I-STAND - Effects of a Sitting Reduction Intervention for Obese Older Adults with Chronic Illnesses

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Abstract

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Little is known about the impact of sedentary behavior reduction interventions on obese older adults who also have one or more chronic conditions. A mixed methods exploratory analysis was completed to examine the cardio-metabolic and psychologic health effects of a sedentary behavior intervention. Participants were obese older adults with depressed mood, pre-diabetes/diabetes or hypertension, who were a part of the I-STAND study at Kaiser Permanente Washington Health Research Institute. Linear regression models compared pre and post measures between intervention and control groups adjusting for baseline values. A post-hoc qualitative analysis assessed I-STAND participant interview data. There were 60 participants in the study population. In all three sub-groups, participants were primarily female and white. Significant mean reductions in sitting time were observed for intervention groups compared to controls in each sub-group. There was not strong evidence for health benefits with reductions in sitting time. Key qualitative themes included barriers to stand, perceived physical health improvements and perceptions of physical activity. Further research should examine whether sitting reduction can act as a facilitator to increased physical activity and benefit cardio-metabolic health and psychologic health.

INTRODUCTION

Chronic Illness in the United States

Chronic diseases account for seven of the ten leading causes of death in the United States (US) (1). In addition to the high burden of disease chronic illnesses place on the US, the total cost to treat these diseases is astronomical, totaling $1.1 trillion in 2016. Some of the most common conditions include type 2 diabetes, hypertension, heart disease, arthritis and obesity (2). Among adults 65 and older, 85 percent have at least one chronic condition, while 56 percent have two or more with varying severity (3). Obesity is the greatest risk factor exacerbating this burden (2). In fact, between 2015-2016, the prevalence of obesity among older adults ages 60 and above was 41 percent (4).

A lack of physical activity is one of the leading health risk behaviors that is causally related to chronic illnesses and premature death (1). It is recommended that adults either complete 150 minutes of moderate-intensity, 75 minutes of vigorous-intensity, or some combination of the two activity levels per week. This recommendation applies to older adults and individuals with chronic conditions too, and for those already have a chronic condition, regular physical activity is recommended to lower the risk of developing another condition (5).

However, it can be difficult for older adults to achieve the recommended physical activity guidelines because of contributing factors such as reduced mobility, comorbidities and disability (5). Additionally, data indicates that physical inactivity steadily increases with age. In 2016, data showed that inactivity for adults aged 50-64 was at 25.4 percent, 26.9 percent for adults aged 65-74, and 35.3 percent for adults aged 75 and older (6).

Sedentary Time

Though physical activity is recommended to prevent the onset of chronic illness and manage current illnesses, research has found that physical activity alone may not be enough to reduce the risk of morbidity, especially if majority of an individual's time is spent being sedentary (7). Thirty-five chronic diseases, including frailty, diabetes, and hypertension, are associated with sedentary time (8). In 2004, average adult sedentary time accounted for 7.7 hours per day in the US (9). For the older adult population, sedentary time accounts for an average of 9.4 hours per day (10).

Purpose of Research

It is crucial for public health professionals and clinicians to find innovative ways to promote positive health behaviors for older adults with chronic conditions to better manage their health and prevent the acquisition of comorbidities, in addition to bending the cost curve associated with treating these diseases. Given the prevalence of chronic conditions such as obesity, hypertension, diabetes and depression in the older adult population, the purpose of this research was to explore the cardio-metabolic health and psychologic health benefits associated with reducing sitting time and explore how the presence of these conditions influence current sedentary behaviors.

Literature Review

For this study, sedentary behavior was defined as, "any waking behavior characterized by an energy expenditure ≤1.5 METs while in a sitting or reclining posture" (7). Prior studies have addressed feasibility of sitting reduction interventions, examined the relationship between

sedentary behavior and health outcomes and focused on testing varying energy expenditure levels (11, 12, 13, 14). Findings from previous studies indicate associations between higher sedentary behaviors and both physical multimorbidity and increased risks for all-cause mortality (7, 14, 15). Researchers have also observed health benefits associated with breaking up prolonged sitting time (16, 17, 18).

Comorbidities associated with obesity include hypertension, type 2 diabetes mellitus and psychologic problems. These three comorbidities are all associated with higher sitting time (19, 20, 21). In one study examining the relationship between sedentary behaviors and mental health, an increase in depressive symptoms due to prolonged sedentary time was observed (20, 22).

