Patterns of Sedentary Behavior in US Middle-Age and Older Adults: The REGARDS Study

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ABSTRACT

DIAZ, K. M., V. J. HOWARD, B. HUTTO, N. COLABIANCHI, J. E. VENA, S. BLAIR, and S. P. HOOKER. Patterns of Sedentary Behavior in US Middle-Age and Older Adults: The REGARDS Study. *Med. Sci. Sports Exerc.*, Vol. 48, No. 3, pp. 430–438, 2016. **Purpose**: The purposes of this study were to examine patterns of objectively measured sedentary behavior in a national cohort of US middle-age and older adults and to determine factors that influence prolonged sedentary behavior. **Methods**: We studied 8096 participants from the REasons for Geographic and Racial Differences in Stroke (REGARDS) Study, a population-based study of black and white adults 45 yr or older. Seven-day accelerometry was conducted. Prolonged sedentary behavior was defined as accumulating 50% or more of total sedentary time in bouts of 30 min or greater. **Results**: The number of sedentary bouts greater than or equal to 20, 30, 60, and 90 min were 8.8 ± 2.3, 5.5 ± 1.9, 1.9 ± 1.1, and 0.8 ± 0.7 bouts per day, respectively. Sedentary bouts greater than or equal to 20, 30, 60, and 90 min accounted for 60.0% ± 13.9%, 48.0% ± 15.5%, 26.0% ± 15.4%, and 14.2% ± 12.9% of total sedentary time, respectively. Several factors were associated with prolonged sedentary behavior in multivariate-adjusted models (odds ratio [95% confidence interval]): older age (65–74 yr: 1.99 [1.55–2.57]; 75 yr or older: 4.68 [3.61–6.07] vs 45–54 yr), male sex (1.41 [1.28–1.56] vs female), residence in nonstroke belt/buckle region of the United States (stroke belt: 0.87 [0.77–0.98]; stroke buckle: 0.86 [0.77–0.95] vs non–belt/buckle), body mass index (BMI) (overweight: 1.33 [1.18–1.51]; obese: 2.15 [1.89–2.44] vs normal weight), winter (1.18 [1.03–1.35] vs summer), and low amounts of moderate-to-vigorous physical activity (MVPA) [0 min·wk^{-1}: 2.00 [1.66–2.40] vs ≥150 min·wk^{-1}). **Conclusions**: In this sample of US middle-age and older adults, a large proportion of total sedentary time was accumulated in prolonged, uninterrupted bouts of sedentary behavior as almost one-half was accumulated in sedentary bouts greater than or equal to 30 min. Several sociodemographic (age, sex, and BMI), behavioral (MVPA), environmental (region), and seasonal factors are associated with patterns of prolonged sedentary behavior. **Key Words:** SEDENTARY, ACCELEROMETER, AGING, EPIDEMIOLOGY, PHYSICAL ACTIVITY

Technological advancements in the past 50 yr have led to an increasingly sedentary lifestyle in developed nations (2,8). Changes in transportation, communication, the workplace, and domestic-entertainment technologies have fostered environments in occupational, home, and social settings that demand or encourage prolonged sedentary behavior (6). Observational studies reveal 60% of an adult's nonsleeping hours are spent in sedentary behaviors; corresponding to an alarming 9–10 h·d^{-1} (9). Epidemiological evidence indicates time spent in sedentary behavior is associated with incident cardiovascular disease (CVD), incidence of CVD-related risk factors, and CVD-related and all-cause mortality, even among individuals who meet physical activity recommendations (33,37). As such, sedentary behavior represents a unique and clinically important aspect of an individual's overall activity profile and is no longer considered simply to be the extreme low end of the physical activity continuum (9).

Recent laboratory-based studies demonstrate acute periods of prolonged, uninterrupted sedentary behavior elicit detrimental cardiometabolic effects (5,10,29,32), suggesting

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it is not just the total sedentary time that is relevant to CVD risk but also the manner in which it is accumulated. Data from epidemiologic studies corroborate these findings as adults whose sedentary time is mostly uninterrupted (e.g., prolonged uninterrupted sitting) have been reported to have a poorer cardiometabolic profile compared with those who have interrupted or more frequent breaks in their sedentary time (7,14,15).

Currently, few data exist on how sedentary behavior is patterned among US adults (e.g., does most sedentary behavior occur in a few long bouts or in many short bouts? how often are breaks from sedentary behavior taken and how long do these breaks last?). As physical activity guidelines now advocate for reductions in sedentary time as an adjunct to structured exercise/physical activity programs (12), such data may be helpful to inform specific recommendations regarding how to reduce sedentary behavior. A recent analysis of objective sedentary behavior data from the Women's Health Study found that most sedentary time (~71%) was accumulated in shorter bouts lasting less than 30 min (31). However, these data are limited to middle- and older-age women who are primarily white and of higher socioeconomic status. The purpose of this study was to examine and describe the patterns of sedentary behavior in a national biracial cohort of US middle-age and older adults enrolled in the Reasons for Geographic and Racial Differences in Stroke (REGARDS) study and to investigate factors that may influence prolonged, uninterrupted sedentary behavior in this sample.

