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Do Short Spurts of Physical Activity Benefit Cardiovascular Health? The CARDIA Study

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Abstract

Background—For optimal health benefits moderate to vigorous intensity physical activity (MVPA) is recommended in sustained bouts lasting 10 minutes. However, short spurts of MVPA lasting < 10 minutes are more common in everyday life. It is unclear whether short spurts of MVPA further protect against the development of hypertension and obesity in middle-aged adults beyond bouts of MVPA.

Methods—Objectively measured physical activity was collected in the Coronary Artery Risk Development in Young Adults (CARDIA) study at the 20-year (2005–2006) examination, and blood pressure and BMI were collected at the 20-year and 25-year (2010–2011) examinations. Time spent in MVPA was classified as either bouts of MVPA, i.e., 10 continuous minutes or short spurts of MVPA, i.e., < 10 continuous minutes. To examine the association of short spurts of MVPA with incident hypertension and obesity over five years, we calculated risk ratios (RR) adjusted for bouts of MVPA and potential confounders.

Results—Among 1,531 and 1,251 participants without hypertension and obesity, respectively at Year 20 (Age 45.2 ± 3.6, 57.3% Women, BMI 29.0 ± 7.0), 14.8% and 12.1% developed hypertension and obesity by Year 25. Study participants in the highest tertile of short spurts of MVPA were 31% less likely to develop hypertension 5 years later (RR=0.69 [0.49, 0.96]) compared with those in the lowest tertile. There was no statistically significant association of short spurts of MVPA with incident obesity.

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Conclusion—These findings support the notion that accumulating short spurts of MVPA protects against the development of hypertension, but not obesity in middle-aged adults.

Keywords

Physical activity; cohort study; obesity; hypertension

Introduction

Regular participation in moderate to vigorous intensity physical activity (MVPA) is associated with numerous health benefits including reducing risk of cardiovascular disease, functional limitation, and premature death.(20) In order to maximize these and other health benefits from physical activity, the 2008 Physical Activity Guidelines for Americans recommend all adults participate in 150 minutes/week of MVPA occurring in bouts 10 minutes.(20) Exercise is one type of MVPA, which involves participation in planned, structured, recurring movements that typically last 10 minutes, such as aerobic walking. Consequently, time spent exercising counts towards meeting the physical activity recommendation.

Unstructured activity is another type of MVPA, which is typically unplanned and occurs during daily life, such as climbing a flight of stairs. However, unstructured activity typically occurs in short spurts lasting < 10 minutes. While being at the prerequisite intensity, short spurts do not count towards meeting physical activity guidelines by virtue of not being sustained for at least 10 minutes. Nevertheless, short spurts are commonly suggested to initiate behavioral change and increase total physical activity volume. For instance, commonly recommended strategies to increase physical activity that typically take less 10 minutes to complete include parking the car in the back of a parking lot and taking the stairs instead of the elevator.(21, 25)

Little is known about the health benefits of short spurts of physical activity, i.e., MVPA < 10 minutes in duration.(12, 17) Short spurts of MVPA are not captured on self-report instruments due to issues related to accurate recall. Moreover, guidelines for physical activity are based upon cohort studies that employed self-reported questionnaire measures of physical activity. Subsequently, recommended guidelines for physical activity do not include recommendations related to unstructured physical activity. However, short spurts may still be associated with health benefits. Recent cross-sectional studies objectively measuring physical activity with monitors show that short spurts of MVPA have a similar protective association with the prevalence of cardiovascular disease risk factors,(10) markers of obesity,(21) and metabolic syndrome(4) as bouted MVPA, i.e., MVPA lasting 10 minutes. However, the cross-sectional design of these studies limits the ability to establish a causal association. A prospective investigation would improve understanding of the potentially protective association of short spurts of MVPA with the development of unfavorable health outcomes.

Therefore, the purpose of this study was to investigate the impact of short spurts of MVPA on the development of hypertension and obesity over five years in a large observational prospective cohort study of cardiovascular disease risk factors among middle-aged adults.

