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Pattern Analysis of Sedentary Behavior Change after a Walking Intervention

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Abstract

Objectives: We examined the pattern of change in sedentary behavior (SB) resulting from a physical activity (PA) intervention in older adults, and the influence of sex on changes in SB.

Methods: One hundred twenty (N = 120) inactive older adults from 2 12-week step/day-target interventions were included in this pooled reanalysis. Participants were randomly assigned to an intervention (STEP) or control group (CON). A Hip-worn accelerometer (Actigraph) was used to assess SB and PA.

Results: Significant decreases in SB (–25 minutes) were largely accounted for by the increase in moderate- to vigorous-intensity PA (MVPA; +17.3 minutes). More broadly, data showed that for every 1% increase in proportion of time spent in MVPA, SB decreased by 1.21%. Results of the pattern analysis showed significant pre-post decreases in the number of daily sedentary bouts lasting 10, 20, and 30 minutes and the number of sit-to-stand transitions in the STEP group. Males tended to decrease time spent in longer bouts and females tended to decrease the number of sit-to-stand transitions to achieve lower SB.

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Conflict of Interest Disclosure Statement

The authors have no conflicts of interest to declare.

Clinical Trials Registration

[Clinicaltrials.gov](https://clinicaltrials.gov) NCT-01212978

Conclusions: Decreases in SB were accomplished through reductions in shorter bouts of SB and likely through a variety of small changes that differed between individual participants and sexes.

Keywords

actigraphy; walking; sedentary lifestyle

As adults age, they tend to become more sedentary and less active. Research shows that older adults spend at least 60% of their waking day engaging in sedentary behavior (SB),¹ and just over 50% do not meet physical activity (PA) guidelines.² These high levels of sedentary behavior and low levels of physical activity can have negative impacts on health. Prolonged or high amounts of time engaging in SB increases risk for chronic disease and reduces physical functioning.³⁻⁶ The effects of SB can compound the high rates of chronic disease and poorer physical function seen in older adults. Given that current physical activity guidelines recommend reductions in SB in addition to engaging in regular PA,⁷ reducing sedentary time and increasing PA is a priority for practitioners and researchers.

Sedentary behavior⁸ and PA⁹ behavior are both part of the energy expenditure continuum and are behaviors that can be changed. Interventions aimed to decrease SB have shown modest reductions in SB in older adults,¹⁰⁻¹⁴ and research has shown that PA levels of older adults can be increased as a result of interventions designed to improve physical activity level.¹⁵ Despite SB and PA being part of the energy expenditure continuum, these 2 behaviors are thought to be distinct. Therefore, research has explored the transferability of interventions targeting one behavior (eg, PA) on the other behavior (eg, SB). A handful of studies have addressed the direct effect of an aerobic-based PA intervention on changing SB in older adults.¹⁶⁻²⁰ Overall, these studies suggest PA interventions have a positive influence on SB, with the largest changes to SB seen with self-report data or in studies using objective assessment of SB that included both adults and older adults (25 years – 75 years).^{16,17,19} Specifically, changes in SB ranged from a 48-minute reduction in objectively measured (by ActivPal) sedentary time after 12 weeks of a pedometer based intervention,² to a 51-minute reduction in subjectively determined (IPAQ) sedentary time after a 6-month intervention,¹⁶ to a 2-hour reduction in subjectively determined (IPAQ) sedentary time after a 6-month intervention.¹⁹ Whereas research shows that high levels of SB are detrimental to health, and reducing high levels of SB has positive impacts on health, evidence suggests that the pattern in which sedentary time is accumulated may be as important as total sedentary time.²¹ Specifically, prolonged SB bouts have been shown to be more detrimental than short bouts, the pattern of change in SB may be important when evaluating the intervention impact. A better understanding of the change pattern of sedentary behavior resulting from physical activity interventions will strengthen our understanding of SB in older adults.

Older males have been shown to be more sedentary than older females with more sedentary time accumulated in both short and long bouts.^{22,23} Furthermore, older females break up their sedentary time more than older males.^{22,23} Whereas cross-sectional studies show a difference in SB and SB patterns between males and females, there is a lack of information on the influence of sex on changes in sedentary behavior in response to a physical activity intervention within the older adult population. Understanding how changes to these patterns

of sedentary behavior differ between sex, and whether males and females respond differently will deepen our understanding of SB.

