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Sustained and Shorter Bouts of Physical Activity are Related to Cardiovascular Health

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Abstract

Purpose—Whereas greater physical activity (PA) is known to prevent cardiovascular disease (CVD), the relative importance of performing PA in sustained bouts of activity versus shorter bouts of activity on CVD risk is not known. The objective of this study was to investigate the relationship between moderate-to-vigorous physical activity (MVPA), measured in bouts ≥10 minutes and <10 minutes, and CVD risk factors in a well-characterized, community-based sample of white adults.

Methods—We conducted a cross-sectional analysis of 2109 Framingham Heart Study Third Generation participants (mean age 47 years, 55% women) who underwent objective assessment of PA by accelerometry over 5–7 days. Total MVPA, MVPA done in bouts ≥10 minutes ($MVPA_{10+}$), and MVPA done in bouts <10 minutes ($MVPA_{<10}$) were calculated. MVPA exposures were related to individual CVD risk factors, including measures of adiposity and blood lipid and glucose levels, using linear and logistic regression.

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Conflicts of Interest: Dale Esliger is the owner and vendor of KineSoft, the accelerometer data analysis software used for the creation of the accelerometer outcome variables. No other conflicts were reported.

Results—Total MVPA was significantly associated with higher high-density lipoprotein (HDL) levels, and with lower triglycerides, BMI, waist circumference and Framingham risk score ($P < 0.0001$). $MVPA_{<10}$ showed similar statistically significant associations with these CVD risk factors ($P < 0.001$). Compliance with national guidelines (≥150 minutes of total MVPA) was significantly related to lower BMI, triglycerides, Framingham risk score, waist circumference, higher HDL, and a lower prevalence of obesity and impaired fasting glucose ($P < 0.001$ for all).

Conclusions—Our cross-sectional observations on a large middle-aged community-based sample confirm a positive association of MVPA with a healthier CVD risk factor profile, and indicate that accruing physical activity in bouts <10 minutes may favorably influence cardiometabolic risk. Additional investigations are warranted to confirm our findings.

Keywords

accelerometer; heart disease; exercise; guidelines

INTRODUCTION

Lack of physical activity (PA) has been consistently and directly related to the development of cardiovascular disease (CVD) risk factors such as obesity, hypertension, dyslipidemia, and glucose intolerance. (26, 27, 38) Conversely, PA reduces the risk of CVD events, functional disability, cognitive decline, and all-cause mortality. (1, 9, 10, 19, 20, 29, 40)

Prior studies of PA and health outcomes have been constrained by a lack of objective assessment of activity and a focus on leisure-time PA. Accelerometers substantially improve the accuracy, reliability and comprehensive profiling of PA by measuring both movement and its intensity during each daily minute, thereby quantifying the frequency, duration and total volume of PA. However, there are limited data regarding the association of PA assessed by accelerometry (including compliance with current national PA guidelines) with the CVD risk factor profile in the community. Additionally, whereas PA is known to play a significant role in the prevention of CVD, the relative importance of accumulating activity in sustained versus shorter bouts of time requires further investigation. A comprehensive review concluded that there is insufficient data comparing the effects of short versus longer bouts of PA, independent of activity intensity and amount.(24) In interventional studies comparing single long bouts of exercise with multiple short exercise bouts, there is relatively strong evidence that comparable cardiorespiratory fitness may be achieved with different fractionation of total PA volume.(27) There is conflicting evidence as to whether continuous PA exposure has a more favorable impact on CVD risk factors and a reliable estimate of the effect of fractionated exercise on CVD risk factors is lacking. National guidelines indicate that PA should be accrued in bouts of at least 10 minutes for potential health benefits, (25, 27) yet the guidelines also state that more research is needed to determine the health benefits of PA done in bouts <10 minutes.(13) In this context, accelerometry offers the opportunity to evaluate the impact of PA accrued in bouts ≥10 minutes versus bouts <10 minutes, independent of activity intensity and amount.(24)

In the present investigation we assessed the clinical correlates of moderate-to-vigorous physical activity (MVPA), measured in total minutes of MVPA, MVPA accumulated in bouts ≥10 minutes ($MVPA_{10+}$), and MVPA accumulated in bouts <10 minutes, as measured by accelerometry in the 3rd Generation cohort of the Framingham Heart Study (FHS), a well-characterized, community-based cohort study of white US adults.

