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Sedentary behavior and blood pressure control among osteoarthritis initiative participants

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SEDENTARY BEHAVIOR AND BLOOD PRESSURE CONTROL AMONG OSTEOARTHRITIS INITIATIVE PARTICIPANTS

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Abstract

OBJECTIVE—To examine the association between sedentary behavior and BP among Osteoarthritis Initiative (OAI) participants.

DESIGN—We conducted a cross-sectional analysis of the OAI 48-month visit participants whose physical activity was measured using accelerometers. Participants were classified into four quartiles according to the percentage of wear time that was sedentary (<100 activity counts per minute). Users of antihypertensive medications or NSAIDs were excluded. Our main outcomes were systolic and diastolic blood pressures (SBP and DBP) and "elevated BP" defined as BP ≥ 130/85 mm Hg.

RESULTS—For this study cohort (N = 707), mean BP was 121.4 ± 15.6/74.7 ± 9.5 mm Hg and 33% had elevated BP. SBP had a graded association with increased sedentary time (P for trend = 0.02). The most sedentary quartile had 4.26 mm Hg higher SBP (95% CI, 0.69 – 7.82; p = 0.02)

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COMPETING INTERESTS
None of the authors have any competing interests in relation to this work.

CONTRIBUTIONS
Drs. Sohn and Dunlop had had full access to the data. Dr Sohn takes responsibility for the integrity of the data and the accuracy of the data analysis. Authors contributions are as follows: Study concept and design (Sohn, Dunlop, Chang, Semanik, Greenland), acquisition of data (Dunlop, Nevitt, Hockberg), *a*nalysis and interpretation of the data (Sohn, Dunlop, Manheim, Chang, Semanik, Greenland, Stone), drafting of the manuscript (Sohn), critical revision of the manuscript for important intellectual content (All authors), statistical analysis (Sohn), obtained funding (Dunlop), administrative, technical, or material support (Dunlop), and study supervision (Dunlop, Chang). Dr Sohn had full access to the data and assumes responsibility for the integrity of the work as a whole.

than the least sedentary quartile, adjusting for age, moderate-to-vigorous (MV) physical activity, and other demographic and health factors. The probability of having elevated BP significantly increased in higher sedentary quartiles (P for trend = 0.046). There were no significant findings for DBP.

CONCLUSION—A strong graded association was demonstrated between sedentary behavior and increased SBP and elevated BP, independent of time spent in MV physical activity. Reducing daily sedentary time may lead to improvement in blood pressure and reduction in cardiovascular risk.

Keywords

sedentary lifestyle; blood pressure; physical activity; osteoarthritis

INTRODUCTION

Sedentary behavior is a recognized risk factor for cardiovascular disease. It has been associated with a broad range of cardiometabolic factors, including increased hemoglobin A1c, insulin resistance, elevated cholesterol levels, obesity, and metabolic syndrome.[1,2] Sedentary behavior is suspected to be a risk factor for hypertension, but its effect on blood pressure (BP) has not been clearly established.

Earlier studies demonstrated self-reported sedentary behavior to be linked to elevated BP and incident hypertension among adults,[3,4] but more recent studies which objectively measured sedentary behavior did not show a significant relationship between sedentary behavior and BP.[1,2,5] These studies did not exclude persons who used antihypertensive medications from analysis and the selective prescribing may have confounded their results. These mixed findings raise the question if sedentary behavior is an independent risk factor for increased blood pressure. Given the lack of reliability and validity of subjective measures of sedentary behavior[6–8] and the limitations of previous studies using objective measures, more rigorous studies based on objectively measured sedentary behavior are needed.

The objective of this study is to examine the association between sedentary behavior and BP using objectively measured physical activity/sedentary behavior data from community adults at high risk for cardiovascular events due to older age and/or obesity and who were not taking antihypertensive medications. We hypothesize that sedentary behavior is significantly associated with elevated blood pressure.

