Feasibility and preliminary efficacy of an intervention to reduce older adults' sedentary behavior

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Abstract:

Older adults represent the segment of the population that sits the most. This study evaluated the feasibility, acceptability, safety, and preliminary efficacy of an intervention to reduce sedentary behavior (SB) in older adults that can be disseminated broadly for limited cost and delivered by paraprofessionals with limited training. Senior centers in Central Pennsylvania were randomized to receive one of two healthy aging programs (i.e., intervention or comparison). Participants in both groups attended three 90-min meetings over 2 weeks. Behavior change content was delivered at the second session (i.e., day 7). Forty-two participants ($n_{intervention} = 25$, $n_{comparison} = 17$) were recruited from five senior centers. Content for the intervention group focused on reducing SB while comparison group content focused on reducing social isolation. Self-reported SB was assessed on days 7 and 14. Repeated-measures ANOVA revealed a significant group × time interaction for total and weekday, but not weekend, SB. In the week following the delivery of group content, participants in the intervention group reported an average decrease in total SB of 837.8 min/week; however, the comparison group reported a nonsignificant average decrease of 263.0 min/week of total SB. Participants in the intervention group also reported an average decrease in weekday SB of 132.6 min/weekday ($d = -0.83$) in the week following the delivery of group content; however, the comparison group reported a nonsignificant decrease of 24.0 min/weekday ($d = -0.16$). There were no significant changes in weekend SB in either group in the week following the delivery of group content. Participants' attendance, measurement completion, and program ratings were high. Safety issues were minimal. This intervention was feasible to implement and evaluate, acceptable to older adults, and showed promise for reducing older adults' SB.

Keywords: Sitting | Behavior change | Dual-process | Aging Hybrid intervention

Article:

Implications

Researchers: This intervention is designed to be delivered by paraprofessionals so future research needs to investigate the extent to which program champions, such as senior center managers, would be willing and able to deliver this intervention content.

Practitioners: Healthcare providers should investigate the possibility of tapping into existing social support networks, such as senior centers, to facilitate behavior change among older adults.

Policymakers: Resources should be directed toward innovative healthy aging interventions such as this one to target this largely overlooked health threat that is prevalent in the fastest growing segment of the population.

Adults age 65 and older represent one of the fastest growing segments of the population as well as the most sedentary [1, 2]. In addition to accumulating evidence of the negative health consequences associated with excessive sedentary behavior, sedentary behavior is especially problematic for this population because it detracts from the only form of physical activity engaged in by many older adults (i.e., light-intensity physical activity) [3, 4]. A normative need exists for effective, scalable interventions to reduce older adults' sedentary behavior.

INTERVENTIONS TO REDUCE OLDER ADULTS' SEDENTARY BEHAVIOR

Interventions have been successful in reducing older adults' sedentary behavior (e.g., 9 to 76 min/day via self-reported behavior; 24 to 35 min/day via objectively measured behavior) [5, 6, 7, 8, 9]. These interventions typically require interventionists with specialized training, behavioral feedback from expensive activity monitors that are not commercially available, expensive individual behavior coaching, or extensive group counseling. These features limit the potential to scale these interventions to improve population health. Low-cost, scalable interventions that employ familiar technology would be valuable for reducing older adults' sedentary behavior and promoting successful aging.

Video provides an alternative mode for delivering expert content knowledge in a low-cost manner that is more likely to reach older adults in the community because of its potential for broad dissemination. Videos are useful for unidirectional information transfer but may fail to engage older adults sufficiently. This limitation can be addressed by combining videos with group discussions based on scripted questions aimed at stimulating an open dialogue of reflections on and common experiences with intervention content, making content more personally meaningful and stimulating peer influence.

APPLYING A DUAL-PROCESS MODEL TO INTERVENE ON OLDER ADULTS' SEDENTARY BEHAVIOR

In addition to previous interventions being limited in their ability to be broadly disseminated at low cost, these interventions have also targeted motivational constructs that have previously been associated with physical activity. Only recently has there been a formal evaluation of the motivational processes underlying older adults' sedentary behavior [10]. This work supports the notion that the intrapersonal determinants of sedentary behavior are dual-process in nature [11].