METHODS

The FHS is a longitudinal community-based cohort that was initiated in 1948 to prospectively identify risk factors for CVD.(6) Recruitment of the 3rd Generation (children of the Offspring cohort(28) and grandchildren of the original FHS cohort) occured between 2002 and 2005 (examination 1).(33) For the present investigation, our study sample was derived from the 3rd Generation cohort participants who attended the second examination (May 2008-October 2010), when accelerometry was routinely performed.

At each FHS examination, participants undergo a routine medical history and physical examination including measurement of resting blood pressure, anthropometry and laboratory evaluation of standard CVD risk factors.(18) Data on education, employment status, current smoking, and levels of self-reported general health are also obtained. Hypertension was defined as a BP ≥140/90 mmHg, or current use of anti-hypertensive medication; Diabetes (DM) was defined by a fasting glucose ≥126 mg/dl or use of anti-diabetic medications; impaired glucose tolerance (IGT) as a fasting glucose 100 to <126 mg/dl. Overweight was defined as body mass index (BMI) ≥25 kg/m^2 and obesity was defined as BMI ≥30 kg/m^2. Prevalent CVD includes CHD (angina, and acute coronary syndrome, including myocardial Infarction), cerebrovascular disease (stroke and transient ischemic attack [TIA]), intermittent claudication, and heart failure. The 10-year Framingham risk score was computed using gender-specific equation.(39)

Physical activity was monitored by an omnidirectional accelerometer (Actical model #198-0200-00; Philips Respironics, Bend, OR). It records accelerations in the range of 0.05–2.0 g and is sensitive to movements in the range of 0.5–3.0 Hz. The Actical has an internal time clock and a 64 KB memory and measures the magnitude of acceleration and deceleration associated with body movements at a sampling rate of 32 Hz. The recorded signals are scored as "counts" summed over a user-defined epoch (30 seconds). At their routine FHS clinic examination, participants were asked to wear the Actical on a waist-worn belt for 24 hours a day for 8 days (to achieve a full 7 'wear' days) and to take the device off only when showering. Participants returned the activity monitor to the FHS by mail. FHS clinic staff downloaded the data and visually screened the raw accelerometer files for spurious data. Checks for spurious data include the following: 1) comparing the count maxima; 2) relating count maxima with device serial number to rule out 'batch' effects; 3) comparing count plateau conditions. Data were processed in-house using custom KineSoft software (KineSoft, Saskatchewan, Canada)(8) and quality control screening was regularly performed. Accelerometer data files were used if they had at least '5 of 7' valid 'wear days' with at least one of the valid days being a weekend day;(7) >10 hours of wear time were required for a 'valid day'.(36)

Of the 3,101 individuals attending the 2nd examination cycle during May 2008-October 2010, 2,616 had accelerometry data available passing initial QC checks. Participants were excluded from the present investigation if they did not wear the accelerometer for at least 5 valid days with at least 1 weekend day (n=407), had prevalent cardiovascular disease (n=49), were missing one or more covariates (n=48) or their self-reported health was poor (n=3). After these exclusions, 2,109 participants were eligible for the present analyses. The study protocol was approved by the Boston University Medical Center Institutional Review Board and all attendees provided written informed consent.