Therefore, the purpose of this study was to expand on previous research by: (1) performing an extensive pattern analysis of the change in SB resulting from a physical activity intervention; and (2) examining the influence of sex on changes in SB.

METHODS

Overview and Participants

The current study focuses on a secondary analysis of 2 12-week pedometer-based 10,000 step/day interventions in previously inactive older adults. Full methods and design of each randomized controlled trial have been described in detail elsewhere.^{24,25} Briefly, each study recruited older adults (50 and 80 years of age) that were community dwelling, inactive, but in relatively good health with no uncontrolled cardiovascular or metabolic disease. Specific inclusion and exclusion criteria were previously reported.^{24,25} Study 1 included a sample of 61²⁵ and Study 2 included a sample of 107.²⁴ All older adults accumulated less than 8000 steps/day over a one-week blinded baseline pedometer assessment period, with group means ranging from 4931±1667 to 5474±1512 (mean ± SE) steps/day. Both randomized controlled trials had an intervention group (STEP) and a control group (CON). The intervention component was designed to increase steps/day above baseline values by setting targets to increase steps by 10% per week up to a maintenance target of 10,000 steps/day by intervention end. Different intervention delivery modalities were used across the trials: mail, telephone, and Internet. The current study is a secondary analysis that is limited to 120 individuals across both studies who had complete accelerometry data at baseline and post-12-week intervention, with a focus to evaluate the change (or lack of) in SB, not the intervention efficacy (previously reported by Suboc et al²⁴ and Strath et al²⁵).

Study Procedures

All study procedures were carried out prior to and immediately following the 12-week intervention. Participants completed the following measures: self-reported current and past health, age, sex, height,²⁶ weight,²⁶ and the 7-day accelerometer-based PA assessment.

7-day Physical Activity and Sedentary Behavior Assessment

Participants completed a 7-day PA and SB assessment before the intervention and during the 12th and final week of the intervention. Participants were asked to wear a hip-worn accelerometer-based motion sensor (Actigraph GTX3, Actigraph 7164) during all waking hours for 7 consecutive days. In Study 1,²⁵ 61 individuals wore an Actigraph 7164, and in Study 2,²⁴ 107 individuals wore an Actigraph GT3X.

Accelerometer data were downloaded onto a laboratory computer and processed using R software (R Core Team (2016). Data were analyzed in 60-second epochs without the use of the low-frequency extension (GT3X option only). The Choi algorithm²⁷ was used to determine non-wear time. Valid accelerometer wear was defined as 600 minutes of accelerometer wear time per day and a minimum of 4 days of data per week. Data were

averaged over the 7-day assessment periods (baseline and end of intervention). To determine time spent in SB and PA, vertical plane data were analyzed and a combination of Freedson et al.²⁸ and Matthews et al.²⁹ cut points were applied. Sedentary behavior was defined as <100 counts per minute (CPM); light intensity physical activity (LPA) was defined as 100–759 CPM; lifestyle-moderate intensity physical activity (LMPA) was defined as 760–1951 CPM; moderate intensity physical activity (MPA) was defined as 1952–5724 CPM; vigorous intensity physical activity (VPA) was defined as ≥5725 CPM; and moderate to vigorous physical activity (MVPA) was defined as ≥1952 CPM.

The Actigraph GT3X (Pensacola, FL; 3.8×3.7×1.8 cm; 27 g) is a triaxial accelerometer-based PA monitor with a dynamic range of 2 g. The Actigraph 7164 accelerometer (5.08 × 4.06 × 1.53 cm; 42g), an earlier version of the GT3X, was a uniaxial accelerometer capable of recording accelerations ranging from 0.05 to 2 G with frequencies of 0.25–2.5 Hz.³⁰ The Actigraph 7164 and GT3X have demonstrated congruency, and have been shown to be valid and reliable activity monitors across many different populations.^{28,29,31-36}

Outcome Measures

The primary outcomes of interest (dependent variables) for this study are time spent in sedentary behavior as expressed relative to wear time (proportion of time spent in SB (percentage of day) and total sedentary time (hours or minutes per day) before and after the intervention. Additionally, to improve understanding of the pattern of sedentary behavior,^{37,38} characteristics of sedentary behavior were examined. These characteristics are listed and defined in Table 1. Additionally, measures of PA are reported, including time spent in light-intensity, lifestyle-moderate-intensity, moderate-intensity, and vigorous-intensity PA (percentage of day and total time (minutes per day)) before and after the intervention are reported.