Dual-process theories of motivation posit that both reflective and automatic processes regulate our behavior [12, 13]. Reflective processes are conscious, effortful, and volitional, such as those outlined in social-cognitive theories of motivation (e.g., intentions). Automatic processes are relatively nonconscious, effortless, and unintended (e.g., habits). The present intervention was based on a dual-process model.

To account for the automatic motivational processes that regulate behavior, we drew on previous work which suggested that sedentary behavior habits are a direct influence on behavior [10, 11]. To account for the reflective motivational processes that regulate sedentary behavior, we used the Health Action Process Approach (HAPA) [14]. HAPA is a social-cognitive theoretical model which has successfully been applied to explain the reflective processes that regulate various health behaviors [14]. One of the main tenets of HAPA is that individuals develop intentions to change behavior, and then translate those intentions into behavior. The habitual nature of sedentary behavior suggests that simply forming intentions to limit sedentary behavior will not be sufficient to change behavior—a phenomenon known as the intention-behavior gap [11]. Rather, efforts need to be made to overcome sedentary habits when attempting to translate counter-habitual intentions into behavior. The HAPA model proposes that a key process for bridging the intention-behavior gap involves developing detailed plans for implementing those intentions [15]. Figure 1 depicts the HAPA + habit dual-process framework that informed intervention content.

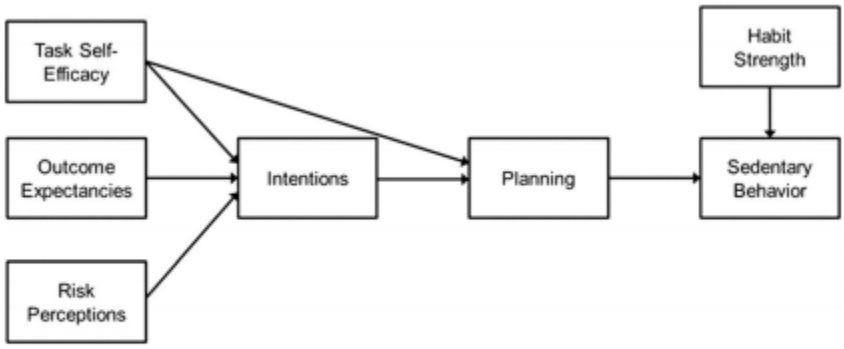

Fig. 1 | HAPA + habit dual-process framework used to inform the intervention and comparison program delivered to senior centers in central Pennsylvania between February and April 2014. Task self-efficacy, outcome expectations, risk perceptions, intentions, and planning reflect reflective motivational processes influencing sedentary behavior. Habits represent an automatic motivational process influencing sedentary behavior

THE PRESENT STUDY

This study was designed to evaluate the feasibility, acceptability, safety, and preliminary efficacy of an intervention that combined video with group discussions to reduce older adults' sedentary behavior. We hypothesized that it would be feasible to implement and evaluate this intervention for reducing older adults' sedentary behavior and that the intervention would be acceptable, safe, and efficacious for reducing total, weekday, and weekend sedentary behavior.

METHODS

Participants

This study took place at five senior centers in rural Pennsylvania between February and April of 2014. At the time of this study, five senior centers were operational within the county and each was approached about participating. Participants at senior centers were recruited via flyers and announcements describing the study. Exclusion criteria for senior center patrons included having (a) been diagnosed by a physician as having dementia or Alzheimer's disease or (b) injuries or illnesses that precluded standing or walking. Participants self-reported this information during the screening process. Eligible participants were invited to participate in the program.

Cluster randomization was used to reduce the threat of contamination within sites. Randomization was stratified based on senior center size (large centers had ≥30 regular attendees, small had <30) using data from the county's Office of Aging. A computer-generated allocation sequence yielded one large and two small senior centers in the intervention group and one large and one small senior center in the comparison group.

Procedures

Both the intervention and comparison group participated in three, 1.5 hour meetings over 2 weeks. On day 1, participants were familiarized with study procedures and provided informed consent. On day 7, participants completed a measure of sedentary behavior over the past week, received assigned content based on group allocation, and evaluated the program. On day 14, participants completed a measure of sedentary behavior and adverse events experienced over the past week. The first author delivered the program for senior centers across both groups. To increase implementation fidelity, scripts for each session were developed and screened for consistency by the first and third authors, respectively. Study procedures were approved by the local Institutional Review Board.