METHODS

Study Design and Sample

Participants were a subcohort from the Osteoarthritis Initiative (OAI), which recruited community-dwelling adults with or at high risk for developing symptomatic knee osteoarthritis (OA). Sedentary behavior is common among persons with knee OA, who comprised about half of OAI participants and were highly physically inactive.[9] The OAI is a multi-center, longitudinal, observational study of 4796 men and women aged 45 – 79 years

at the 2004–2006 enrollment. Adults eligible for the OAI were either required to have symptomatic OA in at least one knee (a definite tibiofemoral osteophyte [osteophyte grade≥ 1[10]] and pain, aching, or stiffness on most days for at least one month during the past 12 months) or were required to have at least one from a set of established knee OA risk factors. OAI eligibility criteria are detailed elsewhere.[11]

The study sample was drawn from the 2127 participants enrolled in an OAI accelerometer monitoring substudy[9] at the OAI 48 month follow visit (2008–2010), from which data were obtained for the present analysis. We included OAI participants who had valid and reliable measures of physical activity (at least 10 hours per day for four or more days, n = 1927). Our exclusion criteria were participants who did not have blood pressure measurements (n = 5), had self-reported rheumatoid arthritis or other inflammatory arthritis at the 48 month visit (n = 87), or had missing information on covariates (n = 10). We then excluded participants who used non-steroidal anti-inflammatory drugs (NSAIDs) (n = 439), which are known to increase BP.[12–15] Finally, to mitigate against the common bias in pharmacoepidemiology that sicker patients are generally treated with more potent therapy (e.g., increased dosage or number of drugs),[16] we excluded all participants who used antihypertensive medications during 30 days before the 48 month visit (n = 679). After these exclusions, 707 adults contributed to the analytic sample. See Figure 1 for the study flow diagram.

Blood Pressure

Seated systolic and diastolic blood pressures (SBP and DBP) were measured by trained project staff using a conventional mercury sphygmomanometer. The OAI study protocol rigorously followed the Seventh Report for the Joint National Committee (JNC7) guideline for BP measurement procedures.[17] Participants were asked to rest for five minutes or longer and at least 30 minutes after phlebotomy before BP was measured. While only one measurement was recorded per patient, a second measure was encouraged with at least 30-second intervals in between whenever incorrect reading was suspected. We used SBP and DBP as our two outcome measures. We also used elevated BP status as our third outcome, defined as BP ≥130/85 mm Hg based on Adult Treatment Panel III metabolic risk factor thresholds. [18,19]

Measurement of Sedentary Behavior and Physical Activity

Sedentary behavior and physical activity were objectively measured by activity counts derived from accelerometer data.[9] Participants were provided with a uniaxial accelerometer and were instructed to wear it on a belt at the natural waistline on the right hip in line with the right axilla upon arising in the morning and continuously until retiring at night, except during water activities, for seven consecutive days. Participants maintained a daily log to record time spent in water and cycling activities, which may not be fully captured by accelerometers.

Uniaxial accelerometers sample and record the number and magnitude of vertical accelerations and decelerations. Activity counts were computed as the weighted sum of accelerations measured over one minute periods, where the weights are proportional to the

magnitude of measured acceleration. Accelerometer data were analytically filtered using methodology validated in adults with rheumatic disease.[18–20] Non-wear periods were defined as ≥90 minutes with zero activity counts (allowing for two interrupted minutes with counts < 100).[20] Because physical activity may be underestimated when accelerometers are worn only part of the day,[21] accelerometer data for a given day was considered valid if it was worn for 10 or more hours that day.[18] For simplicity, the terms waking hours and wear hours are used interchangeably.

Total daily minutes of moderate-to-vigorous (MV) physical activity were calculated using the intensity thresholds used by the National Cancer Institute (counts ≥2020/minute).[18] Sedentary behavior was defined as activity counts <100 per minute.[2,18,22] We used the daily percent of waking time spent in sedentary behavior to define four quartiles from the least to the most sedentary (<60.9%, 60.9 – 69.9%, 67.0 – 72.4%, >72.4%). Because light activity (100–2019 counts/minute) time highly correlated with the daily percent spent being sedentary ($r = 0.9$; $p < 0.001$), we did not include it in our main analysis, but conducted sensitivity analyses to examine if light activity had any significant association with BP, independent of age and MV physical activity.