Data Analysis

Continuous variables are summarized as mean ± standard deviation (SD) and categorical variables are described as frequency (*n*) and percentage (%). To compare baseline differences between the intervention and control groups, Pearson's chi-square test was used for categorical variables and the t-test and non-parametric Wilcoxon rank sum test were used to compare continuous variables, where appropriate. For univariate (unadjusted) comparisons of pre-post differences in the sedentary and PA behaviors, paired t-tests were used. To model each of the sedentary, PA intensity, ratio measures, and the characteristics and patterns of sedentary measures at pre- and post-intervention time points (see outcome measures section for list and definitions of dependent variables), mixed -effects models with a random intercept, which allows participants to vary with respect to their baseline activity level, was used. The main independent variables of interest are Group and Time and the covariates adjusted for include age and sex. Specifically, this model was used to test whether the pre-post change was different between the intervention and control groups (ie, time × group interaction). To control for the potential confounding effects of age and sex, all models included these 2 variables. All analysis was performed using SAS 9.4 (Cary, NC).

RESULTS

A total of 120 older adults were included in this pooled reanalysis, with 48 participants excluded from the original cohorts due to incomplete accelerometer data. Eighty-four individuals were assigned to the STEP group (64% female), and 36 participants were assigned to the CON group (27% female). On average, the participants were 63.3 years of age and approximately one-fifth of the participants were classified in the normal BMI category.³⁹ When comparing the baseline characteristics between the STEP group and the CON group, no statistically significant baseline demographic differences were observed (Table 2). A significant difference in the proportion of waking day spent being sedentary was the only between-group difference in SB or indicators of pattern of SB at baseline, with the CON group spending a significantly higher portion of the day in SB than participants in the STEP group (67% vs 63.3% of day, $p = .0249$; Table 2). Accelerometer wear time did not differ between groups at baseline and did not change with the intervention.

Within-group analyses (pre-post) showed significant pre-post changes in SB in the STEP group (Table 3). Specifically, the STEP group exhibited significant decreases in the percent of wear time spent sedentary ($-3 \pm 0.07\%$, $p = .0004$), minutes/day sedentary (-25 ± 98 minutes, $p = .0247$), the number of sit-to-stand transitions (-3.4 ± 12.5 , $p = .0177$), and in the number of daily sedentary bouts lasting 10 (-1.04 ± 3.59 , $p = .0121$), 20 (-0.72 ± 2.06 , $p = .0028$) and 30 (-0.46 ± 1.39 , $p = .0042$) minutes. There were no changes in the number of daily sedentary bouts lasting 60, 120, or 240 minutes. No significant changes were seen in any SB characteristics in the CON group. The only between group difference in pre-post change scores was seen in percent of day spent in SB ($p = .0324$; Table 3).

Results of the mixed-effects models show that the group by time interaction for total sedentary time in minutes/day ($p = .0232$) and number of sit-to-stand transitions ($p = .0031$) was significant (Table 4). However, the group by time interaction for any of the sedentary behavior pattern variables were not statistically significant (Table 4). A group by sex interaction was seen with females having lower sedentary time ($p = .0413$), a higher number of sit-to-stand transitions ($p = .0002$), lower maximum sedentary bout length ($p = .0266$), lower weighted median sedentary bout length ($p = .0008$), lower percentage of total sedentary bouts of a length greater than the weighted median (Est. = $-.02$, SE = $.01$, $p = .014$), a higher alpha ($p = .0018$) and a lower Gini index (Est. = $-.02$, SE = $.01$, $p = .0035$) compared with males (Table 4).

Further analyses by sex revealed that within the STEP group, males showed a statistically significant pre-post intervention decrease in the percentage of total sedentary time accounted for by bouts greater than the weighted median ($p = .0374$), and females in the STEP group significantly decreased the number of sit-to-stand transitions ($p = .0176$) (Table 5). The CON group did not show pre-post changes in any of the characteristics of sedentary behavior in either the males or females.