Intervention and comparison group content

The development of content for both the intervention and comparison group was a collaborative, community-engaged effort between researchers with expertise in motivation, behavior change, and aging and officials within the Centre County Office of Aging. Content for the intervention group focused on reducing sedentary behavior while the comparison group content focused on reducing social isolation. Social isolation was chosen as the topic for the comparison group because the number and quality of social interactions a person has can have implications for a person's physical and mental health, and social isolation also tends to increase with age, similar to sedentary behavior [16]. Content in both groups involved watching video segments and participating in group discussions.

In the intervention group, Part I was designed to define sedentary behavior as well as create awareness about the behavior. Initially, participants estimated the number of hours they spent engaging in sedentary behavior on an average day in the last week. Participants then watched a video segment that defined sedentary behavior and provided examples of sedentary behavior [17].

Participants then completed a self-reported measure of their average weekday and weekend day sedentary behavior over the past week. The total number of hours spent sedentary behavior on an

average day was calculated, and the discussion leader asked participants to compare this sum to their initial guess. Participants discussed whether they were surprised by their totals and about possible reasons for discrepancies between their initial guesses and the calculated total.

Part II was designed to create awareness regarding sedentary behavior, place individuals' sedentary behavior in perspective relative to their peers' sedentary behavior, and guide intention formation and plans to limit sedentary behavior. Participants watched a video segment that described normative estimates of sedentary behavior across the adult lifespan and particularly among adults greater than 60 years old [18]. Participants then answered a series of questions asking if anyone sat for more or less than 9 h/day—the average amount of time for adults over age 60—and how their sedentary behavior differed throughout the week.

Part III was designed to enhance outcome expectancies for light-intensity physical activity and risk perceptions for sedentary behavior. Additionally, a group activity that involved standing for a short period of time was introduced to enhance task self-efficacy for interrupting sedentary behavior. Participants watched a video segment that reviewed available evidence regarding the risks associated with excessive (i.e., 8+ waking hours/day) sedentary behavior. The video segment outlined the risk associated with excessive sedentary behavior regarding premature death, cardiovascular disease, type II diabetes, and aspects of mental health [19, 20]. The video segment also outlined the benefits associated with displacing sedentary time with light intensity physical activity (e.g., standing, slow walking) such as decreased risk of premature death, cardiovascular disease, and maintenance of physical and cognitive functioning. Following this segment, participants stood while answering discussion questions. The discussion leaders asked participants to comment on the information presented, relative to their own personal experiences or family medical history.

Part IV was designed to define action planning and allow participants to create their own action plans to enact over the next week. Developing action plans was intended to strengthen counterhabitual plans to limit sedentary behavior and disrupt sedentary habits. Participants identified (1) times during the day or activities when they typically sat for at least 30 min at a time and (2) ways that participants could break up that sedentary behavior. Participants were told that at the next session on day 14 discussions would be had regarding progress or barriers in achieving these goals; however, participants' goal completion was not tracked formally.

A video segment then defined action planning and focused on developing action plans that specified when, where, and how participants would break up or limit their sedentary behavior over the next week. Participants were then asked to use their responses from the previous activity to develop three action plans that specified when, where, and how they would interrupt or limit their sedentary behavior and then share an action plan with the group. Developing and sharing action plans served to provide a bridge between intentions and behavior as well as increase accountability for following through with those plans.

Part V was designed to identify target behavioral goals over the next week to guide intention formation and enactment of action planning. Two target behavioral goals were identified (1) stand or move for at last 10 min each waking hour or (2) limit sedentary behavior to less than eight waking hours/day over the course of the next week.

Video segments and discussions in the comparison group focused on (1) defining social isolation, (2) assessing individuals' social isolation via self-report measure, (3) reviewing normative levels of social connectivity, (4) reviewing evidence of the consequences associated with social isolation as well as benefits associated with social engagement, (5) developing action plans to increase or improve social connectivity, and (6) establishing target goals.