Medication assessment

A standardized medication assessment was used. Participants were asked to bring all medications they had been taking in the last 30 days. Medications were classified and coded using the Iowa Drug Information Service (IDIS) classification system in the medication inventory data. An antihypertensive medication user was defined as someone who had used one or more of the following medications: beta blockers (IDIS code 121601), alpha blockers (121604), alpha-2 agonists (240800), angiotensin-converting-enzyme inhibitors (240802), angiotensin receptor blockers (240804), diuretics (402800, 402801, 402804), calcium channel blockers (241204), and vasodilators (241200, 241202). NSAID use was identified both from self-reports of prescription or non-prescription use as well as the medication inventory data. An NSAID user was identified as someone who positively answered the questions about NSAID or COX-2 inhibitor use or someone who was taking NSAIDs (IDIS code 280804) or COX 2 inhibitors (280806) according to the medication inventory data. Users of antihypertensive medications or NSAIDs were excluded from the analysis sample.

Covariates

We identified demographic, health, and lifestyle factors that can potentially affect blood pressure. Demographic factors included age, gender, and race/ethnicity (white, black, and other). Health factors included the number of Charlson comorbidities (0, 1, 2, or ≥3), body mass index (BMI), abdominal circumference, knee pain, and knee OA status. We used height and weight measured at the 48 month visit to compute BMI and placed participants into normal weight (< 25 kg/m^2), overweight (25 – 29.9 kg/m^2), and obese (≥ 30 kg/m^2) groups. Self-reported knee pain severity was measured by the highest [worse] Western Ontario and McMaster University Osteoarthritis pain index score of both knees; range: 0–20). In addition, as a measure of global pain, we used the question “During the past 4 weeks, how much did pain interfere with normal work (include work outside home and

housework)?" to identify participants who were not affected by pain. Knee OA was identified by Kellgren-Lawrence radiographic grade ≥2 in at least one knee.

Lifestyle factors that are known to affect blood pressure include alcohol intake, smoking, and sodium intake.[23,24] We used any answer other than "None" as an indicator of alcohol intake to the question "During the past 12 months, how many drinks did you have in a typical week?" For smoking, we used the question "Have you ever smoked cigarettes regularly?" and "Do you smoke cigarettes now?" to identify past and current smokers. Sodium intake was not available.

Statistical Analysis

We used bivariate analysis between participant characteristics and sedentary behavior quartiles to present unadjusted association between them (Table 1). We used ordinary least squares regressions to separately model SBP and DBP. Elevated BP was modeled using logistic regression. Because age is a known confounder of blood pressure (i.e., associated with both blood pressure and physical activity), we examined estimates from models with age alone and models with all covariates to assess how adjustment for additional risk factors may change the association between sedentary behavior and BP. Our full model controlled for demographic characteristics (age, race/ethnicity, sex), health factors (abdominal circumference, Charlson comorbidities, OA status, WOMAC pain, and global pain), lifestyle factors (alcohol drinking, past or current smoking, average MV physical activity minutes per day). Body mass index (kg/m^2) was not significant in the presence of abdominal circumference and was not used in multivariable models reported in Table 2. Full models with estimates for all covariates are available in an online supplementary table.

We conducted a sensitivity analysis using an augmented sample (n = 1,386) that included all users of antihypertensive medications and defined a participant as having elevated BP if they had BP ≥ 130/85 mm Hg or used antihypertensive medications. In another sensitivity analysis, we defined the sedentary quartiles that are representative of the US population[1] and estimated all multivariable analyses with the new quartiles. We used STATA/SE v. 12 (Stata Corp, College Station, TX) for all statistical analyses. This study was approved by our local institutional review board.

RESULTS

This sample of 707 participants not recently on antihypertensive medications, NSAIDs and known vasodilators included 41% aged 65 years old or older (mean age = 62.8 ± 9 years), 45% men, and 9.6% non-Hispanic black. Mean blood pressure was 121.4 ± 15.6/74.7 ± 9.5 mmHg, with almost one-third (33.1%) having elevated blood pressure (≥130/85 mm Hg) and 15% had blood pressure ≥140/90 mm Hg. Fifty-four percent had radiographic knee OA, over a quarter (25.4%) were obese (BMI ≥30 kg/m^2), 84% were current alcohol drinkers, 3.3% were current smokers, and 28% had at least one and 9% had two or more comorbidities (Table 1). The mean and median abdominal circumferences were 102.2±10 cm and 101.7 cm for men and 98.1±12.6 and 98.5 for women, respectively.