METHODS

Study population. The REGARDS study is an ongoing population-based cohort study designed to prospectively examine racial and regional disparities in stroke risk and mortality. It is comprised of 30,239 white and black adults 45 yr or older, enrolled between January 2003 and October 2007 from across the contiguous United States, with oversampling from the stroke buckle (coastal plain region of North Carolina, South Carolina, and Georgia), and stroke belt (remainder of North Carolina, South Carolina, and Georgia, plus Alabama, Mississippi, Tennessee, Arkansas, and Louisiana) regions (18,24). First identified in 1965, the stroke belt region comprises an eight-state area of the southeastern United States, which has a stroke mortality rate considerably higher than the rest of the country (17). Within the stroke belt, the 153-county area comprising the coastal plains region of the southeastern United States, termed the stroke buckle, has the highest stroke mortality rate in the country (17).

Detailed design and methods for REGARDS are described elsewhere (19). Briefly, demographic and cardiovascular risk factor data were collected by a computer-assisted telephone interview (CATI) upon study enrollment. An in-home physical assessment was subsequently conducted approximately 3 to 4 wk later to collect anthropometric measurements and other risk factor data. Participants (or their proxies) were then followed at 6-month intervals by CATIs to ascertain vital status. Objective measurements of sedentary behavior and physical activity were collected from May 2009 to January 2013 (mean number of years from study enrollment: 5.8 ± 1.5 yr). The current analysis is restricted to individuals who were compliant with a 7-d accelerometry protocol requiring at least 4 d with 10 or more hours of wear as previously described (20). Briefly, 20,076 eligible participants were invited to conduct a 7-d accelerometry: 12,146 (60.5%) consented, 7312 (36.4%) declined, and 618 (3.1%) deferred without the opportunity to be invited again. Characteristics of participants who agreed to wear the accelerometer versus those who declined have been reported elsewhere (20). Accounting for lost, defective, or nonworn devices (n = 2173), and excluding those with device errors, missing log sheets, or noncompliant wear time (n = 1877), usable data were available from 8096 participants. Characteristics of participants with compliant and noncompliant wear time are presented in the Supplemental Digital Content (SDC) (see Document, SDC Supplemental Table 1: Characteristics of participants in REGARDS accelerometer study with and without compliant wear time, http://links.lww.com/MSS/A587). The REGARDS study protocol was approved by institutional review boards at participating institutions. All participants provided informed consent.

Accelerometer data collection and analysis. Detailed methods for accelerometer data collection are described elsewhere (20). Briefly, trained staff initialized an Actical (Mini Mitter Respironics, Inc., Bend, OR), secured to a nylon belt, and mailed it to participants with written and visual wear instructions, log sheet, and return envelope. The participants were instructed to start wearing the device the day after they received it, remove at bedtime and reattach upon awakening, position the device snugly over the right hip, complete the log sheet daily recording the times(s) the device was put on and taken off each day, and return the device immediately after completing the protocol.

Nonwear periods were defined as 150 or more consecutive minutes of zero activity count using an automated algorithm exclusively. This nonwear algorithm was previously validated against the daily log sheet in a subsample of REGARDS participants with meticulously completed log sheets (22). Activity counts were summed over 1-min epochs. Counts of 0–49 counts per minute, 50–1064 counts per minute, and 1065 counts per minute or greater distinguished sedentary behavior, light-intensity physical activity (LIPA), and moderate or vigorous intensity physical activity (MVPA), respectively, as determined in a previous laboratory-based calibration study among middle- and older-age adults (16). Although a 0- to 99-counts per minute threshold has conventionally been used to define sedentary behavior, the empirical evidence for this threshold is mixed (3). Furthermore, it has not been validated for the Actical in a sample representative of the REGARDS study population (e.g., middle- and older age adults). Accordingly, the 0–49 sedentary threshold was instead

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selected as informed by our previous laboratory calibration study, which showed that Actical counts during simulated light physical activities frequently fell below 100 counts per minute, but not 50 counts per minute among middle- and older-age adults (16). Future studies explicitly testing the optimal sedentary cut point for the Actical device, however, are still needed.

Time spent in a defined intensity (sedentary, LIPA, or MVPA) was determined by summing minutes in a day when the activity count met the criterion for that intensity. Duration of MVPA occurring in 10-min or longer bouts was also calculated. A 10-min or longer bout was defined as 10 or more consecutive minutes above the MVPA activity count threshold with allowance of 1–2 min below threshold (26,34). A sedentary bout was defined as consecutive minutes in which the accelerometer registered less than 50 counts per minute. A sedentary break was defined as at least 1 min in which counts registered at least 50 counts after a sedentary bout. Both sedentary bouts and sedentary breaks were exclusively continuous periods with no interruptions allowed in the definition. Nonwear intervals were not considered part of any sedentary bout; thus, each minute of Actical data was assigned to one of the three categories (nonwear, sedentary bout, and sedentary break) with no overlap.