Methods

We used data from the Coronary Artery Risk Development in Young Adults (CARDIA) study, which has been described in detail elsewhere.(9, 14) In brief, CARDIA is a population-based prospective epidemiologic study of the predictors and development of cardiovascular disease (CVD) risk factors and subclinical CVD in young adults. Study participants were 18 to 35 years of age at the baseline examination that occurred from 1985 to 1986. For the current analysis using the 20-year CARDIA follow-up visit, the age range was 37 to 55 years of age. Subjects were enrolled in approximately equal proportions of race (White/Black), sex, education (high school, > high school), and age (24 years and > 24 years) from Birmingham, AL, Chicago, IL, Minneapolis, MN, and Oakland, CA. All CARDIA study participants provided informed consent and each study site's IRB approved the parent study.

This particular analysis focused on a subset of the CARDIA cohort that attended both the year-20 (2005 to 2006) and year-25 (2010–2011) examinations. The year-20 and year-25 examinations were attended by 3,549 and 3,498 study participants, respectively. The year-20 examination was the first study visit in which objectively measured physical activity was collected. Of the 3549 study participants who attended the year-20 examination, 41% or 2076 had valid accelerometer data and comprised of our analytic cohort. For the purposes of this secondary data analysis, the 20-year examination was considered our study 'baseline' and the 25-year examination was the 'five-year follow-up'.

Physical Activity

Physical activity was measured with an ActiGraph monitor (model 7164; Pensacola, FL), a uniaxial accelerometer. CARDIA study participants were asked to wear an accelerometer around their waist except when sleeping or bathing for 7 consecutive days after the 20-year clinic visit. Data were collected and expressed as 60-second epochs.

Data from the accelerometer were downloaded and screened for wear time using methods reported by Troiano et al (6). Briefly, device nonwear was defined as 60 consecutive minutes of 0 counts, with an allowance for 1–2 minutes of detected counts between 0–100. Wear time was determined by subtracting derived nonwear time from 24 hours. A minimum of 10 hours/day of wear time on at least 4 of 7 days was necessary to be included in analyses.

MVPA was defined by the Freedson criteria, i.e., activity counts 1952.(8) Minutes of MVPA was classified into either 1) bouts of MVPA, i.e., activity lasting 10 continuous minutes or 2) short spurts of MVPA, i.e., activity lasting < 10 continuous minutes. Bouts were defined in accordance with National Health and Nutrition Examination Survey criteria for a modified 10-minute bout.(22) In particular, bouts of MVPA were defined as 10 consecutive minutes above the Freedson criteria, with allowance for one- or two-minute interruptions below the 1952 count threshold. Time spent in short spurts was defined as MVPA not meeting the modified 10-minute bout criteria (Short Spurts of MVPA = Total time in MVPA – Time spent in bouts of MVPA). Minutes in bouts of MVPA and short spurts of MVPA were averaged over the number of valid days and expressed as minutes/day. For

analysis, we classified data three ways: 1) continuously into 10-minute increments of time spent in short spurts of MVPA and bouts of MVPA, 2) categorically into separate tertiles of time spent in short spurts of MVPA and bouts of MVPA, and 3) a nine-level categorical variable using each pair of bouts and short spurts of MVPA tertiles. The reference value for the nine-level categorical variable was combination of the tertile for the least time spent in bouts of MVPA and the tertile for the least time spent in short spurts of MVPA.

Hypertension

Blood pressure was measured using a standardized protocol.⁽⁵⁾ Briefly, blood pressure was measured three times at one-minute intervals after study participants sat for five minutes. The average of the second and third blood pressure measures were used for analysis. Incident hypertension was defined as a systolic blood pressure ≥ 140 mmHg, diastolic blood pressure ≥ 90 mmHg, or initiation of treatment with antihypertensive medications at follow-up among study participants not meeting these criteria at baseline.⁽³⁾

Obesity

Height and body weight were measured using a standardized protocol with participants wearing light clothing without shoes.⁽⁵⁾ Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Incident obesity was defined as a BMI ≥ 30 kg/m² at follow-up among those with a BMI < 30 kg/m² at baseline.