Insulin resistance is a major contributor to the development of type two diabetes. Findings from a study that used three exercise and energy expenditure conditions to test the effects of prolonged sitting time on insulin sensitivity showed that longer durations of lower expenditure activity, such as simply standing or walking, was a more effective way to improve insulin levels than just one hour of vigorous physical activity followed by mostly sitting for the rest of the day (23). However, this study was conducted with participants who had normal fasting glucose levels, indicating that there may be an opportunity to test the effectiveness of a similar intervention with pre-diabetic and diabetic individuals struggling with insulin or fasting glucose regulation.

Regarding blood pressure, one lab-based study tested three activity level regimens (uninterrupted sitting, sitting with two-minute light walking sessions every 20 minutes and sitting with two-minute moderate-intensity walking sessions every minutes). Researchers found that breaking up sitting time with bouts of walking reduced blood pressure for overweight and obese adults (18).

Despite the moderate amount of research on sedentary behaviors and different physical activity levels with associated health outcomes, few studies have targeted older adult populations with chronic conditions or tested interventions with more than one study arm. The feasibility studies that have been published are promising, demonstrating initial feasibility and acceptability, though none have focused on older adults with chronic health conditions associated with obesity (12, 24, 25). The I-STAND intervention was designed and tested to fill the identified gaps in research (26). This study collected various self-reported and objective health data from participants, including but not limited to the presence of chronic conditions, fasting glucose, systolic and diastolic blood pressure and measures of depressive symptoms. However, this research did not examine effects of this intervention by chronic condition status.

Research Questions

This exploratory study focused on answering four questions pertaining to participants, with diabetes/diabetes, hypertension and depressive symptoms, in the I-STAND Study:

1. What are baseline patterns of sitting time for participants with pre-diabetes/diabetes, hypertension or depression compared to participants without any of these diseases?
    a. Hypothesis: Sitting time at baseline is greater among participants with pre-diabetes/diabetes, hypertension or depression compared to participants without these diseases.
2. Is sedentary behavior reduction effective among participants with pre-diabetes/diabetes, hypertension or depression?

    a. Hypothesis: There is a greater sitting time reduction for participants that received the I-STAND intervention with pre-diabetes/diabetes, hypertension or depression compared to those who received the Healthy Living control.
3. What are the pre and post changes in health metric outcomes for participants with pre-diabetes/diabetes, hypertension or depression?
4. Do participants with the chronic conditions of interest talk about them in relation to the I-STAND intervention, sitting time, feasibility of standing more and changes in health metrics, and if so, how?

METHODS

Study Setting

This research took place at Kaiser Permanente Washington Health Research Institute (KPWHRI), in Seattle, Washington. Data came from the I-STAND Study, a 12-week, randomized control trial designed to test the effectiveness and efficacy of a sitting reduction intervention (I-STAND). The control (Healthy Living) consisted of healthy aging educational materials easily accessible on Kaiser Permanente's (KP) member website.

Recruitment

Recruitment began in February 2016 and data collection concluded in February 2017. Participants were all KP Washington members. Eligibility requirements included: adults between 60-89 years old; a body mass index of ≥ 30; self-reported siting time of ≥ 7 hours per day; able to stand and walk one block with or without assistive devices; and continuous enrollment in KP's health plan for the prior 12 months to the study's start. To initially identify potential participants,

electronic health records (EHR) were screened. Eligible individuals were mailed invitation letters and asked additional screening questions. Exclusion criteria from the EHR included: residing in a long-term care or skilled nursing facility in the last 12 months, having a new cancer or heart failure diagnosis, or having a new dementia or serious mental health diagnosis.

Procedure

The study period was 12 weeks. Once enrolled, an activPAL device was sent to each participant, which had to be worn on the thigh for seven days before their first in-person appointment to collect baseline sitting time data. Every participant had an in-person visit with a health coach to assess baseline sitting time (collected from an activPAL) and relevant health metrics, which came from a questionnaire, biometric tests and a fasting glucose blood draw. Participants were then randomized into the intervention or control study-arms and met with a coach to go over the I-STAND or Healthy Living workbook that would guide the participant through the study. During week 11, participants in each study arm wore an activPAL for seven days prior to week 12 and returned for an in person visit at week 12 to collect post-study sitting and health data.