Covariates. Demographic factors (age, sex, race, and geographic region of residence), body mass index (BMI), season of accelerometer data collection, and level of MVPA were included as covariates to examine their relationship with patterns of prolonged sedentary behavior. For the current analysis, the age at the time of accelerometer data collection was calculated, and participants were stratified into age groups (45–54, 55–64, 65–74, or ≥75 yr). Region of residence was classified as stroke belt, stroke buckle, or non–belt/buckle. Anthropometric measurements (height and weight) obtained during initial study enrollment were used for BMI calculation. Body mass index was classified as underweight (<18.5 $kg \cdot m^{-2}$), normal weight (18.5–24.9 $kg \cdot m^{-2}$), overweight (25.0–29.9 $kg \cdot m^{-2}$), or obese (≥30 $kg \cdot m^{-2}$). The season of accelerometer data collection was categorized as summer (June 21 to September 20), autumn (September 21 to December 20), winter (December 21 to March 20), or spring (March 21 to June 20). The level of MVPA was defined according to the number of minutes per week of MVPA accumulated in bouts greater than or equal to 10 min. Participants were stratified into the following categories according to the American Heart Association's "Life's Simple 7" metric (25): 0 min, more than 0 min and less than 150 min, or 150 min or more of MVPA per week.

Statistical analyses. Sedentary and physical activity variables were summed across each compliant day (≥10 h of wear) then averaged across all of a participant's compliant days to derive per day values. The distribution of sedentary bouts was examined using the following thresholds: greater than or equal to 1, 5, 10, 20, 30, 40, 50, 60, and 90 consecutive minutes. Daily averages of sedentary bouts exceeding each threshold were computed as: 1) total number of sedentary bouts greater than or equal to XX minutes, 2) percentage of total number of sedentary bouts greater than or equal to XX minutes ([number of bouts greater than or equal to XX minutes / total number of sedentary bouts] × 100), 3) percentage of total daily sedentary time accumulated in bouts greater than or equal to XX minutes ([sedentary time accumulated from bouts greater than or equal to XX minutes / total sedentary time] × 100), and 4) mean length of sedentary bouts greater than or equal to XX minutes. Descriptive statistics, including mean ± SD for continuous variables and percentages for dichotomized variables, were computed to characterize patterns of sedentary behavior in the overall sample. As a secondary analysis, descriptive statistics for sedentary bouts were stratified by race/sex classification (black male, black female, white male, and white female) and, separately, age group.

To examine the factors associated with prolonged uninterrupted sedentary behavior, participants were stratified according to whether or not they accumulated greater than or equal to 50% of their total daily sedentary time in sedentary bouts greater than or equal to 30 min. The 30-min cutpoint for prolonged sedentary bouts was chosen based on evidence from laboratory-based studies that have reported detrimental cardiometabolic effects with sedentary bouts of more than 30 min (29). Logistic regression models were then used to calculate the odds ratio (OR) for being classified as exhibiting prolonged uninterrupted sedentary behavior, stratified by the following subgroups: age group (45–54 [referent], 55–64, 65–74, or ≥75 yr), sex (female [referent] or male), race (white [referent] or black), region of residence (non–belt/buckle [referent], stroke buckle, or stroke belt), BMI classification (underweight, normal weight [referent], overweight, obese), season when accelerometer data were collected (summer [referent], fall, winter, or spring), and level of MVPA (0, >0 and <150, or ≥150 min [referent] of MVPA per week). Crude ORs were initially calculated. Subsequently, ORs were calculated after adjustment for wear time, age, race, region of residence, BMI, season when accelerometer data were collected, and level of MVPA. *P* trend tests were conducted for each ordinal variable (age, BMI, level of MVPA) in regression models. The aforementioned analyses were then repeatedly stratified by race/sex classification and, separately, age group. As a sensitivity analysis, multivariable adjusted linear regression was used to test for differences in mean values among the subgroups for the percentage of total sedentary time accumulated in bouts greater than or equal to 30, 60, and 90 min, respectively.

Daily averages of sedentary breaks were computed as: 1) total number of breaks, 2) breaks per sedentary hour, and 3) mean length of breaks. Differences across subgroups for the number of sedentary breaks per day, the mean sedentary break length, and the number of sedentary breaks per hour were examined in multivariable adjusted linear regression models with adjustment for the previously listed covariates. Data analyses were conducted using SPSS version 22 (SPSS Inc, Chicago, IL).

RESULTS

Participant characteristics. Characteristics of the 8096 participants with usable accelerometer data are presented in Table 1. Participants wore the accelerometer for a mean of 866.0 ± 121.2 min·d^{-1} (14.4 ± 2.0 h·d^{-1}) over a mean of 6.9 ± 0.3 d. Sedentary behavior accounted for 77.4% ± 9.4% of total wear time, equivalent to a mean of 670.2 ± 123.9 min·d^{-1} (11.2 ± 2.1 h·d^{-1}). Light-intensity physical activity and MVPA accounted for 21.8% ± 9.0% and 1.5% ± 2.0% of total wear time, respectively.