At baseline, the STEP group spent approximately 25.8%, 8.4%, and 2.4% of their daily time engaging in LPA, LMPA, and MVPA, respectively. The control group spent 24.4%, 6.5%, and 2.1% of their baseline daily time engaging in LPA (between groups $p = .222$), LMPA

(between groups $p = .0052$), and MVPA (between groups, $p = .234$), respectively. After the 12-week intervention, the change across time was not statistically significant between the 2 groups for percent of wear time in LPA ($p = .3153$) or LMPA ($p = .876$). However, the groups exhibited significantly different trends in their change in proportion of time engaging in MVPA ($p < .0001$). Specifically, when examining the median of the change from baseline, the CON group decreased percent of daily wear time spent in MVPA by 0.1%, resulting in 2.0% of the post intervention day spent in MVPA. The STEP group increased their percent of daily wear time spent in MVPA by 2%, resulting in 4.5% of their post intervention day spent in MVPA, almost doubling their time spent in MPA from their baseline level ($p < .0001$). Results of a mixed-effects model showed a significant group $\times$ time interaction for percent of wear time in SB (Est. = $-.03039$, SE = $.01385$, $p = .0303$) and MVPA (Est. = $.02134$, SE = $.005102$, $p < .0001$), but not LPA ($p = .3153$) or LMPA ($p = .876$).

To investigate whether people who increase their MVPA also tend to decrease their SB, we first explored a simple ratio of time (minutes) spent in SB to time spent in MVPA, then we explored the SB:MVPA change scores. On average, the participants in the CON group spent 37.5 minutes in sedentary activity for every minute in moderate physical activity compared to the 34:1 ratio for the STEP group at baseline ($p = .1264$). However, after the 12-week intervention, the 2 groups followed significantly different trajectories ($p < .0001$). Whereas the participants in the CON group slightly increased their sedentary:moderate ratio to 38:1, the participants in the STEP group significantly reduced their ratio of time to 19:1. To investigate further whether people that increase MVPA over time tend to decrease SB over time, the change in proportion of time spent in SB (post - pre SB) was predicted from the proportion of time spent in MVPA (post - pre MVPA) using multiple regression. The group variable was not included in the model as it was redundant with the MVPA change variable (ie, collinearity issues). Age and sex were included as covariates, but they did not add explanatory value to the model $F_{2,101} = .136$, $p = .874$. Therefore, age and sex were removed from the model. The final model showed that between weeks 1 and 12, for every 1% increase in proportion of time spent in MVPA, SB decreased by 1.21% ($R^2 = .21$, $F_{1,103} = 27.39$, $p < .001$).

DISCUSSION

The aim of this study was to perform an extensive pattern analysis on the change in SB in response to a step-goal based PA intervention. Results of this study showed that the intervention resulted in significantly less sedentary time (almost 3% of wear time, or 25 minutes) accumulated throughout the day. Additionally, the pattern of SB changed from the intervention. The intervention group showed statistically significant decreases in the number of medium-length sedentary bouts lasting 10-, 20-, and 30-minutes or longer and fewer sit-to-stand transitions post-intervention compared with baseline. We saw no changes in longer sedentary bouts (> 60 minutes), or the distribution of sedentary bouts (alpha, Gini Index, weighted median) from the intervention. Because accelerometer wear time did not change, the reduction in sedentary behavior was replaced with an increase in physical activity behavior. Specifically, a large portion of the decrease in SB was accounted for by the increase in MPA (+17.3 minutes).

Recent reviews have addressed whether interventions that aim to increase PA can also have a meaningful impact on SB. Results of a meta-analysis performed by Prince et al⁴⁰ concluded that PA interventions reduced sedentary time of approximately 19 minutes/day; however, results were not consistent among interventions and few studies focused on older adults. More recently, Martin et al⁴¹ concluded that PA interventions did not result in a reduction in sedentary time. Included in these meta-analyses was a 12-week randomized control trial that included inactive adults 65 years and older who were living independently.²⁰ Results from Mutrie et al²⁰ showed a substantial reduction in sedentary time of approximately 48 minutes, whereas the control group increased by approximately 20 minutes. Results of the current study, while statistically significant, were not as large as those reported by Mutrie et al, showing a reduction in sedentary time of approximately 25 minutes or ~3% of wear time. New information from this study helps researchers and practitioners better understand how the decreases in sedentary behavior were realized by participants. Largely, these reductions in sedentary behavior were seen through fewer sedentary bouts 10, 20, and 30 minutes, fewer sit-to stand transitions, and more MVPA. However, changes to the SB variables were small. Therefore, these data suggest that a step-based PA intervention can have a small but positive impact on overall SB, while focusing on changing PA behavior.