Theoretical Frameworks

Researchers drew from the social cognitive theory, theory of habit formation and ecological model to design the I-STAND intervention. The ecological model takes into consideration the idea that there are varying environmental factors influencing health behavior, such as the neighborhood environment or interpersonal relationships (27). An element of I-STAND that utilized this model was an activity where participants evaluated how their living spaces contributed to sitting and standing time. The theory of habit formation suggests that there

are internal and external factors and processes influencing the choice to sit or stand (28). The I-STAND intervention was designed in part to help participants develop their own external habit reminders and better recognize internal ones to reduce sitting time. In I-STAND, participants were given wrist-worn activity monitoring devices that would vibrate every 20 minutes to remind participants to stand up. The social cognitive theory theorizes that there are individual, social and environmental factors simultaneously influencing how health behaviors are learned and regulated. Elements include reciprocal determinism, behavioral capability, observational learning, reinforcements, expectations and self-efficacy (27). Major components of this theory that aided in the design of I-STAND were the ideas of goal-setting and self-efficacy to achieve and maintain reductions in sitting.

Description of I-STAND

Following the baseline visit, those in I-STAND were instructed to wear the ActivPAL for a second week and return for an additional coaching session. Following this visit, participants received 4 additional telephone check-ins. In these coaching sessions, participants went over different topics covered in their I-STAND workbook, completed goal-setting and worked on inner, outer and habit reminders. Participants in I-STAND were given Jawbone Up wrist-worn activity monitors that gave off vibrations every 20 minutes to remind participants to stand.

Description of Healthy Living

Participants in the Healthy Living group only received the first baseline in-person visit. Following this, they received five mailings every two weeks of health information topics they had chosen. Information was compiled from the KP WA member website. When participants

received their mailing, they were also asked to complete and send back a progress report on goal achievement related to the selected health topics.

Measures

For the purposes of this analysis, at baseline and 12-weeks, the quantitative health outcomes of interest included sitting time (in minutes and as a percent), fasting glucose (mg/dl), systolic blood pressure (mm HG), and mood (PHQ-8). Baseline measures of health taken at baseline were used to indicate presence of each of the three conditions examined here.

High blood pressure/hypertension was defined as having an average systolic blood pressure reading at or above 130 mm Hg. Absence of hypertension was defined as having systolic blood pressure reading of less than 130 mm Hg (29). Mean systolic blood pressure was calculated from three blood pressure readings taken using an Omron HEM-907XL device that was worn on the left arm of participants.

Depression was measured using the Patient Health Questionnaire-8 (PHQ-8) depression screening tool (30). Participants rated each of the eight items on a scale of 0 to 3 and scores were summed, within the possible range of 0-24. Scores of 10 or greater were classified as indicating moderate to moderately severe depression.

Diabetes/pre-diabetes status was determined based on a fasting glucose reading of 100 mg/dl ≤ (31). Because the sample size of both the entire study population and separate condition groups were small, participants with pre-diabetes (100-126 mg/dl) and diabetes (≥ 126 mg/dl) were combined into one group. Fasting glucose was collected through a finger prick and analyzed with the Alere Cholestech LDX System.

Sitting time was measured in mean minutes per day and sitting time as a percent of total daily wear time (100 * [sitting time / hours device worn during waking hours]). This was collected using an activPAL device, which is a thigh worn accelerometer device that takes information about the position of an individual's thigh to measure periods of sitting, standing and stepping (32). **Sitting outcomes** were assessed by activPAL data and changes were calculated by taking the difference between sitting time at 12-weeks and at baseline.

Qualitative data was collected from brief phone exit interviews of I-STAND participants. The interviews were conducted using a semi-structured interview guide, audio-recorded, and transcribed.

Analysis

A mixed methods analysis was conducted. All statistical analyses were conducted using R Studio and Microsoft Excel. Observations with any missing relevant health metrics data were excluded from condition specific analyses. Statistically significant changes were indicated by a p-value of < 0.05, and trends were indicated by a p-value of < 0.10. For **Research Question 1**, descriptive statistics comparing baseline sitting time and health metrics between participants with and without each chronic condition of interest. Each condition group was analyzed separately. It was assumed that the data was independent. For **Research Question 2**, each chronic condition was considered a categorical independent variable and the dependent variables (continuous) included sitting time. Linear regression was conducted to test the differences in mean changes in sitting time and percent of the day sitting from baseline to 12-weeks. The analyses were adjusted for baseline values between the I-STAND and Healthy Living groups. For **Research Question 3**, each chronic condition was considered a categorical independent

variable and the continuous dependent variables (continuous) included average systolic blood pressure (mmHg), fasting glucose (mg/dl), and the total score of the PHQ-8 depression screening tool. Linear regression was conducted test the difference in mean changes in health metric measures from baseline to 12-weeks between the I-STAND and Healthy Living groups.