Time spent in MVPA is based on application of count thresholds obtained from calibration studies that relate accelerometer counts to measured activity energy expenditure. Intensity thresholds were calculated similar to the methods of Troiano et al,(36) i.e. we used a weighted average of the available ambulatory-only regression equations from 2 published studies by Heil and Crouter.(5, 17) The resulting cutpoint criteria were 1486–5558 counts per minute for moderate intensity and ≥5559 counts for vigorous intensity, corresponding to MET values of 3–6 for moderate intensity and >6 for vigorous intensity activities. Total PA time at each intensity level is the sum of the minutes at a given intensity while the accelerometer is worn. $MVPA_{10+}$ is calculated as the sum of moderate and vigorous activity accumulated in bouts of at least 10 minutes allowing for a 1–2 minute interruption. $MVPA_{<10}$ was calculated as the sum of moderate and vigorous activity accumulated <10 minutes at a time. The United States Physical Activity Guidelines for Americans recommend that adults get 150 minutes of MVPA per week, with the activity being accumulated in bouts of at least 10 minutes (http://www.health.gov/paguidelines/). We defined compliance with PA guidelines in two ways: ≥150 minutes of MVPA done in bouts of ≥10 minutes ($MVPA_{10+}$); and ≥150 total MVPA regardless of bout duration.

We used means and standard deviations to describe the distributions of MVPA by sex, season, education, employment status, current smoking, and levels of self-reported general health (fair, good, very good, excellent). Generalized linear and logistic regression models were used to examine the cross-sectional association of MVPA with CVD risk factors. Sensitivity analyses using general estimating equations to account for familial correlations were also performed.(21) Total MVPA, $MVPA_{10+}$ and MVPA <10 minutes were related to anthropometric measures (BMI, waist circumference), fasting glucose, triglycerides, HDL cholesterol, systolic and diastolic BP and the Framingham risk score. The binary clinical outcomes of hypertension, obesity, IGT and diabetes were also evaluated using logistic regression models. All models were adjusted for the following covariates: age, sex, education level, self-reported general health and accelerometer 'wear time'. Analyses of $MVPA_{10+}$ and $MVPA_{<10}$ were adjusted for each other to assess their independent effects. Other potential confounders, such as smoking, season and employment status were evaluated and not included in the final models, as they did not materially influence the results. We used the F-statistic to test whether there was a difference in the strength of associations between betas from the $MVPA_{10+}$ models and those from the $MVPA_{<10}$ models. We assessed effect modification of BMI category by modeling appropriate interaction terms in the statistical models. To assess the association of compliance with PA guidelines on CVD risk factors, we estimated separate regression models relating each definition of compliance to CVD risk factors above (adjusting for covariates listed above). To account for multiple testing, statistical significance was set at P<0.001 (Bonferonni correction for 12 CVD risk factors and 3 exposure variables, 0.0014 = 0.05 /36). Analyses were performed using SAS version 9.2 (SAS Institute, Cary, NC) and StataSE version 11.2 (StataCorp, College Station, TX) software.

RESULTS

Table 1 presents the characteristics of the study sample (mean age 47 years, 55% women), by sex, at the time of their FHS examination. Over half of the population was overweight and the majority of participants (74%) reported that they were in very good or excellent health. Although 600 minutes of wear time was required for a 'valid day', the average daily 'wear time' of the accelerometer was much greater, at 926 ± 96 minutes; 69% of participants wore the accelerometer for 7 valid days. On average, participants engaged in 28 ± 21 minutes/day of MVPA, of which approximately 9 ±13 minutes was $MVPA_{10+}$ and 19 ± 14 minutes was $MVPA_{<10}$. The partial correlation between sustained MVPA ($MVPA_{10+}$) and shorter bouts was 0.25 ($P < 0.0001$), after adjustment for age and sex. Ten percent of men and 15% of women met the strict PA guidelines of performing ≥150 minutes/week of $MVPA_{10+}$; 56% of men and 47% of women were compliant when considering total MVPA (Table 1). PA levels were higher in warmer months, among nonsmokers, those with higher education levels, and better self-reported health (Table 2).