Potential Confounders

The following factors were considered as potential confounders (based on their association with physical activity and cardiovascular risk factors in previous studies: Age,⁽²³⁾ sex,⁽²²⁾ BMI,⁽⁷⁾ race (black or white),⁽²²⁾ and income ($< \$16,000$, $\$16,000$ to $\$50,000$, $\geq \$50,000$).⁽¹⁵⁾ Age, sex, race, and income data were obtained from standardized self-report questionnaires.⁽⁵⁾

Statistical Analysis

We computed means, standard deviations, medians, and 25th and 75th percentile values for continuous variables and proportions for categorical variables to describe the study sample. We also evaluated the correlation between bouts of MVPA and short spurts of MVPA as continuous measures using a Pearson correlation coefficient after confirming data were normally distributed.

We examined the association of short spurts of MVPA with the incidence of obesity and hypertension determined at the five-year follow-up by calculating risk ratios using binomial regression with robust variance estimation.⁽²⁷⁾ We conducted these analyses by classifying time in short spurts of MVPA as tertiles and as a continuous measure, i.e., 10-minute increments, in separate models. All models were adjusted for bouts of MVPA and potential confounders.⁽²⁷⁾ For incident obesity, we did not adjust for baseline BMI since the bias introduced by such an adjustment may exceed the bias eliminated.⁽¹¹⁾

To disentangle confounding due to the potential correlation between bouts of MVPA and short spurts of MVPA tertiles, we evaluated the combined association of MVPA types with

the incidence of hypertension and obesity. We calculated the association of each pair of bouts and short spurts of MVPA tertiles with our study outcomes. The tertile pair of the highest values of both bouts and short spurts of MVPA was the reference group. Similar approaches using combined associations with correlated measures have been applied with cardiorespiratory fitness and body fat change,(16) sitting and physical activity,(24) and gait speed and walking endurance.(26)

Results

Of the 3549 study participants who attended the year-20 CARDIA examination, 1041 did not wear an accelerometer, 428 wore a monitor for less than 4 days, and 4 had monitor malfunctions, resulting in an analytic sample of 2076. Of those included, the average (sd) age was 45.2 (3.6) years, 57.3% were women, 58.2% were white, and 8.7% had income < \$16,000. At baseline, the average (sd) BMI was 29.0 (7.0) kg/m², 34.6% were obese (BMI ≥ 30), the average systolic blood pressure was 114.9 (13.8) mmHg and 20.0% met criteria for having hypertension at baseline. Table 1. Participants attending the year-20 exam who did not wear an accelerometer (n=1473) had a higher BMI, higher systolic blood pressure, less income, and were less likely to be White compared with those who wore an accelerometer (n=2076). Table 2.

The average (sd) time spent in short spurts of MVPA was 27.9 (18.9) minutes/day, and the average time in bouts of MVPA was 11.9 (17.7) minutes/day. There was a moderate and statistically significant correlation between bouts of MVPA and short spurts of MVPA, $r=0.33$, $p<0.0001$.

At the five-year follow-up 14.8% (226/1531) of study participants had developed hypertension. Study participants in the highest tertile of short spurts of MVPA were 31% less likely to develop hypertension compared with those in the tertile with the least short spurts of MVPA. Each 10-minute increase in short spurts of MVPA was associated with a 9% decrease in the risk of developing hypertension at follow-up (Adjusted RR [95% CI] 0.91 [0.84, 0.99]). Those in the highest tertile of bouts of MVPA were 26% less likely to develop hypertension compared with those in the lowest bouts of MVPA tertile which approached statistical significance. Each 10-minute increase in bouts of MVPA was associated with a 10% decrease in the risk of developing hypertension at follow-up (Adjusted RR 0.90 [0.82, 0.99]). Table 3. For the combined association of short spurts of MVPA and bouts of MVPA, we observed more time in both to be associated with less risk of developing hypertension. Within each tertile of short spurts of MVPA (table columns), increasing time in bouts of MVPA was generally associated with less risk of incident hypertension. Similarly, within each tertile of bouts of MVPA (table rows), increasing time in short spurts of MVPA was associated with less risk of incident hypertension. Table 4.

Obesity developed in 12.1% (151/1251) of study participants at the five year follow-up. Increased time spent in short spurts of MVPA did not change the risk of incident obesity materially, both quantified as tertiles of MVPA and 10-minute increments. However, more time spent in bouts of MVPA reduced the risk of incident obesity. For each 10-minute increase in bouts of MVPA the risk of obesity was reduced 21% (Adjusted RR 0.79 [0.68,

0.92]). Table 5. Within each tertile of short spurts of MVPA (table columns), increasing time in bouts MVPA was generally associated with less risk of incident obesity. However, within each tertile of bouts MVPA (table rows), increasing time in short spurts of MVPA was not associated with less risk of incident obesity. Table 6.