Studies examining the patterns of sedentary behavior in older adults show that they are indeed highly sedentary and that this population tends to accumulate sedentary time in shorter bouts.^{1,23,42-46} Baseline data from the current study confirmed high levels of SB with substantial amounts being accumulated in short bouts. The weighted median sedentary bout length at baseline was 2.3-2.4 minutes, suggesting that there is a high frequency of short bouts being performed daily. It is likely that these short bouts are utilitarian in nature, and they may be difficult to change, as evidenced by these results that showed no change in the weighted median sedentary bouts after the PA intervention. Further examination of SB bout data showed that when we look at duration of sedentary bouts, participants in this study accumulated ~19.5 bouts/day 10 minutes, ~9.5 and 10 bouts/day 20 minutes, ~5.5 bouts/day 30 minutes, and ~1 bout/day 60 minutes. This quantity of bouts/day is consistent (but slightly higher) with data from the Women's Health Study that showed that participants accumulated 15.9 bouts/day 10 minutes, 7.0 bouts/day 20 minutes, 3.8 bouts/day 30 minutes, and 0.9 bouts/day 60 minutes.⁴⁷ Both data from the Women's Health Study⁴⁷ and the current study confirm that older adults accumulate sedentary behavior in shorter bouts, with little sedentary behavior occurring in bouts of 60 minutes or longer. After completion of the step-based PA intervention, changes to the number of bouts/day showed significant decreases in the number of medium length bouts (10, 20 and 30 minutes), but not 60 minutes, suggesting that interventions focused on increasing PA will reduce sedentary behavior by reducing the medium length sedentary bouts, which are also the most prevalent.

Although the data showed a statistically significant decrease in sedentary behavior, and the number of bouts 10, 20, and 30 minutes, the mean changes in bout numbers were not large. Additionally, the other variables that examine bouts (maximum sedentary bout length, weighted median sedentary bout length, alpha) or accumulation of sedentary time (Gini Index) did not change, suggesting that individuals reduced their sedentary time through a reduction in medium length bouts as well as a variety of small changes that differed between

individual participants. Because the intervention did not focus on decreasing SB, but rather increasing PA, no specific behavior change theories were applied to change SB or the pattern in which sedentary behavior is accumulated. Chastin et al showed that older adults reported their sedentary behavior was determined by sociocultural factors such as self-efficacy, functional limitations, ageist stereotypes, locus of control, and pain.⁴⁸ Further, Gardiner showed that goal setting and behavioral self-monitoring are important to changing sedentary behavior.⁴⁹ Whereas some of these SB determinants are similar to the determinants of PA, the strength of their influence may differ. Therefore, while total sedentary behavior may be changed through a PA intervention, larger and more specific changes to the pattern of accumulation of sedentary behavior may depend on the behavioral theory and intervention approach applied. Therefore, if the goal is to change total time in sedentary behavior and a specific aspect of the pattern of SB, then a tailored and directed approach taking into consideration the individual may be warranted.⁵⁰

Interestingly, the mixed models that accounted for age, sex, intervention/control group, and time showed statistically significant and meaningful sex differences in sedentary behavior (percent of wear time and hours/day) and markers of the pattern of sedentary behavior accumulation (maximum bout length, weighted median sedentary bout length, percent of total sedentary time in bouts longer than weighted median sedentary bout, alpha, or Gini index). Females tended to spend less time in sedentary behavior and engage in shorter bouts of sedentary behavior. These results are in agreement with Bellettiere et al²² who showed males living in retirement communities accumulated significantly more time in sedentary behavior and more time in longer bouts of sedentary behavior than females living in retirement communities; moreover, females accumulated more of their sedentary time in short bouts (< 1 minute) of sedentary behavior. Bellettiere et al²² postulated that engagement in household activities such as cleaning and cooking could help to explain the difference between older males and females, with females engaging in more household activities than males. Data from this study suggested that after the physical activity intervention, females decreased the number of sit-to-stand transitions by possibly spending more time in activity. Males reduced the percent of total sedentary time in bouts that were longer than the weighted median sedentary bouts, thereby reducing the time spent in bouts longer than approximately 2-minutes. These results, along with other research, suggest that successful interventions to reduce sedentary time and to change the pattern of SB accumulation may require different intervention strategies for males and females.