Sedentary bouts. The distribution, percent of sedentary time, and mean length of sedentary bouts are presented in Table 2. On average, participants engaged in 68.3 ± 20.0 sedentary bouts per day, equivalent to 4.7 ± 1.3 sedentary bouts per hour of wear time. Mean (± SD) and median (± median absolute deviation) sedentary bout lengths were 11.4 ± 8.1 min and 9.7 ± 2.3 min, respectively. Most of the sedentary bouts were less than 5 min in duration (~57%) but accounted for only a small proportion of total sedentary time (~12%). Sedentary bouts greater than or equal to 30 min in duration represented 9.8% ± 7.1% of all sedentary bouts, accounting for 48.0% ± 15.5% of total daily sedentary time. The total number of sedentary bouts per day greater than or equal to 60 and 90 min were 1.9 ± 1.1 and 0.8 ± 0.7 bouts per day accounting for 26.0% ± 15.4% and 14.2% ± 12.9% of total daily sedentary time, respectively. Approximately 80% of participants engaged in one or more daily sedentary bouts greater than or equal to 60 min in duration, whereas 31% engaged in one or more daily bouts of 90 min or more. Sedentary bout characteristics stratified by race and sex and, separately, age group, are presented in Supplemental Tables 2 and 3. (See Document, SDC Supplemental Table 2: Sedentary behavior characteristics among participants in the REGARDS accelerometer study stratified by sex and race; Supplemental Table 3; Sedentary behavior characteristics among participants in the REGARDS accelerometer study stratified by age group, http://links.lww.com/MSS/A587).

TABLE 1. Characteristics of participants in REGARDS accelerometer study, 2009–2013 (n = 8096).

Variable	Mean ± SD or %
Age, %	
45–54 yr	4.7
55–64 yr	25.1
65–74 yr	41.8
≥75 yr	28.4
Male (%)	45.8
Black (%)	31.6
Region of residence,[a] %	
Non–belt/buckle	45.5
Stroke buckle	21.5
Stroke belt	33.1
BMI classification,[b] %	
Underweight	0.9
Normal weight	26.0
Overweight	39.0
Obese	33.7
Season accelerometer worn, %	
Summer	25.0
Fall	24.4
Winter	23.0
Spring	27.6
Wear time, min·d^{-1}	866.0 ± 121.2
Valid wear days, %	
4–5 d	1.4
6–7 d	98.6
Sedentary time,[c] min·d^{-1}	670.2 ± 123.9
LIPA,[d] min·d^{-1}	187.9 ± 78.3
MVPA,[e] min·d^{-1}	13.2 ± 17.7
Level of MVPA,[f] %	
0 min·wk^{-1}	63.6
>0 and <150 min·wk^{-1}	27.5
≥150 min·wk^{-1}	8.8

[a]Stroke buckle: coastal plain region of North Carolina, South Carolina, and Georgia; stroke belt: remainder of North Carolina, South Carolina, and Georgia, plus Alabama, Mississippi, Tennessee, Arkansas, and Louisiana.
[b]Underweight, <18.5 kg·m^{-2}; normal weight, 18.5–24.9 kg·m^{-2}; overweight, 25.0–29.9 kg·m^{-2}; obese, ≥30 kg·m^{-2}.
[c]Minutes in which the accelerometer registered <50 counts per minute.
[d]Minutes in which the accelerometer registered 50–1064 counts per minute.
[e]Minutes in which the accelerometer registered ≥1065 counts per minute.
[f]Defined according to the number of minutes per week of MVPA accumulated in bouts of ≥10 min.
BMI, body mass index; LIPA, light intensity physical activity, MVPA, moderate or vigorous intensity physical activity.

TABLE 2. Sedentary behavior characteristics among participants in the REGARDS accelerometer study, 2009–2013.

	Sedentary Behavior[a]			
Bout Duration (min)	No. of Bouts per Day	Percentage of All Bouts	Percentage of Total Sedentary Time	Mean Bout Length (Min)
≥1	68.3 ± 20.0	100	100	11.4 ± 8.1
≥5	28.0 ± 5.9	43.3 ± 9.6	88.2 ± 5.7	22.5 ± 10.2
≥10	16.9 ± 3.4	27.0 ± 9.6	76.7 ± 9.7	31.7 ± 11.2
≥20	8.8 ± 2.3	14.9 ± 8.3	60.0 ± 13.9	46.4 ± 12.5
≥30	5.5 ± 1.9	9.8 ± 7.1	48.0 ± 15.5	59.1 ± 13.5
≥40	3.8 ± 1.6	6.9 ± 6.2	39.1 ± 16.0	70.5 ± 14.6
≥50	2.6 ± 1.3	5.1 ± 5.4	31.8 ± 15.9	81.5 ± 16.1
≥60	1.9 ± 1.1	3.8 ± 4.7	26.0 ± 15.4	92.2 ± 17.9
≥90	0.8 ± 0.7	1.7 ± 3.3	14.2 ± 12.9	123.7 ± 24.0

Data are presented as mean ± SD.
[a]A sedentary bout is defined as consecutive minutes in which the accelerometer registered less than 50 counts per minute.