Outcome measures

Feasibility

Feasibility was measured as the participation, adherence, and measurement completion rates. *Participation* represented the number of senior centers that had meaningful recruitment (≥5 senior center patrons) out of the total number invited. *Adherence* represented the percentage of (1) participants who attended all three sessions and (2) sessions attended by participants. *Measurement completion* represented the percentage of observations obtained out of the total observations possible.

Acceptability

Participants were asked to rate four aspects of the program on a five-point Likert scale including the program's relevance to the participant's daily life (ranging from 0 [*not relevant at all*] to 4 [*very relevant*]), and quality of video, quality of presenter, and overall quality of the program (ranging from 0 [*not good at all*] to 4 [*very good*]). Each of the four aspects of the program were assessed using a single item (e.g., "Did you find the information presented in this program relevant to your daily life?", "How would you rate the quality of the video?"). Responses were moderately-to-strongly correlated (0.26–0.76) and were averaged to create a single acceptability score ($\alpha = 0.81$). Acceptability was measured after the delivery of the intervention content on day 7 in both groups.

Safety

Safety was assessed using the classification of adverse events described by Ory et al. [21]. Participants reported whether they experienced adverse events as a result of standing or walking in the past week. Safety was measured at the conclusion of the program on day 14 in both groups.

Sedentary behavior

Weekday and weekend day sedentary behavior were assessed using a nine-item domain-specific measure of behavior. The measure created by Gardiner et al. served as the basis for this measure and was supplemented with additional activities from Visser and Koster [22, 23]. Participants reported the time spent sitting or lying down while engaging in each of the nine sedentary activities on an average weekday and average weekend day over the past week. Responses to the nine items were summed to create separate estimates of weekday and weekend day sedentary behavior. A total sedentary behavior score was calculated by weighting these respective scores (= [5 × weekday sedentary behavior] + [2 × weekend day sedentary behavior]). Sedentary

behavior was measured on day 7 (prior to the delivery of the sedentary behavior content in the intervention group or after the delivery of the social isolation content in the comparison group) and on day 14 in both groups.

Statistical analysis

Frequency counts and descriptive statistics were used to determine feasibility, acceptability, and safety of the protocol. Efficacy was determined by testing a repeated-measures ANOVA in which the effect of intervention on sedentary behavior across time was compared in the intervention and comparison groups. Separate models were tested for weekday, weekend, and total sedentary behavior.

RESULTS

All five senior centers (100 %) agreed to participate in this study. Figure 2 documents participant flow. Participants comprised 42 community-dwelling older adults ($n_{\text{intervention}} = 25$, $n_{\text{comparison}} = 17$) whose demographic characteristics are summarized in Table 1.

A baseline assessment of SB (i.e., on day 7) revealed that the intervention group reported less total sedentary behavior ($M = 4808.2$ min/week, $SD = 1066.5$) than the comparison group ($M = 5477.8$ min/week, $SD = 705.2$), $t(37) = 2.1$, $p < 0.05$, $d = -0.72$. This difference was attributed to the intervention group reporting less weekend day sedentary behavior than the comparison group at the baseline assessment (see Table 2; $t(37) = 3.08$, $p < 0.05$, $d = -0.96$). Weekday sedentary behavior did not differ between the intervention and comparison group at the baseline assessment, $t(37) = 1.58$, $p = 0.12$, $d = -0.32$.

Repeated measures ANOVAs revealed significant group × time interactions for total ($F[2, 79] = 8.06$, $p < 0.001$) and weekday ($F[2, 79] = 11.54$, $p < 0.001$), but not weekend sedentary behavior ($F[2, 79] = 0.43$, $p = 0.65$) in the week following delivery of the program content. In the week following the delivery of group content, participants in the intervention group reported an average decrease in total sedentary behavior of 837.8 min/week ($d = -1.02$); however, participants in the comparison group reported a nonsignificant average decrease of 263.0 min/week of total sedentary behavior during that interval ($d = -0.30$). This change was due to a reduction in weekday sedentary behavior following the intervention because participants in the intervention group reported an average decrease in weekday sedentary behavior of 132.6 min/weekday ($d = -0.83$) whereas participants in the comparison group reported a nonsignificant decrease of 24.0 min/weekday during that interval ($d = -0.16$). In contrast, weekend sedentary behavior did not change significantly following the intervention.