Discussion

More time spent in short spurts of MVPA reduced the risk of developing hypertension but not obesity over 5 years. Specifically, those in the highest tertile of short spurts of MVPA had a 31% reduced risk of developing hypertension. However, increased time spent in short spurts of MVPA did not materially change the risk of becoming obese. These findings provide longitudinal evidence that short spurts of activity in adults may provide protection over and above that which is associated with bouts MVPA against the onset of hypertension, although not against obesity. These findings partially support the notion that MVPA does not need to be performed in bouts of 10 continuous minutes in order to have health benefits.(20)

Short spurts of MVPA may elicit enough of a physiological response from the cardiovascular system to reduce the risk of developing hypertension. Previous studies have used total time in MVPA and did not differentiate between bouts vs short spurts of MVPA in children(13) and adults.(2) For instance, Camhi and colleagues reported a trend for an additional 30 minutes of objectively measured total MVPA to reduce the risk of prevalent hypertension by 10% in adults (OR = 0.90 [0.77, 1.04]).(2) Likewise, a published study using data from CARDIA showed that more time in self-reported MVPA was associated with less risk of developing hypertension 15 years later.(18) Our findings add that short spurts of MVPA may elicit enough of a physiological response independent of bouts MVPA from the cardiovascular system to reduce the risk of developing hypertension.

While evidence supports the notion that sustained MVPA promotes weight stability,(20) we did not find the same to be true for short spurts of MVPA. We hypothesize that there may not have been enough energy expenditure from short spurts of MVPA to overcome weight gain and the development of obesity among study participants. Despite this finding, it is important to consider that there may be non-physiologic benefits to such short spurts of physical activity. For instance, taking the stairs or parking further away may help facilitate positive changes in self efficacy to perform physical activity(1) and ultimately may lead to the adoption of an active lifestyle.(19)

Limitations of our study should be acknowledged. First, a clinical trial should ideally be employed to examine whether an increase in short spurts of MVPA protect against the development of hypertension and obesity in adults. However, the incidence of hypertension and obesity over five years were low, i.e., < 16%. Hence, it would likely be somewhat impractical from a cost perspective to test an adequately powered clinical trial with appropriate follow-up. Second, there is no definitive count cut-point threshold to define for MVPA from an Actigraph monitor. However, our selected method, using the Freedson criteria, is a well-established and validated(8) method commonly employed in the physical activity literature. Third, we only adjusted for a limited number of potential confounders,

which did not include dietary factors, smoking, alcohol use, and monitor wear time. Our study findings should be interpreted considering the exclusion of these behavioral risk factors as potential covariates in analyses. Fourth, we did not distinguish primary hypertension from secondary hypertension. Hence, some cases of hypertension maybe due to sources unrelated to physical activity. Nevertheless, we found increased short spurts of MVPA to have a moderate effect with preventing the development of hypertension in our sample.

Our study has several strengths. First, we employed a prospective study design, which is an advance over previous cross-sectional studies.(4, 10, 21) Second, we analyzed data from a large, well characterized cohort with standardized measures of CVD risk factors in middle aged adults with close to equal proportions people who are White and Black. Lastly, we were able to examine short spurts of MVPA from a well-validated and objective measure of physical activity, the ActiGraph monitor.

In summary, we found increasing time spent in short spurts of MPVA to be associated with more protection against the development of hypertension, but not obesity over five years. The implication of these findings is that participation in short spurts of MVPA, such as climbing the stairs, may protect against the development of hypertension, but not obesity, in middle-aged adults.