For **Research Question 4,** a post-hoc exploratory qualitative analysis was completed. Only interviews from I-STAND participants were analyzed to better understand perceptions of chronic diseases and associated topics in relation to sitting reduction. Because it was possible to have more than one of the conditions of interest, interviews were categorized into three groups according to which of the conditions of interest a participant had. This resulted in some transcripts getting coded more than once, so themes were identified for each group individually as well as collectively. Coding was conducted using Atlas.TI. A working code book was created through initial open coding of transcripts in each condition group. After each transcript was coded one time, a fixed code book was then developed for each condition group and a second round of coding was completed. Excel spreadsheets were created to visualize the frequency of codes, code definitions, examples of the codes and key quotes. Utilizing this spreadsheet, codes and sub-codes were consolidated and key themes were drawn out.

RESULTS

Characteristics of Study Sample

The total study population had 60 participants (29 in I-STAND, 31 in Healthy Living Control). There were 22 participants in the pre-diabetes/diabetes group, 28 participants in the hypertension group and 29 participants in the depression group. In all three groups, participants were primarily female and white, with a mean BMI ranging from 35.0-36.0 at baseline (see Table 1).

Research Question 1 - Baseline Comparisons of Participants with and without Chronic Diseases

The aim of Research Question 1 was to describe baseline sitting patterns of participants with and without one of the chronic conditions of interest. For those with pre-diabetes/diabetes, mean sitting time at baseline was about 15 minutes higher compared to those without diabetes/pre-diabetes (see Table 2). Mean sitting time at baseline was about 20 minutes higher for participants without hypertension compared to those with hypertension. For those with depression, sitting time at baseline was approximately 37 minutes higher for those without depression.

Research Question 2 - Sitting Time & Percent Sitting Time

For participants with pre-diabetes and diabetes, a significantly greater mean reduction in sitting time was observed for I-STAND participants compared to the Healthy Living group (-50.66 minutes/day, p=0.04) (see Table 3). Also observed was a non-significant but greater mean reduction in percent sitting time by 4.75 percent for I-STAND participants compared to the Healthy Living group (p=0.09). For participants with hypertension, a significantly greater mean reduction in sitting time was observed for I-STAND participants compared to the Healthy Living group (-82.67 minutes/day, p=0.01). Similarly, a significantly greater mean reduction in percent sitting time of 7.78 percent was also found for the I-STAND group compared to the Healthy Living group (p=0.04). Regarding participants with depression, I-STAND participants had a significantly greater mean reduction in sitting time than the Healthy Living group (59.32 minutes/day, p=0.04). The I-STAND group also had a greater mean reduction in percent sitting time by 6.04 percent compared to the Healthy Living group (p=0.04).

Research Question 3 - Health Metrics

Although not significant, among participants with pre-diabetes and diabetes, mean reductions in fasting glucose were greater for the Healthy Living group compared to the I-STAND group (12.79 mg/dL, p=0.10) (see Table 3). Among participants with hypertension, non-significant, but greater mean reductions in systolic blood pressure in the I-STAND group were observed compared to the Healthy Living group (-4.46 mm Hg, p=0.37). Regarding the depression sub-group, there were non-significant, greater mean PHQ-8 scores reductions among the I-STAND group compared to the Healthy Living group (0.95 points, p=0.25).

Research Question 4 - Qualitative Results

Among I-STAND participants, 16 transcripts were coded for the pre-diabetes/diabetes group, 21 were coded for the hypertension group and 19 were coded for the depression group. Through coding and thematic analysis, three main themes were identified that applied to all three condition categories: (1) barriers to stand, 2) perceived physical health improvements, and (3) perceptions of physical activity (see table 4).