Total MVPA was significantly associated with lower circulating triglycerides, BMI, waist circumference, overall Framingham risk score, and higher HDL concentrations (Table 3, $P < 0.0001$ for all). Total MVPA was also related to a lower prevalence of obesity. An increase of 10 minutes/day of MVPA was associated with 15% lower obesity prevalence (Odds Ratio [OR] per 10 MVPA minutes/day = 0.85, 95% confidence interval [CI] 0.80 – 0.90). Shorter bouts of MVPA ($MVPA_{<10}$) showed a similar pattern of statistically significant relations with these CVD risk factors, independent of $MVPA_{10+}$ (Table 3). Both shorter bouts of MVPA and $MVPA_{10+}$ were associated with lower triglycerides, waist circumference, BMI, and higher HDL. $MVPA_{<10}$ was also significantly related to lower Framingham risk score. There was no difference in the strength of associations when comparing the betas from $MVPA_{10+}$ models to those from the $MVPA_{<10}$ models. (Table 3). None of the MVPA measures were associated with blood pressure, fasting blood glucose level, diabetes prevalence or impaired fasting glucose. In sensitivity analyses, we examined the effect of additional adjustment for BMI, which may act as both a confounder and mediator in the relationship between PA and CVD risk factors. Inclusion of BMI in the models resulted in slight attenuation of beta coefficients, but remained highly statistically significant for most risk factors (Supplemental Digital Content Table 1. Relations of MVPA measures to Risk Factors, adjusted for BMI).

Using the strict PA guideline definition (>150 minutes of $MVPA_{10+}$), compliance was significantly related to lower triglycerides, BMI, waist circumference, and higher HDL ($P<0.001$ for all, Table 4). Similarly, when considering both bout and non-bout MVPA, guideline compliance (>150 minutes of total MVPA) was also related to lower Framingham risk score and prevalence of obesity and IGT, in addition to the risk factors above ($P < 0.001$ for all, Table 4). Limiting analyses to those participants who wore the accelerometer for the full 7 days did not notably change the results.

We examined relations of MVPA to CVD risk factors by sex and BMI category (normal weight vs. overweight or obese). While the pattern of associations was similar between the sexes, beta coefficients were generally stronger for women than men (Supplemental Digital Content Table 2. Relations of MVPA to Risk Factors, by sex). When examining associations of MVPA levels by BMI category, there were no notable differences in risk estimates between the different BMI categories, with the exception of the relationship with waist circumference. The strength of the associations between MVPA measures and waist circumference was greater among those who were overweight or obese as compared to those who had a normal BMI.

DISCUSSION

The present investigation examined the associations between moderate-to-vigorous physical activity, accumulated in both ≥10 minute and <10 minute bouts, and CVD risk factors using objectively measured PA by accelerometry. While PA guidelines recommend accumulating doses of MVPA in bouts of at least 10 minutes, in our community-based study of white adults in the US, the majority of MVPA was accumulated in shorter bouts. Shorter bouts of MVPA were independently related to lower triglyceride levels, BMI and Framingham risk score, smaller waist circumference, and a lower prevalence of obesity, even after controlling for $MVPA_{10+}$. In addition, $MVPA_{<10}$ had similar magnitudes of association as $MVPA_{10+}$ associations. Approximately half of our middle-aged adult population met the recommendation of at least 150 minutes of total MVPA per week, but only 12% engaged in this level of activity in bouts of ≥10 minutes. Compliance with national PA guidelines was associated with a statistically significant lower CVD risk factor burden and lower prevalence of obesity and IGT, regardless of how MVPA was accrued ($MVPA_{10+}$ or in non-bouts).

The amount of MVPA among our Framingham participants was similar to that of the National Health and Nutrition Examination Survey (NHANES) using accelerometry. While NHANES used the Actigraph accelerometer, limiting direct comparison, the 2005–2006 NHANES accelerometry sample (mean age 47 years, 50% male, 71% non-Hispanic white) engaged in 24.2 minutes/day of total MVPA,(3) and approximately 8–10% (depending upon measurement approach) of their non-Hispanic white sample met the 2008 Physical Activity Guidelines of 150 minutes/week of MVPA.(37) Our FHS sample was slightly more active, engaging in approximately 28 minutes/day of total MVPA and 12% meeting the 2008 Physical Activity Guidelines for Americans. This could be due to accelerometer measurement differences, choice of intensity thresholds, or a reflection of a temporal trend in increasing PA levels among Americans, as our study collected data from 2008–2011 and national surveys results suggest that activity levels may be increasing.(4)