Domain-specific sedentary behavior is displayed in Table 2. Significant decreases in sedentary behavior while watching TV ($M_{\text{Difference}} = -44.0$ min/weekday) and reading ($M_{\text{Difference}} = -31.0$ min/weekday) drove the weekday effect in the intervention group. The comparison group reported significant reductions in weekday sedentary behavior via hobbies ($M_{\text{Difference}} = -37.9$ min/weekday) and eating ($M_{\text{Difference}} = -28.2$ min/weekday) but a significant increase in sedentary behavior while doing other activities ($M_{\text{Difference}} = 23.8$ min/weekday).

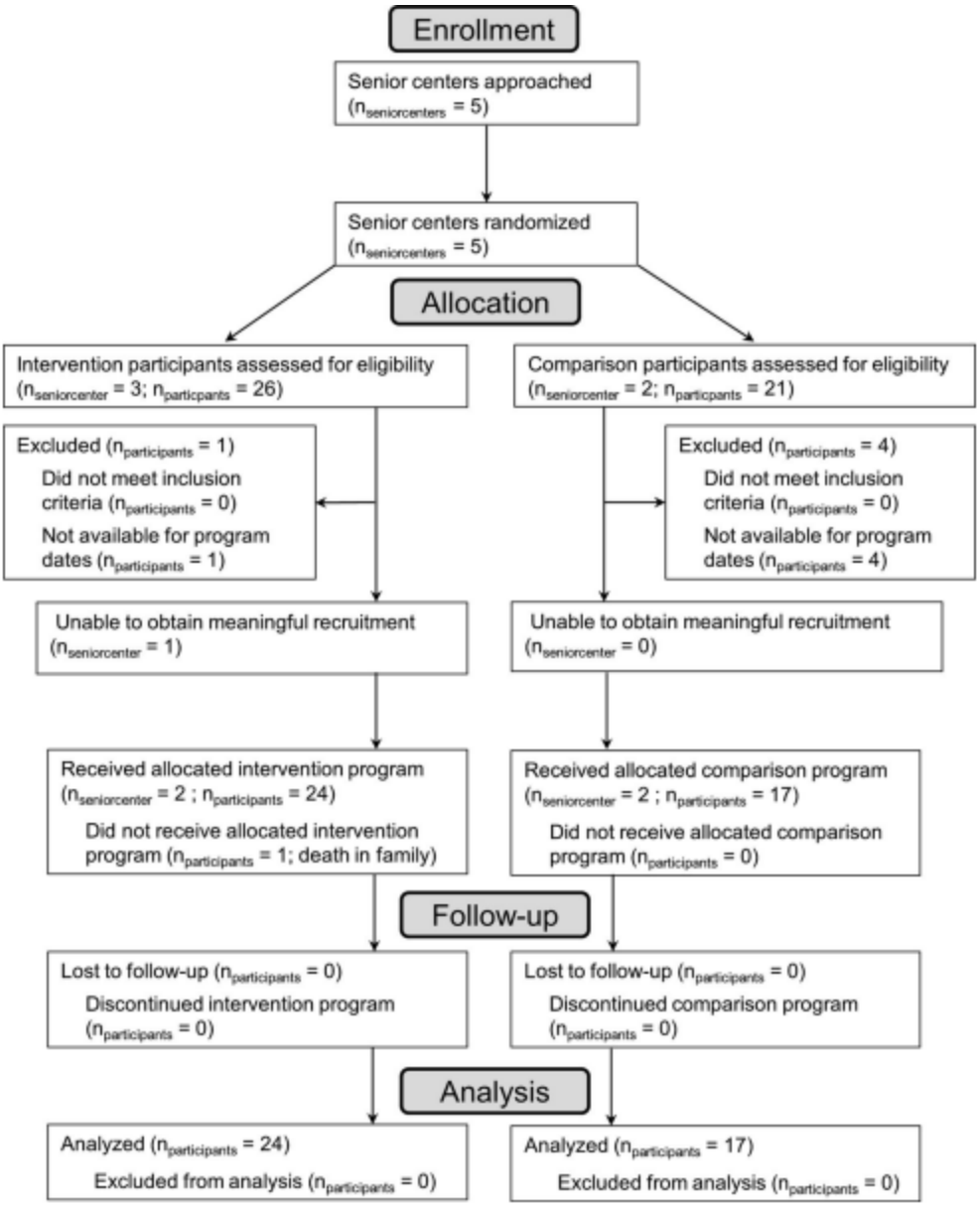

Fig. 2 | CONSORT diagram showing flow of senior centers and participants through each stage of the study which took place in central Pennsylvania between February and April 2014