Study participants on average spent almost two-thirds of their waking day in sedentary behaviors (range 33% – 88%). This represents an average of 9.8 hours in sedentary behavior per day. On average participants were engaged in MV physical activity 23.7±21.7 minutes per day (range 0 – 136 minutes/day). MV physical activity time was significantly and negatively associated with sedentary time ($r = -0.39$; $p < 0.001$). Participants in the most sedentary quartile group (>72% sedentary) engaged in MV physical activity for only 11.4±11.3 minutes per day on average, in contrast to the least sedentary quartile (<61% sedentary) who engaged in an average 32.4±24.6 minutes daily MV activity.

Sedentary Behavior and Blood Pressure

Sedentary behavior had a strong and graded association with SBP (Table 2). Age-adjusted SBP was higher with each more sedentary quartile by 2.0, 3.2, and 5.1 mm Hg (P for trend = 0.040) compared to the least sedentary group (mean SBP= 119.0 mm Hg). A significant trend in association between sedentary behavior and SBP persisted after controlling for demographics, life style, health factors, and MV physical activity (P for trend = 0.020). The relationship between sedentary behavior and DBP did not demonstrate a graded association. Figure 2 shows the fully-adjusted mean SBP and DBP with their 95% confidence intervals in the sedentary quartiles.

For increasingly sedentary quartiles, odds ratios for elevated BP (≥130/85 mm Hg) were 1.00, 1.40, 1.18, and 1.92, respectively, in the fully adjusted model (P for trend = 0.046). We found that the most sedentary quartile was almost twice as likely to have elevated BP as the least sedentary group (fully-adjusted model OR = 1.92; 95% CI, 1.13 – 3.26; P = 0.016). Figure 3 shows the predicted probability of having elevated BP and their 95% confidence interval in each sedentary quartile.

Other factors associated with BP

Abdominal circumference was strongly associated with all measures of BP. After adjusting for physical activity and other covariates, every 10 cm higher abdominal circumference was associated with 1.8 and 1.0 mm Hg higher SBP and DBP, respectively, and 1.0% higher likelihood of elevated BP. In fully-adjusted models, non-Hispanic black race was associated with 10.6 mm Hg higher SBP, 6.2 mm Hg higher DBP, and 2.5 times higher likelihood of elevated BP compared to all other race/ethnicities combined.

Sensitivity Analysis

A sensitivity analysis showed that overall 66% of participants in this sample had elevated BP (BP ≥ 130/85 mm Hg or antihypertensive medication use) and percentages of participants with elevated BP increased (58%, 63%, 65%, and 77%) with quartiles representing more sedentary behavior. In the age- and sex-adjusted model, odds ratios for elevated BP were 1.0, 1.3, 1.4, and 1.9 (P for trend = 0.001) in increasing sedentary quartiles.

When our sample was divided into quartiles that were representative of the US population, we found that only 4% were placed in Quartile 1 and 57% in Quartile 4. Regressions

estimated using the new quartiles did not show any significant association of sedentary quartiles with SBP or elevated BP.

DISCUSSION

Our results show that objectively measured sedentary behavior is associated with higher SBP and with elevated BP, independent of age, MV physical activity, and other demographic and health factors. The most sedentary participants had 4.3 mm Hg higher SBP and were almost twice as likely to have elevated BP as the least sedentary participants in fully adjusted models. We did not find systematic patterns of association between sedentary behavior and DBP.