Our finding that objectively measured MVPA is cross-sectionally related to a lower CVD risk factor burden is consistent with published reports using NHANES accelerometry data. Sisson et al reported that accelerometer-derived steps/day was associated with lower prevalence of the metabolic syndrome, and adults who took more steps had lower waist circumference, higher HDL levels and lower triglycerides.(31) Using accelerometry, total MVPA was associated with a lower odds of all risk factors for the metabolic syndrome.(23) In our study, we did not find any association of MVPA or $MVPA_{10+}$ with systolic blood

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pressure (SBP), diastolic blood pressure (DBP), fasting glucose levels, or hypertension or diabetes prevalence, although there was a borderline-significant association of MVPA with lower SBP (P-value = 0.03) and lower glucose levels (P-value = 0.05). Similarly, Atienza et al, using NHANES 2003–2006 data, reported that $MVPA_{10+}$ was associated with continuous measures of SBP, BMI, waist circumference, HDL, triglycerides, glucose and insulin, but was not significantly associated with DBP, total or LDL cholesterol levels.(2) However, there is emerging evidence that lower levels of activity, as well as sedentary behavior, may have associations with cardiometabolic health outcomes. (3, 14–16) Self-reported TV viewing time has also been reported to be associated with cardiometabolic risk factors and type-2 diabetes.(12, 35) In future studies it will be important to assess the associations of lighter-intensity PA and sedentary behavior with CVD risk factors.

We observed significant associations between shorter bouts of MVPA and CVD risk factors, independent of $MVPA_{10+}$. Likewise, a recent study from the NHANES using accelerometry data reported that there may be metabolic health benefits associated with shorter bouts of MVPA.(34) Strath et al reported that MVPA accumulated in <10 minutes was independently associated with BMI and waist circumference, after controlling for confounding variables. Our observed associations with BMI and waist circumference were similar to that in the NHANES. In NHANES 10 minutes/day of MVPA <10 minutes was associated with a 0.1 and 0.3 decrease in BMI and waist circumference, respectively. While the current PA guidelines require that MVPA be accumulated in bouts of ≥10 minute, given the high rates of sedentary behavior in the U.S. and the public health focus on increasing PA,(22) it is crucial to know whether accumulating PA in shorter bouts is beneficial. There is limited prior evidence regarding the effect of shorter bouts of PA on CVD risk factors, independent of activity intensity and amount.(24) The present investigation fills this gap in our current knowledge.

While we did not formally test for differences by sex, we did observe that associations of MVPA levels with CVD risk factors were consistently stronger in women than in men, although the reason for this is unclear. It could be due to underlying differences in the type or setting of PA by sex, biological differences in physiologic responses to MVPA, or other unmeasured confounding factors. In our sample, women tended to engage in more $MVPA_{10+}$ than men, whereas men tended to accumulate MVPA in shorter bouts. While prior studies have not reported more favorable effects of PA on CVD risk factors among women compared to men, a recent meta-analysis of 33 prospective cohort studies from Sattelmair et al observed significant effect modification by sex of the relationship between leisure-time PA and risk of CHD.(30) Comparing the most active with least active, they reported men had a 22% lower risk of CHD whereas women had a 33% lower risk.

Our investigation is limited by the possibility of unmeasured confounders. Physical activity may also occur in the presence of other healthy lifestyle factors, such as diet or physical fitness, which were not adjusted for. Our sample was primarily white and we do not yet have accelerometry data from other race or ethnic groups, but plan on examining data from the multi-ethnic Framingham Omni cohort as it becomes available. While the accelerometry is the state-of-the-art tool for measuring PA, because the Actical is worn at the hip, it is limited in capturing certain activities where the participant is stationary or has limited hip movement, such as strength training or bicycling. Additionally, we cannot capture activity done while not wearing the device. While the act of wearing the accelerometer may cause participants to increase their PA levels, accelerometers do not provide any feedback, making that less likely. Finally, although the most appropriate regression approach to classify PA intensity levels is not certain, we used methods similar to those previously published. (36)