Table 1 | Demographic characteristics of the sample

	Mean	*SD*	Min	Max
Age (years)	76.9	9.2	60	95
BMI (kg/m^2)	29.7	7.1	21.2	54.9
Sex (%)				
Female	90.7			
Male	9.3			
Ethnicity identity (%)				
Not Latino/a	100			
Latino/a	0			
Racial identity (%)				
White	93.0			
Asian	4.7			
Two or more races	2.3			
Income (%)				
≤$4999	4.7			
$5000–19,999	27.9			
$20,000–39,999	14.0			
$40,000–59,999	14.0			
≥$60,000	4.5			
Choose not to answer	34.9			
Marital status (%)				
Married	23.3			
Divorced	20.9			
Widowed	51.2			
Never married	4.7			
Housing (%)				
Independently in home/apartment	81.4			
Assisted living community	9.3			
Other	9.3			
Living arrangement (%)				
Spouse/partner	16.3			
Child/ren	9.3			
Grandchild/ren	2.3			
Other family members	2.3			
Other nonrelatives	2.3			
Pet/animal companion	4.7			
Alone	60.5			
Other	2.3			

Forty-two participants supplied demographic information on day 1. Demographic characteristics did not significantly differ between (1) intervention and comparison groups or (2) senior centers. All data were collected from senior center patrons in central Pennsylvania between February and April 2014

Table 2 | Changes in total and domain-specific sedentary behavior by group.

Sedentary domain	Intervention group			Comparison group		
	Baseline, *M* (*SD*)	Follow-up, *M* (*SD*)	Mean difference (*SE*)	Baseline, *M* (*SD*)	Follow-up, *M* (*SD*)	Mean difference (*SE*)
Total						
Weekday	699.4 (164.0)	566.8 (141.1)	−132.6** (28.5)	770.7 (115.3)	746.7 (133.3)	−30.4 (36.9)
Weekend day	655.6 (204.8)	568.2 (166.6)	−87.4 (44.8)	812. 8 (94.3)	747.0 (142.8)	−65.0 (39.4)
TV						
Weekday	189.6 (82.3)	145.6 (59.2)	−44.0* (21.0)	245.3 (96.6)	248.8 (129.8)	5.1(25.9)
Weekend day	164.6 (119.7)	136.0 (85.1)	−28.60 (22.3)	273.2 (77.9)	254.7 (108.3)	−18.5(27.0)
Computer						
Weekday	60.0 (98.7)	52.6 (94.6)	−7.4 (11.3)	41.2 (80.4)	52.9 (76.1)	6.0 (14.0)
Weekend day	47.4 (60.5)	30.4 (39.5)	−17.0* (7.1)	39.0 (76.2)	42.3 (69.5)	−1.1 (8.7)
Reading						
Weekday	86.0 (56.8)	55.0 (55.5)	−31.0* (14.9)	85.6 (65.5)	98.8 (78.8)	13.1 (18.5)
Weekend day	109.8 (77.2)	86.0 (65.5)	−23.8 (15.0)	79.6 (80.2)	91.1 (99.6)	14.9 (18.6)
Socializing						
Weekday	93.4 (60.3)	92.6 (65.81)	−0.8 (16.2)	141.7 (68.8)	120.5 (62.9)	−21.17 (19.6)
Weekend day	110.4 (81.9)	104.6 (80.1)	−5.8 (16.5)	140.6 (79.0	142.9 (67.0)	2.6 (20.4)
Transportation						
Weekday	58.8 (28.4)	63.0 (37.0)	4.2 (7.2)	64.3 (32.2)	58.8 (31.2)	−5.1 (9.0)
Weekend day	43.4 (40.6)	52.2 (47.7)	8.8 (10.8)	58.4 (66.1)	28.5 (26.9)	−29.6* (13.4)
Hobbies						
Weekday	74.4 (66.1)	53.8 (59.7)	−20.6 (15.1)	90.0 (88.2)	52.0 (64.4)	−37.9* (18.3)
Weekend day	47.0 (67.2)	50.8 (59.4)	3.8 (18.1)	89.0 (100.0)	62.3 (63.1)	−27.55 (22.3)
Paperwork						
Weekday	44.6 (47.6)	37.0 (38.1)	−7.6 (8.7)	36.7 (42.7)	21.7 (30.1)	−15.0 (10.5)
Weekend day	34.8 (34.2)	33.4 (42.7)	−1.4 (7.7)	27.5 (37.3)	12.3 (31.9)	−15.6 (9.6)
Eating						
Weekday	64.2 (48.1)	48.4 (48.9)	−15.8 (10.2)	75.5 (36.6)	47.3 (57.4)	−28.2* (12.3)
Weekend day	76.6 (50.0)	64.0 (48.0)	−12.6(11.9)	83.4 (56.1)	67.6 (42.0)	−14.3 (14.7)
Other						
Weekday	28.4 (36.2)	18.8 (32.1)	−9.6 (9.4)	21.7 (41.0)	45.5 (53.2)	23.8* (11.4)
Weekend day	21.6 (38.2)	10.8 (22.7)	−0.8 (9.8)	15.9 (35.7)	45.0 (69.9)	29.1** (12.2)