Factors associated with prolonged sedentary behavior. In multivariable adjusted models, older age, male sex, overweight and obese BMI classifications, winter season, and lower amounts of MVPA were associated with a greater likelihood of exhibiting prolonged sedentary behavior (Table 3). Residence in the stroke belt and stroke buckle were each associated with a lower likelihood of exhibiting prolonged sedentary behavior. There were no differences by race (black vs white) in adjusted models. Results were similar when stratified by race/sex categories (see Document, SDC Supplemental Table 4: Odds ratio for prolonged sedentary behavior among participants in the REGARDS accelerometer study stratified by sex and race, http://links.lww.com/MSS/A587) and age group (see Document, SDC Supplemental Table 5: Odds ratio for prolonged sedentary behavior among participants in the REGARDS accelerometer study stratified by age group, http://links.lww.com/MSS/A587). In sensitivity analyses, the pattern of results were similar when the percentage of total sedentary time accumulated in bouts greater than or equal to 30, 60, and 90 min were expressed as continuous variables, with the exception of race (see Document, SDC Supplemental Table 6: Percent of sedentary time accumulated in sedentary bouts greater than or equal 30, 60, or

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TABLE 3. Odds ratio for prolonged sedentary behavior among participants in the REGARDS accelerometer study, 2009–2013.

	No.	% of Subgroup	Odds Ratio (95% CI) for Prolonged Sedentary Behavior[a]	
			Unadjusted	Adjusted[b]
Age, yr				
45–54	91	23.8	1 (ref)	1 (ref)
55–64	616	30.4	1.40 (1.09–1.80)	1.29 (0.99–1.68)
65–74	1363	40.3	2.17 (1.70–2.77)	1.99 (1.55–2.57)
≥75	1388	60.3	4.87 (3.80–6.26)	4.68 (3.61–6.07)
			P trend <0.001	*P* trend <0.001
Sex				
Female	1695	38.7	1 (ref)	1 (ref)
Male	1763	47.5	1.44 (1.32–1.57)	1.41 (1.28–1.56)
Race				
White	2320	41.9	1 (ref)	1 (ref)
Black	1138	44.5	1.11 (1.01–1.22)	1.06 (0.96–1.18)
Region of residence[c]				
Non–belt/buckle	1679	45.6	1 (ref)	1 (ref)
Stroke buckle	700	40.3	0.81 (0.72–0.90)	0.87 (0.77–0.98)
Stroke belt	1079	40.3	0.81 (0.73–0.89)	0.86 (0.77–0.95)
BMI classification[d]				
Underweight	21	29.2	0.78 (0.47–1.31)	0.81 (0.47–1.38)
Normal weight	725	34.5	1 (ref)	1 (ref)
Overweight	1323	41.9	1.37 (1.22–1.54)	1.33 (1.18–1.51)
Obese	1366	50.0	1.90 (1.69–2.13)	2.15 (1.89–2.44)
Season				
Summer	855	42.2	1 (ref)	1 (ref)
Fall	824	41.7	0.98 (0.86–1.11)	0.96 (0.84–1.10)
Winter	845	45.4	1.14 (1.00–1.29)	1.18 (1.03–1.35)
Spring	934	41.8	0.98 (0.87–1.11)	0.94 (0.83–1.07)
Level of MVPA,[e] $min \cdot wk^{-1}$				
0	2497	48.5	2.35 (1.98–2.78)	2.00 (1.66–2.40)
>0 and <150	755	34.0	1.28 (1.07–1.54)	1.21 (1.00–1.47)
≥150	205	28.6	1 (ref)	1 (ref)
			P trend <0.001	*P* trend <0.001

[a]Defined as participants who accumulate ≥50% of total sedentary time in bouts of ≥30 min.
[b]Adjusted for the following covariates: wear time, age category, sex, race, region of residence, body mass index classification, season, and level of moderate/vigorous intensity physical activity.
[c]Stroke buckle: coastal plain region of North Carolina, South Carolina, and Georgia; stroke belt: remainder of North Carolina, South Carolina, and Georgia, plus Alabama, Mississippi, Tennessee, Arkansas, and Louisiana.
[d]Underweight, <18.5 $kg \cdot m^{-2}$; normal weight, 18.5–24.9 $kg \cdot m^{-2}$; overweight, 25.0–29.9 $kg \cdot m^{-2}$; obese, ≥30 $kg \cdot m^{-2}$.
[e]Defined according to the number of minutes per week of MVPA accumulated in bouts of ≥10 min.

