95% CI) for the respective groups were 0.55 (0.45-0.68; P<0.001), 0.60 (0.48-0.74; P<0.001), 0.56 (0.40-0.78; P=0.001), 0.52 (0.39-0.68; P<0.001), 0.53 (0.31-0.90; P=0.02), and 0.48 (0.36-0.64; P<0.001).
Table 3 also displays the gender-stratified prospective results. For men, and compared to those self-reporting < 2,000 MET-min-month of MVPA, the only significant findings were for those self-reporting 6000-7999 (HR=0.59; 95% CI: 0.39-0.88) and 10,000+ (HR=0.51; 95% CI: 0.37-0.71) MET-min-month of MVPA. For women, and compared to those < 2,000 MET-min-month of MVPA, the only significant findings were for those self-reporting 2000-3999 (HR=0.67; 95% CI: 0.50-0.90) and 4000-5999 (HR=0.61; 95% CI: 0.39-0.96) MET-min-month. These findings suggest a non-dose response association between MVPA and all-cause mortality for women. However, the gender-specific findings should be interpreted with caution due to cell size considerations. For the entire sample, the number of adults who died over the follow-up period for the 6 respective groups were: 934, 117, 70, 51, 29 and 89. For men, the sample sizes were: 499, 71, 40, 32, 22 and 69. For women, the sample sizes were: 435, 46, 30, 19, 7 and 20.

**Prospective Association of High Physical Activity Behavior and All-Cause Mortality**

To examine whether very high levels of leisure-time physical activity had a harmful effect on all-cause mortality, a 5-level MVPA MET-min-month variable was created: 0 leisure-time MVPA MET-min-month (n=6257), 1-1999 MVPA MET-min-month (n=2959), 2000-10000 MVPA MET-min-month (n=4592), 10000-19999 MVPA MET-min-month (n=1336) and 20000+ MVPA MET-min-month (n=905). After adjusting for age, gender, race-ethnicity and weight status, and with 0 MET-min-month as the referent group, the hazard ratios (95% CI) for the respective groups were: 0.55 (0.45-0.68), 0.56 (0.48-0.65), 0.42 (0.26-0.67) and 0.61 (0.45-0.83). This suggests that very high levels of MVPA (e.g., 20000+ MET-min-month) did not have a harmful effect on survival, but the protective effect was the lowest for this group. When
changing the referent group to 2000-9999 MET-min-month, the hazard ratio (95% CI) for those with 20000+ MET-min-month was 1.07 (0.76-1.52, P=0.65)

**Prospective Association of Individual Physical Activities and All-Cause Mortality**

A single weighted multivariable Cox proportional hazard model was used to examine the association between the 10 individual binary (meets/doesn’t meet guidelines) physical activities and all-cause mortality (not shown in tabular format). Due to cell size considerations, gender-stratified results were not computed, with this model including the following independent variables: total MET-min-month of MVPA (continuous variable), the previously mentioned 10 binary individual physical activity variables, age, gender, race-ethnicity and weight status. In this model, for every 2,000 MET-min-month MVPA increase, participants had a 6% reduced risk of all-cause mortality (HR=0.91-0.98). The only other significant physical activity variable was meeting guidelines from aerobic physical activity (HR=0.42; 95% CI: 0.22-0.81).

**Discussion**

The purpose of this study was to examine cross-sectional and prospective dose-response associations of total MVPA and individual physical activities with cardiovascular biomarkers and all-cause mortality. Major findings were as follows:

- Greater engagement in MVPA was associated with more favorable cardiovascular biomarkers, particularly for men;
- Even after adjustment for total MVPA, different individual physical activities were associated with cardiovascular biomarkers across gender;
• When compared to those not meeting guidelines (0-1999 MVPA MET-min-month), a dose-response association between MVPA and mortality was observed, with those engaging in 5 times the guideline level having the lowest risk of all-cause mortality (45% reduced risk);

• There was no evidence of a harmful effect of very high MVPA (e.g., 20000+ MVPA MET-min-month), but the protective effect of very high MVPA on mortality was not as strong when compared to lower levels of MVPA; and

• After adjusting for total MVPA, there was little evidence of an association between individual physical activities and all-cause mortality risk. However, this finding should be interpreted with caution given the limited sample size for the individual physical activities along with the interrelationship between total MVPA and the individual physical activities.

Taken together, the primary conclusions of this study are twofold: 1) with regard to the mortality risk, total leisure-time MVPA seemed to play a more important role in survival than individual physical activities; and 2) although higher levels of MVPA appeared to have the greatest survival benefits (with the exception of very high MVPA engagement), this effect was marginal beyond meeting the MVPA guidelines, and survival benefits even occurred for individuals engaging in MVPA below the guideline threshold.

These findings of an approximate 30-45% (Table 3; entire sample) reduced risk of all-cause mortality for leisure-time MVPA engagement is within the range of previous meta-analyses on this topic. Unlike previous studies which demonstrated protective effects of individual
physical activities, the present study suggests that overall energy expenditure may play a more important role than specific physical activities with regard to mortality risk. Notably, however, the cross-sectional results presented herein do suggest a differential association between individual physical activities and the evaluated cardiovascular biomarkers. This was not entirely surprising as, for example, it would be reasonable to expect that physical activities that may typically be performed in longer durations (e.g., dancing and running) would be associated with HDL-cholesterol; this was the case in the present study as dancing, bicycling and running, for example, were associated with higher HDL-cholesterol. The discrepant findings for individual physical activities with regard to their association with cardiovascular biomarkers and mortality risk may be a result of the study design (i.e., cross-sectional vs. prospective). Future prospective research may wish to explore this further to confirm, if indeed, individual physical activities have a differential association with cardiovascular biomarkers and mortality risk. The present findings, however, suggest that health promotion efforts should focus on any form of physical activity engagement that is desirable by the patient.