Strengths of our investigation include the use of a robust and objective measurement of PA. Currently, the most widely used methods for measuring PA in community-based studies are self-reported measures, typically ascertained via questionnaires. However, questionnaire information is subjective, and prone to respondent and recall bias.(11, 32) In its 2008 report, the CDC Physical Activity Guidelines Advisory Committee noted that all of the studies included in its review used self-reported information on PA and many specified only leisure-time activity, ignoring substantial components of PA.(27)

Our investigation takes advantage of a well-characterized, community-based sample and uses new technology to bridge a fundamental gap in our current knowledge regarding the health benefits of PA accumulated in shorter lengths of time, and contributes to the evidence base for future public health recommendations and clinical guidelines for PA in adults. These results underscore the idea that “some activity is better than none,” and may encourage inactive persons to become more active by allowing for PA in bouts <10 minutes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of the study sample (N=2109), by sex

	Men (n=959)	Women (n=1150)	All
Age, years	47 ± 8	47 ± 9	47 ± 9
White race, %	99	99	99
BMI, kg/m^2	28.9 ± 4.6	26.5 ± 5.8	27.6 ± 5.4
SBP, mmHg	120 ± 12	112 ± 14	116 ± 14
DBP, mmHg	77 ± 8	71 ± 9	74 ± 9
Total cholesterol, mg/dl	187 ± 34	186 ± 33	187 ± 33
HDL, mg/dl	51 ± 14	67 ± 17	60 ± 18
Triglycerides, mg/dl	127 ± 81	92 ± 48	108 ± 67
Waist circumference, cm	102 ± 13	91 ± 15	96 ± 15
Fasting glucose, mg/dl	99 ± 17	92 ± 13	95 ± 15
CRP, mg/L	2.2 ± 3.7	2.8 ± 4.4	2.5 ± 4.1
Framingham risk score, %	8.2 ± 6.5	3.1 ± 2.9	3.1 ± 2.9
Hypertension, %	26	16	21
Overweight, %	81	52	65
Obese, %	34	23	28
Impaired Fasting Glucose, %	37	16	25
Diabetes, %	5	3	4
Current Smoking, %	13	11	12
Very good or excellent health, %	71	76	74
Highest degree of education, %			
≤ High school degree	16	12	14
More than high school	63	67	65
Graduate degree	21	21	21
Employment status, %			
Homemaker or full-time student	1	11	6
Unemployed/retired	7	7	7
Employed (full or part-time)	91	81	86
Unemployed/on-leave for disability or health reasons	1	1	1
Accelerometer wear time, min/day	939 ± 103	915 ± 88	926 ± 96
Light PA, min/day	143 ± 53	133 ± 47	137 ± 50
Moderate PA, min/day	28 ± 20	24.2 ± 17.6	25 ± 18
Vigorous PA, min/day	2 ± 5	3 ± 6	2 ± 6
MVPA total, min/day	30 ± 22	26 ± 10	28 ± 21
$MVPA_{10+}$, min/day	7 ± 11	10 ± 14	9 ± 13
$MVPA_{<10}$, min/day	22.8 ± 16.3	16.3 ± 11.0	19 ± 14

	Men (n=959)	Women (n=1150)	All
PA Guideline compliance (MVPA), %	56	47	51
PA Guideline compliance ($MVPA_{10+}$), %	10	15	13

Values are mean ±SD, or % as indicated.