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Table 1

Subject characteristics from CARDIA

	All Study Participants (N = 2076)	Incident Hypertension (n= 226)	Incident Obesity (n= 151)
Age (years) [Mean (sd)]	45.2 (3.6)	45.4 (3.4)	45.4 (3.4)
Median (25 th , 75 th p [*])	46.0 (43,48)	46.0 (42,48)	46.0 (43,48)
Women [%]	57.3	57.1	53.6
Body Mass Index [kg/m] [Mean (sd)]	29.0 (7.0)	30.4 (6.4)	28.7 (1.2)
Median (25 th and 75 th p)	27.7 (24.2, 32.2)	29.6 (25.6, 34.0)	29.0 (28.1, 29.5)
Systolic Blood Pressure [Mean (sd)]	114.9 (13.8)	121.6 (9.2)	114.6 (13.6)
Median (25 th , 75 th p)	113.2 (105.5, 121.8)	121.8 (115.1, 128.5)	113.2 (105.5, 120.9)
Income [%]			
< \$16,000	8.7	23.9	5.3
\$16,000 to \$50,000	23.3	15.2	23.8
> \$50,000	68.1	13.6	70.9
Race [% White]	58.2	44.7	57.6
Physical Activity			
Bouted MVPA [†] [Minutes/day (sd)]	11.9 (17.7)	9.2 (12.8)	10.0 (14.9)
Median (25 th , 75 th p)	5.4 (0, 17.1)	3.0 (0, 14.4)	4.6 (0, 13.3)
Short spurts of MVPA [‡] [Minutes/day (sd)]	27.9 (18.9)	25.5 (16.6)	27.8 (15.3)
Median (25 th , 75 th p)	23.6 (15.4, 35.3)	21.5 (14.7, 31.7)	26.0 (17.0, 35.0)

* p=percentile

[†] Bouted activity is 10 consecutive minutes of moderate to vigorous physical activity (MVPA), with the allowance for one- or two-minute interruptions

[‡] Short Spurts of MVPA = Total time in MVPA – Time spent in bouted MVPA

Table 2

Characteristics of subjects who attended the year-20 CARDIA exam and were included (n=2076) and not included (n=1473) in analyses.

	Included Study Participants (N = 2076)	Excluded Study Participants (n= 1473)	p-value
Age (years) [Mean (sd)]	45.2 (3.6)	45.2 (3.7)	0.69
Women [%]	57.3	55.9	0.42
Body Mass Index [kg/m] [Mean (sd)]	29.0 (7.0)	30.1 (7.5)	<0.0001
Systolic Blood Pressure [Mean (sd)]	114.9 (13.8)	116.9 (15.7)	<0.0001
Income [%]			<0.0001
< \$16,000	8.7	12.5	
\$16,000 to \$50,000	23.3	27.5	
> \$50,000	68.1	60.0	
Race [% White]	58.2	46.8	<0.0001

Table 3

Association of short spurts of MVPA* and bouts MVPA with incident hypertension

Tertiles of short spurts of MVPA (range[minutes/day])	Incident hypertension[†] [% (n)]	Adjusted RR[‡] [95% CI] for Incident hypertension
1: Least short spurts (3.0, 17.9)	18.3 (87/475)	1.00 [Reference]
2: Middle short spurts (18.0, 30.6)	14.5 (78/538)	0.86 [0.65, 1.13]
3: Most short spurts (30.7, 116.8)	11.8 (61/518)	0.69 [0.49, 0.96]
Per 10-minute increase in short spurts of MVPA		0.91 [0.84, 0.99]

Tertiles of Bouted MVPA (range[minutes/day])	Incident hypertension[§] [% (n)]	Adjusted RR^{**} [95% CI] for Incident hypertension
1: Lowest bouts (0, 1.5)	20.0 (90/450)	1.00 [Reference]
2: Middle bouts (1.6, 12.1)	13.9 (73/524)	0.87 [0.65, 1.16]
3: Highest bouts (12.3, 287.9)	11.3 (63/557)	0.74 [0.54, 1.01]
Per 10-minute increase in bouts MVPA		0.90 [0.82, 0.99]

* Short Spurts of MVPA = Total time in MVPA – Time spent in bouts MVPA

[†] Incident hypertension was defined as a systolic blood pressure ≥ 130 mmHg at the 5-year follow-up among those with systolic blood pressure 120 mmHg at baseline.

[‡] Adjusted for age, sex, BMI, race, income and bouts MVPA. Quartiles of MVPA and 10-minute increments of MVPA are in separate models.

[§] Incident hypertension was defined as a systolic blood pressure ≥ 130 mmHg at the 5-year follow-up among those with systolic blood pressure 120 mmHg at baseline.