Limitations of the present study include the self-report assessment of physical activity. However, as demonstrated in the first paragraph of the Results section, there was some evidence of convergent validity between self-reported MVPA and accelerometer-assessed MVPA. The NHANES accelerometer-assessed physical activity data was not employed in the present study because participants engaged in relatively little accelerometer-determined MVPA, which rendered difficulty in examining dose-response associations with mortality risk. Another limitation was the cross-sectional assessment with regard to the MVPA associations with the cardiovascular biomarkers. Further, given the emerging research suggesting an independent
association of sedentary behavior on health outcomes, future research on this topic may wish to consider the influence of sedentary behavior on the present study’s observed associations.

Strengths of this study include the nationally representative sample, prospective design with mortality status at follow-up, exploring dose-response associations and the association of individual physical activities on mortality risk. Given the national sample of the present study, generalizability of the present study is enhanced.

In conclusion, the main findings of this study were: 1) engaging in MVPA even below the minimum recommendation was associated with survival benefits, 2) the greatest survival effects occurred at a dose of approximately 5 times the minimum recommendation, and 3) although very high levels of self-reported MVPA did not demonstrate the greatest survival effects, high levels of physical activity did not appear to have harmful effects.

Acknowledgements

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Conflict of Interest

There are no conflicts to disclose.
References

Table 1. Weighted characteristics of the analyzed sample, 1999-2004 NHANES (N=16,049)

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<th>Variable</th>
<th>Point Estimate</th>
<th>95% CI</th>
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<tbody>
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<td>Gender, % Women</td>
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<td>101.6-105.9</td>
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</tbody>
</table>
Table 2. Weighted multivariable linear regression (β, 95% CI) examining the dose-response association between moderate-to-vigorous physical activity and 4 individual cardiovascular biomarkers, 1999-2004 NHANES (N=16,049)

<table>
<thead>
<tr>
<th>Activity Status ‡</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Δ HDL-Cholesterol</td>
<td>Δ Total-Cholesterol</td>
</tr>
<tr>
<td>&lt; 2000 MVPA MET-min-month</td>
<td>Referent</td>
<td>Referent</td>
</tr>
<tr>
<td>2000-3999 MET-min-month</td>
<td>0.63 (-0.47-1.74)</td>
<td>2.54 (0.96-4.12)</td>
</tr>
<tr>
<td>4000-5999 MET-min-month</td>
<td>1.63 (0.21-3.04)</td>
<td>1.97 (0.57-3.37)</td>
</tr>
<tr>
<td>6000-7999 MET-min-month</td>
<td>1.76 (0.47-3.05)</td>
<td>3.16 (1.17-5.14)</td>
</tr>
<tr>
<td>8000-9999 MET-min-month</td>
<td>2.92 (1.03-4.81)</td>
<td>6.06 (3.19-8.93)</td>
</tr>
<tr>
<td>≥10000 MET-min-month</td>
<td>2.50 (1.54-3.46)</td>
<td>3.19 (1.32-5.06)</td>
</tr>
</tbody>
</table>

‡ Models were computed separately for each cardiovascular biomarker. In total 8 models were computed: 4 for men and 4 for women. For each model, covariates included age (yrs, continuous), race-ethnicity (Mexican American, non-Hispanic white, non-Hispanic black and other) and weight status (underweight, normal weight, overweight and obese)

CRP, C-reactive protein
HDL, High-density lipoprotein cholesterol
MAP, Mean arterial pressure
MET, Metabolic equivalent
MVPA, Moderate-to-vigorous physical activity
Table 3. Weighted multivariable Cox proportional hazard model (β, 95% CI) examining the dose-response association between moderate-to-vigorous physical activity and all-cause mortality, 1999-2004 NHANES (N=16,049)

<table>
<thead>
<tr>
<th>Activity Status †</th>
<th>Hazard Ratio (95% CI)</th>
<th>Entire Sample</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 2000 MVPA MET-min-month</td>
<td>Referent</td>
<td>Referent</td>
<td>Referent</td>
<td></td>
</tr>
<tr>
<td>2000-3999 MET-min-month</td>
<td>0.69 (0.55-0.86)</td>
<td>0.71 (0.50-1.02)</td>
<td>0.67 (0.50-0.90)</td>
<td></td>
</tr>
<tr>
<td>4000-5999 MET-min-month</td>
<td>0.65 (0.46-0.90)</td>
<td>0.69 (0.43-1.10)</td>
<td>0.61 (0.39-0.96)</td>
<td></td>
</tr>
<tr>
<td>6000-7999 MET-min-month</td>
<td>0.59 (0.45-0.78)</td>
<td>0.59 (0.39-0.88)</td>
<td>0.60 (0.34-1.07)</td>
<td></td>
</tr>
<tr>
<td>8000-9999 MET-min-month</td>
<td>0.61 (0.36-1.04)</td>
<td>0.69 (0.37-1.27)</td>
<td>0.50 (0.20-1.26)</td>
<td></td>
</tr>
<tr>
<td>≥10000 MET-min-month</td>
<td>0.55 (0.41-0.74)</td>
<td>0.51 (0.37-0.71)</td>
<td>0.69 (0.39-1.22)</td>
<td></td>
</tr>
</tbody>
</table>

† 3 models were computed: entire sample, and separate for men and women. For each model, covariates included age (yrs, continuous), race-ethnicity (Mexican American, non-Hispanic white, non-Hispanic black and other) and weight status (underweight, normal weight, overweight and obese), with gender also included in the entire sample model.
Highlights

- A national sample was employed
- A dose-response relationship between physical activity and mortality was observed
- There was no evidence of a harmful effect of very high physical activity