To our knowledge, this is the first study that showed a significant association between objectively measured sedentary behavior and BP. Several studies in Europe and Australia recently examined deleterious health effects of sedentary behavior using objectively measured physical activity and sedentary time. They showed that sedentary time was associated with several cardiometabolic risk factors, including obesity, abdominal adiposity, increased 2-hour plasma glucose, insulin resistance, low high-density lipoprotein cholesterol, high triglycerides, increased C-reactive protein, and metabolic syndrome.[1,2,5,25,26]

Three of these studies[1,2,5] examined BP as one of the outcomes but none reported a significant relationship with sedentary behavior. A study by Bankoski et al (2011)[2] notably measured sedentary behavior in five different ways (e.g., duration, percent of wear time, etc) using objectively measured physical activity data for persons aged 60 years or older in the 2003 – 2006 NHANES. In an age- and sex-adjusted model, none of the measures of sedentary behavior in this study was associated with elevated BP (≥130/85 mm Hg or antihypertensive medication use). In our sensitivity analysis that adjusted for age and sex (see above), we found a significant graded association between sedentary behavior and higher SBP. The models for both studies were identically specified except that the sample for the Bankoski study was older than the sample used in this study and it is not clear whether this earlier study excluded individuals who used NSAIDs. Results for SBP or DBP were not reported in this earlier study.

So far the evidentiary base for the harmful effect of sedentary behavior on blood pressure outside of this study remains solely comprised of studies based on self-reported measures such as TV viewing or sleeping. A study conducted in the United Kingdom of over 15,515 adults ages 45 – 79 years used self-reported TV viewing time and showed that both DBP and SBP were significantly elevated in the group with >4 hours compared to the group with < 2 hours of TV viewing.[3] Another study of 11,837 college graduates in Spain showed that self-reported total sedentary time was associated with 48% higher risk of hypertension.[4]

One reason for our significant findings may be that previous studies did not adequately adjust for potent effect modifiers such as antihypertensive medications or NSAIDs. Because dosing instructions or strength of medications were not collected, we could not adequately

adjust for the effects of these medications. We thus excluded their users from our study sample to make it as "clean" as possible.

Our study may also have been more capable of detecting associations with sedentary behavior due to the highly inactive population examined. On average, our sample spent almost two hours longer per day being sedentary than the US population.[1] Notably, almost half of our participants had knee OA and the remaining participants had a high risk of developing it.[9] A recent study showed that over 40% of men and 56% of women with knee OA in this cohort were inactive (no MV physical activity that lasted at least 10 minutes during a week) according to the national physical activity guidelines.[9] High prevalence of physical inactivity and cardiometabolic risk factors intrinsic to OA[27–29] may have made our study sample more susceptible to the deleterious effects of sedentary behavior.

Our results are consistent with inactivity physiology hypothesis that sedentary behavior is not merely lack of exercise but has its own physiological consequences that increase cardiovascular and metabolic risks, regardless of the amount of physical activity.[30] These findings indicate that inactivity physiology may extend to SBP. Also, the difference in SBP between the most and least sedentary quartiles in our study was large enough (4.3 mm Hg) to be concerning. Cardiovascular mortality risk linearly increases with increased BP from as low as 115/75 mm Hg[17]. A 5 mm Hg reduction in both SBP and DBP may reduce 5-year risk of cardiovascular disease in the population by about 20%.[31] This implies that promoting physical activity alone may not be sufficient. Reducing sedentary behavior may be equally or even more important for blood pressure management.[32]

Several limitations need to be considered in interpreting our results. First, this is a cross-sectional study and the causal relationship cannot be inferred from our results. Second, sodium intake is an important lifestyle factor that affects BP but was not available to be assessed in our study. Third, only one measure of BP was recorded in the original OAI data and we could not assess the reliability of BP measures used in this study. Fourth, our cohort was drawn from the OAI participants who were assessed at the 48 month visit. They either already have knee OA or at high risk for developing one. Our results may not be generalizable to other, healthier adult population. Finally, odds ratios may seriously inflate the true risk ratios in our data because the overall incidence of elevated BP was 33%. Relative risks computed using the formula in Zhang and Yu[33] show that reported odds ratios overestimated the relative risks by 5 – 15%.