For Theme 1, ***barriers to stand***, in each condition group, participants spoke about similar barriers to reduce sitting that could be classified as physical, social and other. Among participants with physical barriers, the main ones included muscular and joint pain, recent surgeries and weight. A prominent social barrier was being in a public setting where it was the social norm to be sitting, such as in a meeting or at a restaurant. Other barriers, not linked to either social or physical barriers, included poor weather, fears of safety, established sitting habits, activities usually done sitting and perceiving sitting as a reward in older age.

For Theme 2, ***perceived physical health improvements***, participants in each condition group usually saw greater improvements than losses in physical health. Participants perceived less pain or soreness, improved energy levels, and reduced stress after completing I-STAND. When asked about changes to mood, there was a consistent pattern of participants reporting improvements. These improvements appeared to be linked to completing tasks or chores, in addition to completing some sort of physical activity (i.e. stretching, light walking, etc.). There was also a commonality amongst participants with improvements to mood being due to prioritizing activities they enjoyed (i.e. gardening). Lastly, many participants spoke about a new "ability to do more," which included being able to get more chores done as well as activities they wanted to do (as opposed to ones they had to do). For individuals who reported no improvements to mood, reasons given included, "not being a moody person," or being "generally optimistic or cheerful."

For Theme 3, ***perceptions of physical activity***, participants were asked about whether they would have enrolled in the study had been exercise-focused and if they were doing more physical activity during and after the I-STAND intervention. For each sub-group, findings were unanimous in that participants felt that they had been able to improve their physical activity after doing I-STAND. Furthermore, even if participants were not completing more physical activity, they felt that they were better equipped, both mentally and physically to start incorporating physical activity into their daily routines. Regarding whether they would have participated if the study included an exercise intervention, results were mixed across condition groups. There was more of an even split as to whether participants with hypertension and depression would have participated if the intervention focused on exercise. For the pre-diabetes and diabetes group,

participants overwhelmingly felt that they would not have participated had the intervention been focused on exercise.

DISCUSSION

Research Question 1

It was hypothesized that sitting time at baseline for participants with pre-diabetes/diabetes, hypertension or depression would be greater than those without these. Existing literature links chronic diseases, such as diabetes, to greater sedentary time. The findings in this study underscored previous literature findings that participants with pre-diabetes/diabetes had higher baseline sitting times compared to those without either disease (8). This is also consistent with government reports indicating that not only are older adults more inactive, but those with chronic conditions may have increased sedentary time because of their age and health status (5, 6). In contrast to prior studies and existing literature though, this analysis showed that the mean sitting time at baseline was less for those with depression, as well as those with hypertension, than those without either (8, 33, 34). Reasons for this are unknown and should be further explored.

Research Question 2

In the main trial, there was an overall significantly greater mean reduction in sitting time by 58 minutes per day among I-STAND participants compared to Healthy Living participants ($p = .007$; 5.6%, $p < .01$). In this secondary analysis, the I-STAND intervention was significantly associated with reduced sitting time (minutes/day) compared to the Healthy Living control in all three separate condition groups of interest. The greatest change in sitting time was seen in the hypertension I-STAND group (-82.7 mins/day, $p = 0.01$), which was greater than mean difference observed in the I-STAND arm overall. If individuals with hypertension can reduce

their sitting time by almost 1.5 hours per day through a sedentary behavior intervention, there could be an opportunity for future research to explore how standing more could be a potential facilitator to increased physical activity, which is a recommended way to control blood pressure.

Research Question 3

Overall, there was not strong evidence for health benefits with reductions in sitting time. This is consistent with findings in the original I-STAND study. The non-significant findings could be linked to the limited sample size, which led to not having enough power. Additionally, the length of the study may not have been long enough to see meaningful changes to cardio-metabolic health and psychologic health. Moreover, there is the possibility that a sitting intervention on its own is not enough to positively improve cardio-metabolic and psychologic health.

Research Question 4

Three key themes emerged from the qualitative analysis. For Theme 1, ***barriers to stand***, of the three barriers to stand that participants identified, physical and social ones were the most prominent. For adults who still work, there appeared to be a stigma against standing in office spaces, such as meetings. One participant spoke about how standing could look "aggressive." This suggests a need to normalize standing in more formal settings and presents an opportunity for health practitioners and corporations to empower individuals to feel more comfortable taking standing breaks.