Most research to date suggests that there are substantial benefits to increasing MVPA, with the physical activity recommendations focusing on MVPA. There has been emerging evidence to support the negative effect of excessive and prolonged sitting has on health. Therefore, when examining any intervention aimed at improving health, it is logical to examine both moderate-to-vigorous physical activity and sedentary behavior together. A simple ratio that accounts for both sedentary behavior and moderate-to-vigorous physical activity can be useful and informative. The ratio can be favorably altered by engaging in health enhancing behaviors, either decreasing sedentary time, or increasing time in moderate-to-vigorous physical activity, or both, and can be applied to time (minutes) or number of bouts. Such a manner of expressing data lends itself to unguided or individually guided behavior change. Providing a patient or client with a goal of (for instance) 12:1

(which would equate to 6 hours of sitting and 30 minutes of moderate-to-vigorous physical activity), would allow the participant to achieve this goal by either increasing moderate to vigorous physical activity or decreasing sedentary behavior. Furthermore, it would allow day to day flexibility in how this goal is attained. For example, on a particular day, a person may not be able to fit in a 30-minute walk, but could sit less during meetings at work, whereas on another day, they may not be able to sit less at work but may be able to walk for 30 minutes during their lunch hour. In this study, we examined both time and bouts, and results were similar revealing that both the time and bout ratios of sedentary behavior to moderate physical activity or moderate-to-vigorous physical activity decreased from the intervention. Future studies should explore ratios of meaningful activity further.

This study is a secondary analysis of 2 interventions, which provided a larger sample size and a more heterogeneous sample. However, this study is not without limitations. The interventions included in this study provided the same message (increase by 10,000 steps per day), but were delivered through different modalities (ie, telephone, computer). However, the purpose of this study was not to compare intervention modality efficacy, but rather the change in quality of sedentary and physical activity behavior. Furthermore, these interventions employed 2 different models of accelerometer (Actigraph GT3x and Manufacturing Technologies Inc. 7164). However, these 2 accelerometer models both have been shown to be valid and reliable, with the 7164 being an earlier version of the GT3x. Finally, the markers of sedentary behavior patterns, as established by Chastin,^{37,38} were developed using the ActivPal which provided significantly different results than those provided by Actigraph in this paper. For instance, the average median length of sedentary bout in Chastin,^{37,38} was 20 minutes, whereas it is about 2 minutes in this paper, with most SB bouts being one to 4 minutes in length. These differences are likely because ActivPal measures posture, whereas Actigraph measures movement and lack of movement. Therefore, further comparison between the ActivPal and the Actigraph for these measures needs to be made.

This study examines the changes in quality of behavior (time spent in sedentary behavior and different physical activity intensities) in response to a quantitative step goal. The 10,000 steps per day goal has been shown to be an effective method of increasing physical activity in individuals of all ages and both sexes. Furthermore, accumulating 10,000 steps per day has resulted in health benefits. Therefore, the results of this study are encouraging showing that for every 1% increase in proportion of time spent in MVPA, SB decreased by 1.21%. Changes in sedentary behavior were seen in changes to the number of bouts that were less than 30 minutes, and likely through a variety of small changes that differed between individual participants and sexes.

Human Subjects Statement

All study procedures were approved by the University of Wisconsin-Milwaukee and Medical College of Wisconsin Institutional Review Boards, assuring protection of study participants. All participants were required to sign an informed consent document prior to participating.

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List of Abbreviations Used

10K	10,000
CPM	counts per minute
SD	standard deviation
STEP	10,000 steps per day intervention
CON	control group
kg/m²	kilograms per square meter
BMI	Body Mass Index
SB	sedentary behavior; < 100 CPM
LPA	light-intensity physical activity; 100 – 759 CPM
LMPA	lifestyle moderate-intensity physical activity, 760 – 1951 CPM
MPA	moderate-intensity physical activity; 1952 – 5724 CPM
VPA	vigorous-intensity physical activity; 5725 CPM
MVPA	moderate- to vigorous-intensity physical activity; 1952 CPM

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Table 1Variables that Describe the Pattern of Sedentary Behavior^{37,38}