Our results show a significant graded relationship between sedentary behavior and increased SBP and higher likelihood of having elevated BP, independent of age, MV physical activity, and other health and lifestyle factors. This relationship held regardless of the amount of moderate physical activity performed. Interventions to reduce sedentary behavior may be as important as interventions to increase physical activity in the control of blood pressure.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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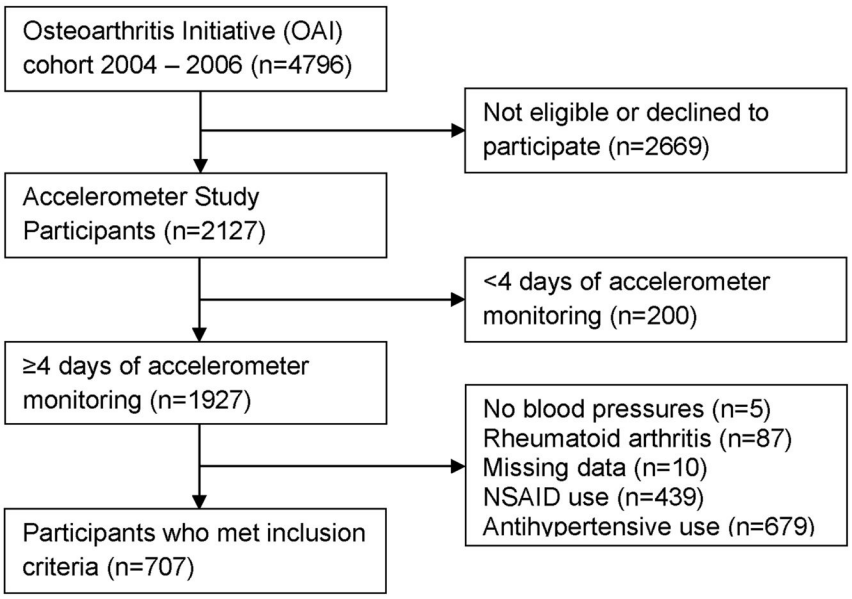

Figure 1.
Study Flow Diagram

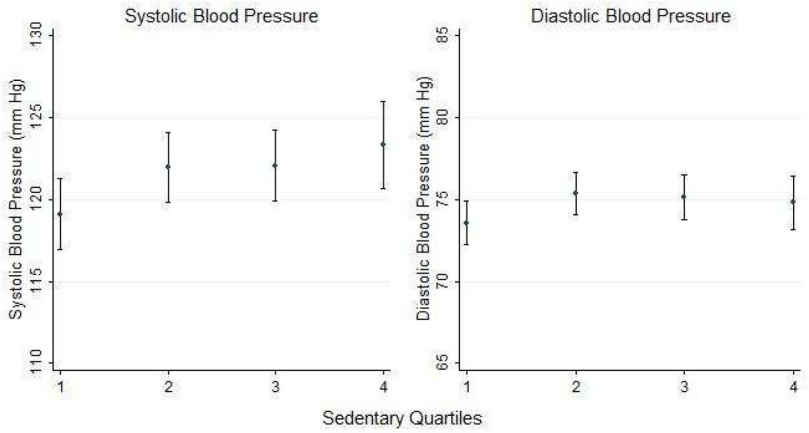

Figure 2.

Adjusted Mean Systolic and Diastolic Blood Pressure (mm Hg) by Sedentary Behavior Quartiles*

* Adjusted for moderate-to-vigorous physical activity, age, sex, race/ethnicity, abdominal circumference, Charlson comorbidities, alcohol drinking, past or current smoker, knee osteoarthritis, WOMAC score, and global pain.