Regarding Theme 2, ***perceived physical health improvements***, the data demonstrated that participants perceived improvements to multiple areas of their health. Considering the simplistic nature of the main component of the intervention, taking frequent standing breaks, this finding

was particularly promising. Furthermore, the high frequency of self-reported improvements to pain and soreness were especially interesting when thinking back to the theme of barriers (physical), which showed a high frequency of pain and uncomfortableness as a deterrent to stand prior to undergoing this intervention. Regarding improvements to mood, the link between improvements and a new ability to do more activities or chores aligned with findings in other studies linking improvements to depression with increased physical activity (35).

For Theme 3, ***perceptions of physical activity***, an interesting finding was the improvement in exercise that occurred for participants in each condition group, as well as a new confidence to begin exercising more because of the I-STAND intervention. Participants also spoke about increasing exercise because of getting bored of just standing or to facilitate increased standing time. This finding suggests that standing more could be an achievable starting target for older adults, followed by a gradual introduction of physical activity into one's routine.

Though not identified as a theme, there was an observed of lack of conversation about the presence of any of the chronic conditions of interest. This could have been in-part due to the structure of the interview questions, but participants were directly asked about changes to specific areas of health, such as cardiovascular or mental health, and yet it was still uncommon to mention diseases directly.

Strengths and Limitations

A key strength of this analysis was the use of data from a randomized control trial to test the effectiveness of a sedentary behavior intervention (I-STAND) for obese older adults with comorbidities. Additionally, this study benefitted from comprehensive objective measurements and use of a mixed methods analysis to answer each research question. Due to the small sample

sizes of participants with the chronic conditions of interest, a key limit was the ability to make meaningful statements about whether sitting less led to objective health improvements. There was also a lack of racial, ethnic and gender diversity in this study. Future research should adjust recruitment strategies to obtain a larger, demographically representative sample of the population in which studies take place. Alternative ways to separate participants into sub-groups should also be explored.

Conclusions

Sitting time was high among older adults with chronic conditions. There were significant associations between sitting reduction and a sedentary behavior intervention among obese older adults with pre-diabetes/diabetes, hypertension or depression. Though reductions in cardio-metabolic and psychologic health measures were not significant, future research should continue to examine the relationships between chronic conditions and sitting time, as well as how a sedentary behavior intervention could positively influence health metrics in larger studies.

The absence of discussion about the presence of chronic conditions in qualitative interviews suggests a need for more qualitative exploration about how chronic diseases influence sitting and standing behaviors to complement the existing quantitative data. One of the most notable findings from this research was the connection between a sedentary behavior intervention and participants' new self-efficacy to participate in more physical activity. This indicates that standing more may be an effective facilitator in encouraging increased physical activity for older adults with chronic conditions, which is especially salient, given that older adults with chronic conditions are still recommended to obtain the same level of physical activity as other adults.

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APPENDIX

Table 1. Results – Characteristics of Study Sample (N=60)			
Characteristic	**Total sample**	**I-STAND**	**Control**
Diabetes	**N=22**	**N=12**	**N=10**
Age, mean (sd)	69.9 (6.3)	69.2 (5.2)	68.6 (7.9)
Female, n (%)	17 (77)	9 (75)	8 (80)
Retired, n (%)	14 (64)	8 (67)	6 (60)
Race/ethnicity, n (%)			
White	15 (68)	11 (92)	4 (40)
Black	3 (14)	1 (8.3)	2 (20)
Other/multi-racial	3 (14)	0 (0)	3 (30)
Education, College degree or higher, n (%)	16 (73)	9 (75)	7 (70)
BMI, mean (sd)	36.0 (4.7)	36.5 (6.3)	35.5 (1.9)
Hypertension	**N=28**	**N=13**	**N=15**
Age, mean (sd)	68.3 (4.8)	69.6 (5.7)	67.1 (3.5)
Female, n (%)	20 (71)	8 (62)	12 (80)
Retired, n (%)	12 (43)	6 (46)	6 (40)
Race/ethnicity, n (%)			
White	22 (79)	13 (100)	9 (60)
Black	2 (7.1)	0 (0)	2 (20)
Other/multi-racial	3 (11)	0 (0)	3 (20)
Education, College degree or higher, n (%)	18 (64)	9 (69)	9 (60)
BMI, mean (sd)	35.0 (3.9)	35.5 (4.8)	34.5 (3.1)
Depression	**N=29**	**N=16**	**N=13**
Age, mean (sd)	66.4 (3.7)	66.9 (3.8)	65.6 (3.5)
Female, n (%)	22 (76)	12 (75)	10 (77)
Retired, n (%)	15 (52)	8 (50)	7 (54)
Race/ethnicity, n (%)			
White	23 (79)	16 (100)	7 (54)
Black	4 (14)	0 (0)	4 (31)
Other/multi-racial	2 (7.0)	0 (0)	2 (15)
Education, College degree or higher, n (%)	24 (83)	14 (88)	10 (77)