	Variable	Definition
Sedentary Bout Characteristics	Number of daily sedentary bouts lasting 10-, 20-, 30-, 60-, 120-, and 240-minutes	Reported as number of bouts. A bout is defined as consecutive sedentary minutes. ²² Bout lengths were not exclusive (ie, 10-minute bout includes the 20-minute bouts). Provides a numerical indication of the number of bouts of a specific length of time.
	Weighted median sedentary bout length	The length of the sedentary bout that corresponds to the median length of bouts. For example, if a day included 2 5-minute bouts, one 10-minute bout, and 2 15-minute bouts, then the median bout is 10 minutes (10 is in the middle: 5, 5, 10, 15, 15). This variable provides a good indication of centrality given bout distribution. Reported in minutes.
	Percent of time by bout lengths greater than weighted median	This is a measure of the percentage of sedentary time spent in bouts longer than the weighted median sedentary bout length (above). Based on the example above, the amount of time spent in sedentary bouts longer than the weighted median is 30 minutes (15 minutes + 15 minutes = 30 minutes). The percentage time spent above median is calculated by dividing 30 minutes by the total SB time $((30/(5+5+10+15+15))*100 = 60\%)$. This percentage is usually above 50% because the majority of sedentary behavior is spent in longer bouts. This could provide information on changes to SB through the introduction of more breaks. Reported as a percent.
	Maximum sedentary bout length	Longest continuous sedentary bout performed across valid wear days while not sleeping. Reported in minutes.
	Alpha	A scaling parameter that provides an indication of the distribution of the length of sedentary bouts, assumed to follow the power law. A lower alpha indicates that sedentary time is largely accumulated in long bouts. Unit-less variable.
Postural Changes	Sit-to-stand transitions	Defined by accelerometer counts per minute increasing up to above 100cpm for at least one minute. Reported as the number of transitions.
Accumulation of Sedentary Time	Gini Index	A standardized measure for comparing patterns of sedentary time accumulation, where $G=0$ indicates all sedentary bouts contribute to total sedentary time equally, $G=1$ indicates that all sedentary time is accumulated with a small proportion of long bouts.

Table 2

Characteristics of Participants (N = 120) at Baseline

Characteristics	Sample (N = 120, 100%)	Group		p
		Intervention (N = 84, 70.0%)	Control (N = 36, 30.0%)	
Age (y, Mean $\pm$ SD)	63.3 $\pm$ 6.1	63.7 $\pm$ 5.9	62.1 $\pm$ 6.6	.1290
Body Mass Index (kg/m², Mean $\pm$ SD)	29.6 $\pm$ 5.4	29.6 $\pm$ 5.1	29.5 $\pm$ 6.1	.5746
Waist Circumference (cm, Mean $\pm$ SD)	97.1 $\pm$ 13.5	96.9 $\pm$ 13.2	97.6 $\pm$ 14.3	.9431
Valid Time Monitor Worn (h/d, Mean $\pm$ SD)	14.2 $\pm$ 1.4	14.4 $\pm$ 1.4	13.9 $\pm$ 1.5	.0525
Female [N (%)]	91 (75.8)	64 (76.2)	27 (75.0)	.8890
Caucasian [N (%)]	113 (94.2)	79 (94.1)	34 (94.4)	1.0000
BMI Category [N (%)]				
Normal	25 (21.0)	14 (16.7)	11 (31.4)	.1295
Overweight	51 (42.9)	40 (47.6)	11 (31.4)	
Obese	43 (36.1)	30 (35.7)	13 (37.1)	

Table 3

Sedentary Behavior Characteristics (N = 120)

	Group	Baseline	Post Intervention
Sedentary Behavior (% of wear time)^{a,c}	Control	0.67 ± 0.08	0.67 ± 0.10
	STEP ^b	0.63 ± 0.08	0.61 ± 0.09
Sedentary Behavior(h/day)	Control	10.0 ± 1.7	9.9 ± 1.7
	STEP ^b	9.5 ± 1.7	9.1 ± 1.7
Number of Sit-to-stand Transitions	Control	85.1 ± 15.8	81.8 ± 16.4
	STEP ^b	87.6 ± 15.2	83.7 ± 14.7
Maximum Sedentary Bout Length (minutes)	Control	104.2 ± 26.8	112.2 ± 43.2
	STEP	103.6 ± 30.9	108.3 ± 38.7
Weighted Median Sedentary Bout Length (minutes)	Control	2.4 ± 0.3	2.4 ± 0.4
	STEP	2.3 ± 0.3	2.2 ± 0.3
Percent of Total Sedentary Time in Bouts of Length Greater than Weighted Median	Control	74.3 ± 5.4	74.1 ± 5.2
	STEP	73.0 ± 4.6	72.5 ± 4.8
Alpha^b	Control	1.8 ± 0.1	1.8 ± 0.2
	STEP	1.9 ± 0.1	1.9 ± 0.1
Gini Index^e	Control	0.6 ± 0.0	0.6 ± 0.0
	STEP	0.6 ± 0.0	0.6 ± 0.0

Note.