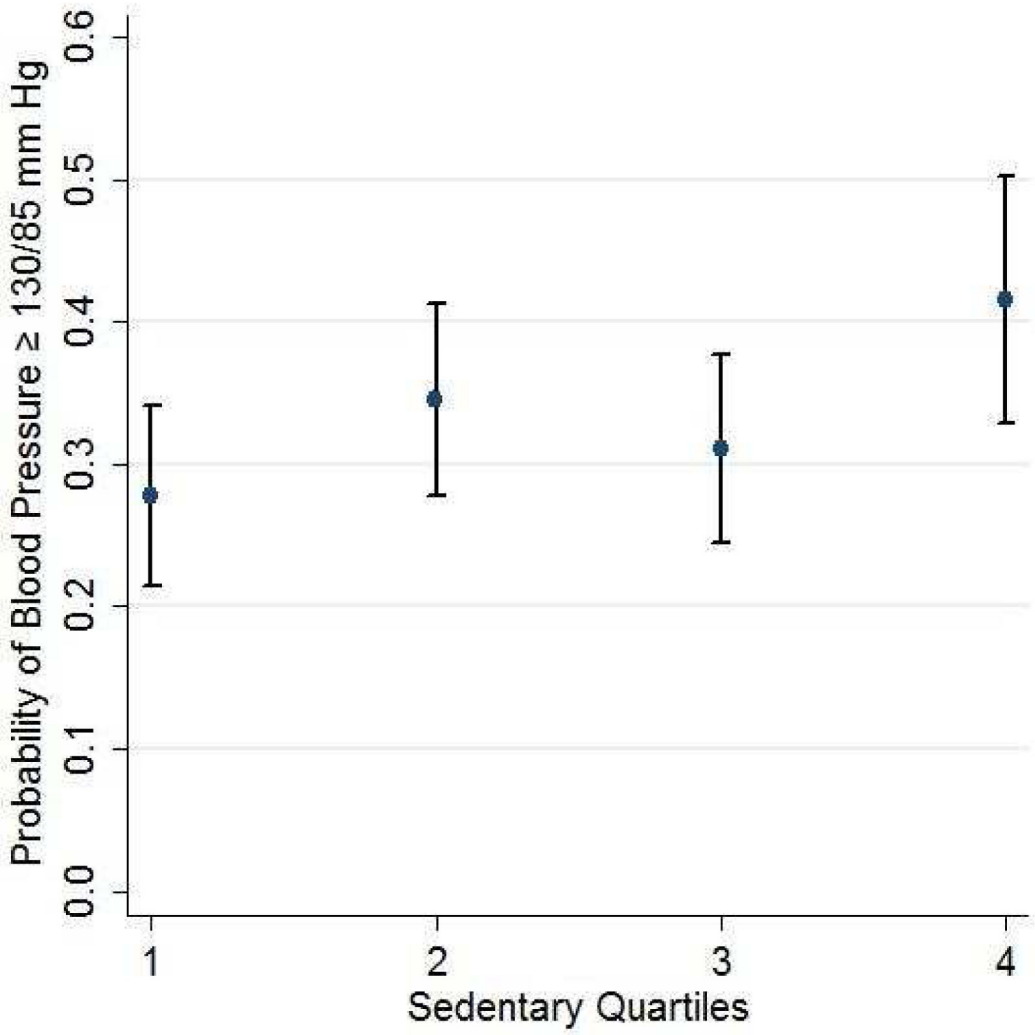

Figure 3.

Adjusted Probability of Blood Pressure ≥ 130/85 mm Hg by Sedentary Behavior Quartiles* * Adjusted for moderate-to-vigorous physical activity, age, sex, race/ethnicity, abdominal circumference, Charlson comorbidities, alcohol drinking, past or current smoker, knee osteoarthritis, WOMAC score, and global pain.

Table 1

Participant Characteristics by Sedentary Behavior Quartiles (N = 707)