BMI, mean (sd)	36.5 (4.7)	36.5 (5.8)	36.4 (3.3)

Table 2. Results — Research Question 1 — Baseline Characteristics of Participants with and without a Chronic Condition

Measure	Condition Absent	Condition Present
Diabetes and Pre-Diabetes vs. No Diabetes		
Total, n	20	22
Female, n	18	17
Age, mean (SD)	68.6 (3.6)	68.9 (6.3)
Baseline Sedentary Time, mean (SD) (minutes / day)	575.0 (124.1)	590.3 (109.1)
Baseline Sedentary Time, median (minutes / day	601.4	604.2
Baseline Percent Sedentary Time, mean (SD) (%)	62.9 (13.7)	68.1 (10.6)
Baseline Percent Sedentary Time, median (%)	68.5	69.2
Fasting Glucose at Baseline, mean (SD) (mg/dl)	93.5 (3.8)	120.9 (25.5)
Fasting Glucose at Baseline, median (mg/dl)	94	109.5
Hypertension vs. No Hypertension		
Total, n	25	28
Female, n	18	20
Age, mean (SD)	68.3 (5.4)	68.3 (4.8)
Baseline Sedentary Time, mean (SD) (minutes / day)	593.2 (112.3)	574.4 (99.8)
Baseline Sedentary Time, median (minutes / day	604.5	340.4
Baseline Percent Sedentary Time, mean (SD) (%)	66.0 (12.4)	64.7 (10.4)
Baseline Percent Sedentary Time, median (%)	68.8	65.1
Systolic Blood Pressure at Baseline, mean (SD) (mm HG)	118.0 (10.5)	145.7 (11.0)
Systolic Blood Pressure at Baseline, median (SD) (mm HG)	121.5	146.2
Depression vs. No Depression		
Total, n	20	29
Female, n	13	22
Age, mean (SD)	69.9 (5.2)	66.3 (3.7)
Baseline Sedentary Time, mean (SD) (minutes / day)	611.9 (115.1)	574.2 (110.4)
Baseline Sedentary Time, median (minutes / day	625.2	591.9
Baseline Percent Sedentary Time, mean (SD) (%)	66.4 (11.9)	67.3 (12.7)
Baseline Percent Sedentary Time, median (%)	69.5	70.8
PHQ-8 score at Baseline, mean (SD)	8.6 (0.5)	13.5 (3.6)
PHQ-8 score at Baseline, median	9	12

Table 3. Results — Research Questions 2 and 3 – Regression Findings				
	Baseline	**Follow-Up**	**Difference in Mean Change from Baseline (I-STAND vs. Control)**	
Measure	**Mean (SD)**	**Mean (SD)**	**Mean Difference (95% CI)**	**p-value**
Diabetes (n=22)				
Sitting time (minutes / day)			-50.66 (-99.8 - -1.6)	0.04
ISTAND	575.4 (108.6)	509.7 (107.5)		
Control	608.2 (112.6)	589.2 (115.2)		
Percent of the day sitting (%)			-4.75 (-10.3 - 0.8)	0.09
ISTAND	66.8 (11.3)	59.6 (12.4)		
Control	69.6 (10.1)	67.0 (11.2)		
Glucose, mg/dL			12.79 (-3.0 - 28.5)	0.10
ISTAND	128.8 (30.3)	137.2 (39.1)		
Control	111.5 (14.8)	110.1 (10.2)		
Hypertension (n=28)				
Sitting time (minutes / day)			-82.7 (-148.0 - -17.3)	0.01
ISTAND	575.1 (106.5)	490.8 (138.2)		
Control	573.8 (97.4)	572.5 (92.7)		
Percent of the day sitting (%)			-7.78 (-15.0 - -0.5)	0.04
ISTAND	65.79 (10.9)	57.69 (14.9)		
Control	63.69 (10.3)	63.78 (8.5)		
Systolic blood pressure, mm Hg			-4.46 (-14.4 - 5.5)	0.37
ISTAND	144.3 (13.5)	135.2 (15.4)		
Control	146.9 (8.7)	140.7 (11.2)		
Depression (n=29)				
Sitting time (minutes / day)			-59.32 (-115.9 - -2.7)	0.04
ISTAND	579.2 (104.6)	536.2 (121.1)		
Control	568.0 (121.1)	585.9 (109.8)		
Percent of the day sitting (%)			-6.04 (-11.7 - -0.4)	0.04
ISTAND	67.3 (12.7)	61.5 (12.9)		
Control	63.9 (12.4)	65.0 (9.8)		
Mood, PHQ-8 score			-0.95 (-2.6 - 0.7)	0.25
ISTAND	12.9 (3.3)	11.2 (2.1)		
Control	14.2 (4.0)	12.8 (3.4)		