90 min among subgroups of participants in the REGARDS accelerometer study, http://links.lww.com/MSS/A587). In adjusted models, black participants accumulated a greater proportion of total sedentary time from bouts greater than or equal to 60 and 90 min, respectively, when compared to white participants.

Sedentary breaks. The number (total and per sedentary hour) and length of sedentary breaks among the entire analytic sample and stratified by subgroups are presented in Table 4. On average, participants took 6.4 ± 2.4 breaks per hour of sedentary time, with each break lasting a mean of 2.8 ± 0.8 min. In multivariable adjusted models, the number of breaks per hour of sedentary time and length of sedentary breaks were both significantly lower among the participants who were older, male, wore the accelerometer during winter, and engaged in lower amounts of MVPA.

DISCUSSION

This study characterized the patterns of sedentary behavior in a US national cohort of 8096 middle- and older-age adults enrolled in the REGARDS study. In this sample, more than 11 h of the waking day on average were spent in sedentary behavior, almost one-half of which was accumulated in prolonged, uninterrupted sedentary bouts of 30 min or longer. Several factors, including older age, male sex, residence in nonstroke belt/buckle region, overweight/obesity, winter season, and lower amounts MVPA were associated with patterns of prolonged sedentary behavior. These findings highlight prolonged, uninterrupted sedentary behavior as a potential target for behavioral intervention and identify populations (e.g., elderly, overweight/obese) in whom interventions targeted at increasing sedentary breaks may be most warranted.

The proportion of total sedentary time accumulated in prolonged, uninterrupted sedentary bouts in this study sample are substantially higher than reported among 7247 middle- and older-age female health professionals enrolled in the Women's Health Study. Sedentary bouts greater than or equal to 20, 30, and 60 min accounted for 44%, 31%, and 11% of total sedentary time in the Women's Health Study (31) but accounted for 60%, 48%, and 26% of total sedentary time in the current study sample. These proportions were greater even when restricting the REGARDS sample to women only (black females: 59%, 47%, and 27%; white females: 58%, 46%, and 24%). Differences in sample characteristics including age, occupation (e.g., health professionals), race/ethnicity, socioeconomic status, and other social or environmental

TABLE 4. Characteristics of sedentary breaks among participants in the REGARDS accelerometer study.

	No. of Sedentary Breaks[a]		Breaks[a] per Sedentary Hour		Length of Sedentary Breaks[a] (min)	
	Mean ± SD	Adjusted Mean Difference[b]	Mean ± SD	Adjusted Mean Difference[b]	Mean ± SD	Adjusted Mean Difference[b]
All Participants	68.8 ± 20.0	—	6.4 ± 2.4	—	2.8 ± 0.8	—
Age, yr						
45-54	78.0 ± 17.3	1 (ref)	8.0 ± 2.5	1 (ref)	3.4 ± 0.9	1 (ref)
55-64	74.6 ± 18.7	−2.3 ± 0.9	7.2 ± 2.3	−0.6 ± 0.1[f]	3.0 ± 0.8	−0.3 ± 0.0[f]
65-74	70.1 ± 18.7	−5.7 ± 0.9[f]	6.6 ± 2.2	−1.2 ± 0.1[f]	2.8 ± 0.8	−0.5 ± 0.0[f]
≥75	60.4 ± 20.6	−15.2 ± 0.9[f]	5.3 ± 2.1	−2.5 ± 0.1[f]	2.3 ± 0.6	−0.9 ± 0.0[f]
Sex						
Female	70.6 ± 20.5	1 (ref)	6.6 ± 2.4	1 (ref)	2.6 ± 0.7	1 (ref)
Male	66.7 ± 19.3	−4.6 ± 0.4[f]	6.2 ± 2.3	−0.4 ± 0.0[f]	2.9 ± 0.9	0.3 ± 0.0[f]
Race						
White	69.5 ± 19.2	1 (ref)	6.5 ± 2.3	1 (ref)	2.9 ± 0.8	1 (ref)
Black	67.4 ± 21.7	−0.5 ± 0.4	6.3 ± 2.5	−0.1 ± 0.1	2.6 ± 0.7	−0.2 ± 0.0[f]
Region of residence[c]						
Non–belt/buckle	67.9 ± 20.2	1 (ref)	6.2 ± 2.3	1 (ref)	2.7 ± 0.8	1 (ref)
Stroke buckle	69.7 ± 19.5	1.6 ± 0.5[f]	6.6 ± 2.4	0.2 ± 0.1[f]	2.8 ± 0.8	0.1 ± 0.0[f]
Stroke belt	69.6 ± 20.1	1.5 ± 0.4[f]	6.6 ± 2.4	0.2 ± 0.1[f]	2.8 ± 0.8	0.0 ± 0.0
BMI classification[d]						
Underweight	76.5 ± 22.0	0.2 ± 2.0	6.9 ± 2.6	−0.1 ± 0.3	2.6 ± 0.8	−0.1 ± 0.1
Normal weight	73.5 ± 20.6	1 (ref)	6.9 ± 2.5	1 (ref)	2.8 ± 0.8	1 (ref)
Overweight	69.4 ± 18.9	−2.8 ± 0.5[f]	6.5 ± 2.3	−0.3 ± 0.1[f]	2.8 ± 0.8	0.1 ± 0.0[f]
Obese	64.5 ± 19.9	−8.2 ± 0.5[f]	6.0 ± 2.3	−1.0 ± 0.1[f]	2.7 ± 0.8	0.0 ± 0.0
Season						
Summer	69.5 ± 19.7	1 (ref)	6.5 ± 2.3	1 (ref)	2.8 ± 0.8	1 (ref)
Fall	69.2 ± 20.2	0.7 ± 0.5	6.5 ± 2.4	0.1 ± 0.1	2.7 ± 0.8	−0.1 ± 0.0
Winter	67.6 ± 20.0	−1.2 ± 0.5	6.3 ± 2.4	−0.2 ± 0.1[f]	2.7 ± 0.8	−0.1 ± 0.0[f]
Spring	68.9 ± 20.2	−0.1 ± 0.5	6.4 ± 2.4	0.0 ± 0.1	2.8 ± 0.8	0.0 ± 0.0
Level of MVPA,[e] $min \cdot wk^{-1}$						
0	65.7 ± 21.2	−2.5 ± 0.7[f]	6.1 ± 2.5	−0.8 ± 0.1[f]	2.5 ± 0.7	−0.9 ± 0.0[f]
>0 and <150	73.9 ± 16.7	1.0 ± 0.7	6.9 ± 2.1	−0.2 ± 0.1	3.1 ± 0.7	−0.5 ± 0.0[f]
≥150	75.1 ± 15.7	1 (ref)	7.3 ± 2.0	1 (ref)	3.6 ± 0.8	1 (ref)