Participant Characteristics	All Participants	Sedentary Behavior Quartiles, n (%)				P-Value
		1 (least sedentary, <60.9%)	2 (60.9 – 69.9%)	3 (67.0 – 72.4%)	4 (most sedentary, >72.4%)	
All	707 (100.0)	200 (100.0)	193 (100.0)	179 (100.0)	135 (100.0)	
Daily MV activity minutes, mean (SD)	23.7 (21.7)	32.4 (24.6)	27.7 (23.4)	18.8 (16.0)	11.4 (11.3)	< 0.001
Age in years						
< 55	147 (20.8)	41 (20.5)	54 (28.0)	29 (16.2)	23 (17.0)	< 0.001
55 – 64	271 (38.3)	96 (48.0)	59 (30.6)	70 (39.1)	46 (34.1)	
65 – 74	197 (27.9)	50 (25.0)	61 (31.6)	55 (30.7)	31 (23.0)	
75 or older	92 (13.0)	13 (6.5)	19 (9.8)	25 (14.0)	35 (25.9)	
Male	315 (44.6)	79 (39.5)	83 (43.0)	86 (48.0)	67 (49.6)	0.208
Black Race	68 (9.6)	27 (13.5)	19 (9.8)	14 (7.8)	8 (*)	0.100
Knee OA	385 (54.5)	108 (54.0)	102 (52.8)	100 (55.9)	75 (55.6)	0.935
WOMAC score, mean (SD)	1.97 (2.5)	1.98 (2.8)	1.98 (2.8)	2.03 (2.7)	1.83 (2.5)	0.932
Pain interferes with normal work						
No	392 (55.5)	106 (53.0)	117 (60.6)	103 (57.5)	66 (48.9)	0.155
Yes	315 (44.6)	94 (47.0)	76 (39.4)	76 (42.5)	69 (51.1)	
Body Mass Index						
< 25 kg/m^2	220 (31.1)	66 (33.0)	66 (34.2)	50 (27.9)	38 (28.1)	0.297
25 – 29.9 kg/m^2	305 (43.1)	88 (44.0)	84 (43.5)	81 (45.3)	52 (38.5)	
≥ 30 kg/m^2	182 (25.7)	46 (23.0)	43 (22.3)	48 (26.8)	45 (33.3)	
Abdominal circumference (cm), mean (SD)	99.9 (11.8)	98.2 (11.8)	98.4 (10.6)	100.7 (12.3)	103.4 (11.7)	< 0.001
Charlson Comorbidities						
0	578 (81.8)	161 (80.5)	166 (86.0)	144 (80.4)	107 (79.3)	0.582
1	67 (9.5)	22 (11.0)	13 (6.7)	16 (8.9)	16 (11.9)	
2 or more	62 (8.8)	17 (8.5)	14 (7.3)	19 (10.6)	12 (8.9)	
Current Smoker	23 (3.3)	5 (*)	6 (*)	7 (*)	5 (*)	0.872
Alcohol Drinker	595 (84.2)	154 (77.0)	172 (89.1)	154 (86.0)	115 (85.2)	0.008

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[*] Percentage was masked due to small number.

[†] P-values were from ANOVA or χ^2 tests.

MV = moderate-vigorous; OA = Osteoarthritis; WOMAC = Western Ontario and McMaster Universities Arthritis Index

Table 2

Unadjusted and Adjusted Association of Sedentary Behavior Quartiles and Blood Pressure (N = 707)*

Models	Sedentary Quartiles				P-Value for trend
	1 (Least sedentary, <60.9%)	2 (60.9 – 69.9%)	3 (67.0 – 72.4%)	4 (Most sedentary, >72.4%)	
Systolic Blood Pressure, mm Hg					
Mean (SD)	119.0 (14.8)	121.4 (16.3)	122.2 (15.2)	124.1 (15.7)	
Mean Difference					
Age-adjusted	Ref	1.97 (−1.07 – 5.01)	2.33 (−0.76 – 5.42)	**3.51 (0.11 – 6.90)**	**0.040**
Fully-adjusted	Ref	2.84 (−0.17 – 5.84)	2.95 (−0.15 – 6.05)	**4.26 (0.69 – 7.82)**	**0.020**
Diastolic Blood Pressure, mm Hg					
Mean (SD)	74.3 (10.0)	75.2 (9.2)	75.0 (9.8)	74.3 (9.1)	
Mean Difference					
Age-adjusted	Ref	1.21 (−0.68 – 3.10)	1.17 (−0.75 – 3.09)	0.99 (−1.12 – 3.09)	0.322
Fully-adjusted	Ref	1.75 (−0.07 – 3.66)	1.59 (−0.34 – 3.52)	1.24 (−0.98 – 3.46)	0.234
Elevated Blood Pressure (BP ≥ 130/85 mm Hg)					
Percent	28.0%	33.7%	31.3%	42.2%	
Odds Ratios					
Age-adjusted	Ref	1.25 (0.81 – 1.93)	1.08 (0.69 – 1.69)	**1.63 (1.01 – 2.61)**	0.101
Fully-adjusted	Ref	1.40 (0.88 – 2.21)	1.18 (0.73 – 1.91)	**1.92 (1.13 – 3.26)**	**0.046**

*Adjusted for moderate-to-vigorous physical activity, age, sex, race/ethnicity, abdominal circumference, Charlson comorbidities, past or current smoker, alcohol drinking, knee osteoarthritis, WOMAC score, and global pain.