Table 4. Results — Research Question 4 — Qualitative Findings		
Theme and Codes	**Examples**	**Representative Quotes**
Barriers - Participants' responses related to different barriers they encounter when trying to reduce sitting time		
Physical	surgery; falling; pain standing; more comfortable sitting	"Well, I'm a heavy woman and so it's hard to stand in one place because it just – it makes my knees hurt. It's just uncomfortable"
Social	Work meetings; public places such as theaters or restaurants; inability to get out and socialize	"For professionals who spend a lot of time in meetings, when those meetings are face-to-face, there's a strong social expectation that the participants will sit down at the table and face each other during the meeting, and getting up and walking around is generally interpreted as being pretty significant, and somewhat aggressive, and somewhat disruptive…"
Other	Weather, safety, needing a purpose to stand, habits, sitting as a reward	I do have some activities that I do on the internet a lot and I have to – which, you know, really tends to require sitting more than I care to.
Physical Health Improvements - responses related to various physical health improvements they did or did not experience		
Weight Loss	Losing a couple pounds; feeling motivated to lose weight	"I lost a little weight, at least I think I did, and I definitely feel better when I go out and walk for an hour."
Cardiovascular Health	Improved; unsure if improved; did not improve	"I don't know if it's part of the study or not, but it seems like my blood pressure is a bit lower than it was, too, so that's a good thing."
Mood	Improvements - general, less low days, associated with task completion; No improvements	"You know, I did feel happier when I'm – and I – you know, I do feel happier when I'm doing more things. You know, my feet, I mean, doing things."
Mood is not an issue	Not a moody person - always cheerful or optimistic, poor use of time	I – You know, I don't do that. I'm the most cheerful person I can think of. Nothing gets me down. I'm always pretty, you know, positive in my outlook on everything. So, you know, the only kind of change would be a bad change there.
Pain and Soreness	No Improvement; improvements - arthritis, back pain	"The other thing I told [health coach] was that I have kind of a 30-years chronic lower back problem that I think has improved as a result of doing this."
Energy	Feeling able to do more and for longer periods of time; stamina	I think that on days when I sit quite a bit, I don't feel as energetic enough. Seems like standing up more gets more oxygen to the brain or something
Fatigue	Feeling less winded; feeling more tired by the end of the day	"I noticed that my stamina is a lot better. I used to huff and puff and now I feel just better so I really liked it."
Stress	Improved; didn't improve; not an issue; no increases noticed	"It definitely hasn't caused any extra stress. I don't know if there's even any impact, whether I'm sitting or standing as far as stress."
Ability to Do More	gardening; chores; activities outside of the house; doing more of what people want to do	"Yeah, I can go out and work in the garden and I can squat and stay in a squat position for a long period of time. I couldn't do that before."
Perceptions of Physical Activity - responses related to participants' perceptions of physical activity		
Feasibility to Complete an Exercise Intervention	Yes - already motivated to exercise; No - self-efficacy, physical limits, time; Unsure - dependent on the exercise	"You know, because the word exercise, I try to put some exercises into my routine it's always been a disaster. So, the exercise, you know, I would've tried and hopefully, you know, get something out of it. But I don't know, I don't think so."
Ability to Improve Physical Activity Post-Intervention	Yes - walking, gardening, improved self-confidence to incorporate physical activity; No - already doing a lot of physical activity	"My body feels like it's in a better position to start incorporating more walking and maybe some aerobic stuff, whereas before I would do that, it was not quite painful, but not pleasant. Now, it feels good again to walk, so that was a good thing."