^a: between group baseline difference, $p < .05$;^b: within group pre-post intervention difference, $p < .05$;^c: between group pre-post intervention difference, $p < .05$;^d: Alpha, a descriptor of the overall pattern of SB, a lower alpha indicates that sedentary time is largely accumulated in long bouts;^e: Gini Index, $G = 0$ indicates all sedentary bouts contribute to total sedentary time equally, $G = 1$ indicates sedentary time is accumulated in long bouts.

Table 4

Mixed Effects Models for Sedentary Behavior Characteristics (N = 120)

Models	Total Sedentary Time (minutes/day)			Number of Sit-to-stand Transitions			Maximum Sedentary Bout Length (minutes)			Weighted Median Sedentary Bout Length (minutes)			Alpha ^a		
	Estimate	SE	p<	Estimate	SE	p<	Estimate	SE	p<	Estimate	SE	p<	Estimate	SE	p<
<i>Fixed Effects</i>															
Intercept	630.57	23.88	<.0001	75.96	3.72	<.0001	117.91	7.70	<.0001	2.56	.07	<.0001	1.75	.04	<.0001
Age (REF: 66+)	3.88	16.86	.8183	1.34	2.64	.6135	-3.97	5.35	.4592	-.03	.05	.6015	.01	.03	.8272
Female (REF: Male)	-37.69	18.25	.0413	11.09	2.86	.0002	-13.01	5.79	.0266	-.20	.06	.0008	.09	.03	.0018
STEP Group (REF: Control)	-35.00	17.19	.0441	2.24	2.69	.4054	-2.22	5.46	.6852	-.14	.05	.0111	.06	.03	.0271
Time	-20.72	9.00	.0232	-3.41	1.13	.0031	5.70	4.09	.1664	-.02	.02	.3887	.01	.01	.1461

Note.

^a: Alpha, a descriptor of the overall pattern of SB, a lower alpha indicates that sedentary time is largely accumulated in long bouts.

Table 5

Pre-Post Sex Differences between Groups (N=120)

Measures	PRE-POST DIFFERENCE											
	Control						Intervention					
	Male (N = 9, 7.5%)			Female (N = 27, 22.5%)			Male (N = 20, 16.7%)			Female (N = 64, 53.3%)		
	Mean	SD	P _{CM}	Mean	SD	P _{CF}	Mean	SD	P _{IM}	Mean	SD	P _{IF}
Total Sedentary Time (h/day)	0.650	2.090	.3784	.057	1.252	.8244	.3244	.3244	.1210	.393	1.723	.0824
Number of Sit-to-stand Transition	7.157	12.166	.1156	1.528	10.081	.4652	.1864	.1864	.5918	4.011	12.726	.0176
Maximum Sedentary Bout Length (minutes)	-19.667	46.041	.2359	-4.042	41.377	.6368	.3556	-15.316	.1672	-2.600	44.037	.6491
Weighted Median Sedentary Bout Length (minutes)	-.093	.256	.3062	.004	.200	.9203	.2577	.071	.0869	.028	.228	.3519
Percent of Total Sedentary Time in Bouts of Length Greater than Weighted Median	.002	.039	.8671	.002	.049	.8401	.9906	.017	.032	.003	.050	.6946
Alpha	.023	.068	.3338	-.012	.102	.5605	.3420	-.036	.1279	-.017	.111	.2419
Gini Index	.001	.042	.9466	-.003	.033	.6811	.7876	-.003	.6416	-.007	.029	.0581

Note.

PCM vs. CF = Pre-Post Change for the Males versus Females in the Control Group; P_{IM} = Pre-Post Change for the Males in the STEP Intervention Group; P_{IF} = Pre-Post Change for the Males versus Females in the STEP Intervention Group; P = Evaluating whether the difference in the Pre-Post Change between Males and Females are the Same in both the Control and STEP Intervention Groups (Interaction Effect) ; Alpha, a descriptor of the overall pattern of SB, a lower alpha indicates that sedentary time is largely accumulated in long bouts; Gini Index, G=0 indicates all sedentary bouts contribute to total sedentary time equally, G=1 indicates sedentary time is accumulated in long bouts.