[a] Defined as at least 1 min in which counts registered at least 50 counts after a sedentary bout.
[b] Adjusted mean difference compared to referent group; adjusted for the following covariates: wear time, age category, sex, race, region of residence, BMI classification, season, and level of moderate/vigorous physical activity.
[c] Stroke buckle: coastal plain region of North Carolina, South Carolina, and Georgia; stroke belt: remainder of North Carolina, South Carolina, and Georgia, plus Alabama, Mississippi, Tennessee, Arkansas, and Louisiana.
[d] Underweight, <18.5 $kg \cdot m^{-2}$; normal weight, 18.5–24.9 $kg \cdot m^{-2}$; overweight, 25.0–29.9 $kg \cdot m^{-2}$; obese, ≥30 $kg \cdot m^{-2}$.
[e] Defined according to the number of minutes per week of MVPA accumulated in bouts of ≥10 min.
[f] $P < 0.01$ vs referent group.

factors may, in part, account for the discrepant results between the studies. Differences in accelerometer protocol/processing may also contribute to the discrepant results. First, different accelerometer devices were used (Women's Health Study: ActiGraph GT3X+; REGARDS: Actical). Second, a higher count threshold to define sedentary behavior was used in the Women's Health Study (0–99 vs 0–49 counts per minute in REGARDS). Finally, nonwear was defined as 90 min or more of zero activity counts with allowances for 2 min or less of nonzero activity counts in the Women's Health Study (vs ≥150 consecutive minutes of zero activity counts in REGARDS). As device, sedentary count threshold, and nonwear threshold duration have all been reported to influence classification of sedentary time (23,27,28), between-study differences should be interpreted cautiously.

Current guidelines recommend all age groups from children to older adults minimize the amount of time spent being sedentary for extended periods (12). These guidelines, however, stop short of making specific recommendations about how often to take sedentary breaks. Investigators have posed sedentary breaks every 30 min as a feasible recommendation (4,9), which are supported by laboratory-based studies showing sedentary breaks every 20–30 min elicit beneficial cardiometabolic effects (5,10,29). Our results suggest guidelines aimed within the window of every 20–30 min could be an optimal target to interrupt sedentary behavior, as our participants averaged approximately 9 and 5 sedentary bouts per day longer than 20 and 30 min, respectively, accounting for 60% and 48% of total sedentary time. A recent laboratory-based study showed that sedentary breaks every 60 min elicited beneficial cardiometabolic effects (1); suggestive that less frequent sedentary breaks may still confer health benefits. From a feasibility/adoption standpoint, sedentary breaks every 60 min may be more tenable for public health uptake and dissemination. However, our findings indicate middle- and older-age adults only averaged about two sedentary bouts per day longer than 60 min; accounting for only 26% of total sedentary time. Future studies investigating the sedentary bout length and frequency of sedentary breaks that elicit the greatest cardioprotective benefit may be warranted to develop more specific sedentary guidelines.