Table 2

Mean MVPA and MVPA10 (in minutes/day) by sociodemographic variables

	Men		Women		All	
	Total MVPA	$MVPA_{10+}$	Total MVPA	$MVPA_{10+}$	Total MVPA	$MVPA_{10+}$
Season of examination						
Fall	28.8 ± 23.6	7.1 ± 11.8	23.8 ± 19.6	7.9 ± 12.1	26.1 ± 21.6	7.6 ± 12.0
Winter	25.6 ± 22.2	5.3 ± 9.1	23.0 ± 15.8	8.6 ± 11.4	24.3 ± 19.4	6.9 ± 10.4
Spring	31.5 ± 20.1	6.9 ± 11.2	26.8 ± 20.2	10.5 ± 14.0	29.1 ± 20.3	10.9 ± 14.1
Summer	34.5 ± 20.1	9.7 ± 11.8	29.4 ± 21.5	11.7 ± 15.3	31.4 ± 21.1	11.7 ± 15.3
Non-smokers	30.7 ± 21.8	7.7 ± 11.3	26.6 ± 19.8	10.3 ± 14.0	28.4 ± 20.8	9.2 ± 12.9
Current smokers	26.4 ± 22.0	4.2 ± 10.0	22.4 ± 20.7	6.0 ± 9.5	24.4 ± 21.4	5.1 ± 9.9
Education Level						
≤ High school degree	26.4 ± 25.9	4.8 ± 10.5	21.3 ± 20.1	6.8 ± 10.9	24.1 ± 23.5	5.7 ± 10.7
More than high school	28.9 ± 20.3	6.3 ± 9.6	25.0 ± 19.3	9.2 ± 13.6	26.7 ± 19.8	7.9 ± 12.1
Graduate degree	36.7 ± 21.7	12.2 ± 14.3	32.1 ± 20.3	13.4 ± 14.4	34.2 ± 21.0	12.9 ± 14.4
Employment status						
Homemaker or full-time student	30.2 ± 28.9	6.9 ± 13.6	27.1 ± 25.4	11.4 ± 17.1	27.2 ± 25.5	11.2 ± 16.9
Employed (full or part-time)	30.6 ± 21.1	7.1 ± 10.5	26.6 ± 19.1	9.7 ± 13.1	28.5 ± 20.2	8.5 ± 12.0
Unemployed/retired	26.8 ± 29.6	9.4 ± 18.0	20.6 ± 19.3	9.3 ± 14.4	23.4 ± 24.7	9.4 ± 16.1
Unemployed/on-leave for disability or health reasons	18.1 ± 13.8	8.2 ± 11.6	17.8 ± 19.0	7.4 ± 9.1	18.0 ± 15.9	7.8 ± 10.2
Self-reported health						
Fair	22.7 ± 15.7	6.7 ± 11.0	17.4 ± 22.0	5.1 ± 10.1	19.7 ± 19.6	5.8 ± 10.4
Good	29.0 ± 24.8	6.3 ± 11.5	19.1 ± 17.8	4.9 ± 8.9	24.2 ± 22.2	5.6 ± 10.3
Very Good	28.0 ± 18.2	6.3 ± 9.2	26.2 ± 19.2	9.8 ± 13.5	27.0 ± 18.8	8.3 ± 11.9
Excellent	35.9 ± 24.0	10.1 ± 13.6	31.9 ± 20.5	13.9 ± 15.6	33.6 ± 22.1	12.3 ± 14.9

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Table 3

Relations of Moderate-to-Vigorous Physical Activity (MVPA) Measures to CVD Risk Factors