^{**} Adjusted for age, sex, BMI, race, income and short spurts of MVPA. Quartiles of MVPA and 10-minute increments of MVPA are in separate models.

Table 4

Combined association of tertiles of short spurts of MVPA (columns) and bouts MVPA (rows) with incident hypertension

% (incident hypertension /no hypertension at baseline)

Adjusted* RR [95% CI]			
MVPA tertile (range [minutes/day])	1: Lowest short spurts (3.0, 17.9)	2: Middle short spurts (18.0, 30.6)	3: Highest short spurts (30.7, 116.8)
1: Lowest bouts (0, 1.5)	22.2% (51/230)	18.5% (27/146)	16.2% (12/74)
	1.00 [Reference]	0.78 [0.51, 1.17]	0.68 [0.37, 1.24]
2: Middle bouts (1.6, 12.1)	17.0% (24/141)	15.4% (29/188)	10.3% (20/195)
	0.86 [0.56, 1.32]	0.81 [0.54, 1.22]	0.49 [0.29, 0.80]
3: Highest bouts (12.3, 287.9)	11.5% (12/104)	10.8% (22/204)	11.7% (29/249)
	0.60 [0.34, 1.05]	0.58 [0.37, 0.92]	0.56 [0.36, 0.87]

* Adjusted for age, BMI, sex, race, and income.

Table 5

Association of short spurts of MVPA* with incident obesity

Tertiles of short spurts of MVPA (range[minutes/day])	Incident obesity[†] [% (n)]	Adjusted RR[‡] [95% CI] for Incident obesity
1: Least short spurts (3.0, 17.9)	11.2 (42/376)	1.00 [Reference]
2: Middle short spurts (18.0, 30.6)	12.3 (53/431)	1.32 [0.89, 1.94]
3: Most short spurts (30.7, 116.8)	12.6 (56/444)	1.40 [0.94, 2.10]
Per 10-minute increase in short spurts of MVPA		1.11 [0.96, 1.27]

Tertiles of bouts of MVPA (range[minutes/day])	Incident obesity [% (n)]	Adjusted RR[§] [95% CI] for Incident obesity
1: Lowest bouts (0, 1.5)	16.3 (54)	1.00 [Reference]
2: Middle bouts (1.6, 12.1)	12.3 (54)	0.72 [0.50, 1.04]
3: Highest bouts (12.3, 287.9)	9.0 (43)	0.54 [0.36, 0.81]
Per 10-minute increase in bouts of MVPA		0.79 [0.68, 0.92]

* Short Spurts of MVPA = Total time in MVPA – Time spent in bouts of MVPA

[†] Incident obesity was defined as a BMI ≥ 30 kg/m² at the 5-year follow-up among those with a BMI < 27 kg/m² at baseline

[‡] Adjusted for age, sex, race, income and bouts of MVPA. Quartiles of MVPA and 10-minute increments of MVPA are in separate models.

[§] Adjusted for age, sex, race, income and short spurts of MVPA. Quartiles of MVPA and 10-minute increments of MVPA are in separate models.

Table 6

Combined association of tertiles of short spurts of MVPA (columns) and bouts MVPA (rows) with incident obesity

% (incident obesity /no obesity at baseline)

Adjusted* RR [95% CI]

MVPA tertile (range [minutes/day])	1: Lowest short spurts (3.0, 17.9)	2: Middle short spurts (18.0, 30.6)	3: Highest short spurts (30.7, 116.8)
1: Lowest bouts (0, 1.5)	13.1% (23/175)	18.8% (19/101)	21.4% (12/56)
	1.00 [Reference]	1.53 [0.88, 2.67]	1.66 [0.88, 3.13]
2: Middle bouts (1.6, 12.1)	12.1% (14/116)	11.2% (17/152)	13.5% (23/171)
	0.97 [0.52, 1.81]	0.91 [0.50, 1.65]	1.08 [0.62, 1.89]
3: Highest bouts (12.3, 287.9)	5.9% (5/85)	9.6% (17/178)	9.7% (21/217)
	0.52 [0.20, 1.34]	0.82 [0.45, 1.53]	0.81 [0.46, 1.43]

* Adjusted for age, sex, race, and income.