To build evidence-based approaches for addressing sedentary behavior, there is a need to understand the factors that influence patterns of prolonged sedentary behavior. This study adds new information related to the correlates of

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prolonged sedentary behavior as we found various sociodemographic (age, sex, and BMI), behavioral (MVPA), environmental (region of residence), and seasonal factors were associated with patterns of prolonged sedentary behavior. These findings are largely consistent with previous studies assessing correlates of total sedentary time, as older age, greater BMI, and lower amounts of MVPA have been associated with greater total sedentary time (30). Thus, it seems the factors associated with overall sedentary behavior may similarly influence patterns of prolonged sedentary behavior. Notably, the most marked differences were observed for older age, as individuals age 65–74 and 75 yr or older had a twofold and fourfold greater likelihood of exhibiting prolonged sedentary behavior compared to individuals age 45–54 yr. Furthermore, when older age individuals engaged in a sedentary break, these breaks were on average shorter in duration relative to younger individuals. These findings highlight older age adults as a potential high-priority population for interventions targeted at increasing sedentary breaks and in whom the public health message "Stand Up, Sit Less, Move More, More Often" (9) may be most pertinent.

Previous studies have reported physical activity behaviors are influenced by several environmental attributes including geographical region, season, and weather (35). Our findings extend this body of evidence to sedentary behavior patterns, as we observed regional and seasonal differences in bouts of prolonged sedentary behavior. We found that individuals who completed 7-d accelerometry during the winter were more likely to exhibit patterns of prolonged sedentary behavior. Sedentary behaviors have been reported to increase on days with lower temperature, less sunshine, inclement weather, and fewer daylight hours (11), conditions common in winter. The increase in prolonged sedentary behavior during winter may also be influenced by changes in psychological mood or emotional state (21). In the present study, we also observed individuals residing in the southeastern United States were less likely to exhibit patterns of prolonged sedentary behavior. As the southeastern United States experiences milder winters, earlier springs, and later falls, the regional differences in prolonged sedentary behavior could, in part, be due to seasonal variations across regions.

Breaks in sedentary time have received considerable interest in recent years as a potentially important adjunct to physical activity guidelines. Data from the 2003–2006 NHANES indicated that on average, adults took 92 breaks in sedentary behavior per day, with the mean break lasting 4.1 min (15). The number of sedentary breaks in the REGARDS sample was substantially fewer, as participants averaged 68 breaks in sedentary behavior per day, with the mean break lasting 2.8 min. The differences may be partially attributed to the use of a higher count threshold to define sedentary behavior (0–99 counts per minute in NHANES vs 0–49 counts per minute in REGARDS) and age differences between the study samples as 38% of the 4757 participants analyzed in the NHANES sample were younger than 40 yr old. Interestingly, in the NHANES sample, a greater number of sedentary breaks was only minimally associated with BMI (a difference of 1.4 breaks per day comparing obese to normal weight), leading investigators to suggest this specific behavior may not be protective against obesity onset (36). Our findings are contrary to this conclusion, as obese individuals in the REGARDS sample took significantly fewer breaks (approximately eight fewer breaks per day) compared to normal-weight individuals. Future studies are needed to determine the causal relationship between breaks in sedentary time and adiposity.

There are several strengths to our study. First, the REGARDS study is one of the largest population-based studies conducted in the United States and includes a biracial sample of participants recruited from across the United States. Second, patterns of sedentary behavior were objectively measured. Finally, participants were extremely compliant to the 7-d protocol, thus providing a large pool of quality accelerometer data. Several limitations, however, should be noted when interpreting our findings. First, the Actical accelerometer cannot distinguish between different postures (e.g., sitting, standing), thus we relied on an intensity-only definition of sedentary behavior (as opposed to an intensity and posture definition) (13). As such, sedentary time may be overestimated as some standing with negligible movement may also be included. Second, it is likely that some participants did not wear the accelerometer during all waking hours. Thus, despite the high compliance to the 7-d protocol, sedentary time may be underestimated, particularly among female, black, and obese participants in whom differential wear time was observed. Third, some of the participant characteristics were collected at baseline, several years before wearing the accelerometer, and may have changed (e.g., BMI). However, even moderate changes within a small proportion of participants would likely not significantly affect group means, proportions, or comparisons in our large sample. Finally, as previously reported (20), participants who agreed to complete the 7-d accelerometer protocol had a higher socioeconomic status compared to those who did not, suggestive of a volunteer bias. In addition, participants with noncompliant wear time were more likely to be female, black, and obese compared to those with compliant wear time. Thus, our findings may not be generalizable to the entire REGARDS cohort.

In conclusion, in a geographically diverse, biracial population-based sample of middle-age and older age US adults, a large proportion of total sedentary time is accumulated in prolonged, uninterrupted bouts of sedentary behavior. Several sociodemographic (older age, male sex, higher BMI), behavioral (lower MVPA), environmental (region of residence in nonstroke belt/buckle) and seasonal (winter season) factors were associated with patterns of prolonged sedentary behavior. If the cardiometabolic risk conferred by prolonged, uninterrupted sedentary behavior is confirmed in future studies, these data may be useful to inform specific recommendations for reducing this potentially hazardous behavior.

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