	Total MVPA*		$MVPA_{10+}$†		$MVPA_{<10}$‡		P for comparison**
	Beta coeff. (SE)	**P value**	**Beta coeff. (SE)**	**P value**	**Beta coeff. (SE)**	**P value**	
Triglycerides, mg/dl	**−3.8 (0.58)**	**<0.0001**	**−3.17 (0.81)**	**<0.0001**	**−4.42 (0.99)**	**<0.0001**	0.48
HDL, mg/dl	**1.14 (0.18)**	**<0.0001**	**1.45 (0.34)**	**<0.0001**	**0.87 (0.26)**	**0.001**	0.17
SBP, mm Hg	−0.33 (0.15)	0.03	−0.19 (0.24)	0.44	−0.46 (0.23)	0.05	0.47
DBP, mm Hg	−0.08 (0.10)	0.42	−0.16 (0.17)	0.35	0.01 (0.15)	0.96	0.55
Framingham risk score, %	**−0.19 (0.04)**	**<0.0001**	−0.10 (0.07)	0.16	**−0.28 (0.06)**	**<0.0001**	0.08
Waist circumference, cm	**−1.01 (0.14)**	**<0.0001**	**−1.17 (0.20)**	**<0.0001**	**−0.86 (0.22)**	**<0.0001**	0.36
BMI, kg/m^2	**−0.38 (0.05)**	**<0.0001**	**−0.46 (0.08)**	**<0.0001**	**−0.30 (0.09)**	**0.0007**	0.27
Glucose, mg/dl	−0.30 (0.16)	0.05	−0.29 (0.19)	0.12	−0.29 (0.28)	0.29	0.99
	Odds Ratio (95% CI)	**P value**	**Odds Ratio (95% CI)**	**P value**	**Odds Ratio (95% CI)**	**P value**	
Hypertension	0.97 (0.91-1.023	0.37	0.93 (0.84–1.04)	0.23	0.98 (0.89–1.08)	0.70	0.55
Obesity	**0.85 (0.80–0.90)**	**<0.0001**	**0. 83 (0.74–0.93)**	**0.0001**	0.86 (0.78–0.94)	0.002	0.67
IGT	0.97 (0.92–1.03)	0.37	0.96 (0.87–1.07)	0.50	0.97 (0.90–1.06)	0.59	0.86
Diabetes mellitus	0.93 (0.80–1.08)	0.36	0.86 (0.66–1.13)	0.28	0.97 (0.79–1.20)	0.81	0.48

Betas and odds ratios are presented per 10 minutes/day of MVPA. Statistical significance was set at P<0.001 (Bonferonni correction for 12 CVD risk factors and 3 exposure variables.

* adjusted for age, sex, average accelerometer wear time (total wear time/number of days worn), education level and self-reported general health

† adjusted for age, sex, average accelerometer wear time, education level, self-reported general health and $MVPA_{<10}$

‡ adjusted for age, sex, average accelerometer wear time, education level, self-reported general health and $MVPA_{10+}$

** P-value comparing beta coefficient from $MVPA_{10+}$ model vs. $MVPA_{<10}$ model

Table 4

Relations of Physical Activity Guideline Compliance to Risk Factors*

	≥ 150 minutes of $MVPA_{10+}$		≥ 150 minutes of total MVPA	
	Beta coeff. (SE)	**P value**	**Beta coeff. (SE)**	**P value**
Triglycerides, mg/dl	**−10.7 (2.9)**	**0.0002**	**−12.8 (2.8)**	**<0.0001**
HDL, mg/dl	**5.3 (1.1)**	**<0.0001**	**3.7 (0.72)**	**<0.0001**
SBP, mmHg	−0.11 (0.86)	0.89	−1.73 (0.62)	0.005
DBP, mmHg	−0.23 (0.58)	0.69	−0.61 (0.42)	0.15
Framingham risk score, %	−0.38 (0.18)	0.37	**−0.93 (0.17)**	**<0.0001**
Waist circumference, cm	**−3.5 (0.7)**	**<0.0001**	**−4.1 (0.6)**	**<0.0001**
BMI, kg/m^2	**−1.31 (0.33)**	**<0.0001**	**−1.62 (0.23)**	**<0.0001**
Glucose, mg/dl	−0.53 (0.64)	0.41	−1.66 (0.64)	0.01
	Odds Ratio (95% CI)	**P value**	**Odds Ratio (95% CI)**	**P value**
Hypertension	0.96 (0.66–1.40)	0.84	0.78 (0.61–0.99)	0.04
Obesity	0.57 (0.40–0.82)	0.003	**0.57 (0.46–0.71)**	**<0.0001**
Impaired fasting glucose	0.98 (0.69–1.38)	0.91	**0.69 (0.55–0.86)**	**0.001**
Diabetes mellitus	0.60 (0.24–1.53)	.29	0.59 (0.36–0.98)	0.05

*Betas and odds ratios are presented for compliance with guidelines (yes versus no). Adjusted for age, sex, education level, total accelerometer wear time, number of valid days worn, and self-reported general health