All values in the table represent minutes/day of total and domain specific sedentary behavior. Values in the "Baseline" columns reflect participants' self-reported sedentary behavior on day 7 in the intervention and comparison groups. Values in the "Follow-up" columns reflect participants' self-reported sedentary behavior on day 14 in the intervention and comparison groups. Values in the "Mean difference" columns reflect the difference in self-reported sedentary behavior in the Baseline and Follow-up columns in the intervention and comparison groups. Positive values in the Mean difference column reflect an increase in sedentary behavior from Baseline to Follow-up whereas negative values reflect a decrease in sedentary behavior from Baseline to Follow-up

*$p<0.05$; **$p<0.01$

Meaningful recruitment of patrons was obtained at 80 % of senior centers. All but one participant (97.6 %) attended all three sessions and, overall, participants attended 124 out the possible 126 total sessions (98.4 %), indicating high adherence. Of those 124 possible measurement occasions, complete data (i.e., participants answered all questionnaire items at a given measurement occasion) were collected on 121 occasions (97.5 %), indicating high measurement completion.

Participants in both groups rated the program highly (intervention: $M = 3.5$, $SD = 0.7$; comparison: $M = 3.35$, $SD = 0.4$). The majority of the sample reported they would recommend the program to a family member or friend (intervention 88 %; comparison 83 %). There were no significant differences in acceptability between groups ($p > 0.05$).

Safety concerns were rare. The most common adverse event was mild soreness from standing or walking ($n = 4$, 9 %). The only other adverse event reported was shortness of breath ($n = 2$, 4 %). There were no significant differences in adverse events between groups ($p > 0.05$).

DISCUSSION

This study provided support for the feasibility, acceptability, safety, and preliminary efficacy of an intervention to reduce older adults' sedentary behavior. Prior to the intervention, the majority of participants in this study reported engaging in sedentary behavior for at least 11 h/day—a level of behavior that (1) is greater than national averages for this age group and (2) associated with significantly greater risk for mortality and noncommunicable disease [18, 19, 20]. In the week following program delivery, participants in the intervention group reduced total and weekday sedentary behavior by approximately 837 min/week and 132 min/weekday, respectively. This preliminary effect was larger than prior sedentary behavior interventions with older adults using self-reported measures of behavior [5, 6, 7].

Reductions in sedentary time from this intervention may be attributable to the mode of delivery that combined technology to deliver intervention content (i.e., expert knowledge) with group discussions among peers to help generate ideas and provide social support. Older adults prefer group settings for exercise, and group settings may also be conducive for modifying sedentary behavior [24, 25]. In fact, the changes in weekday, but not weekend, sedentary behavior may be due to the fact that senior centers were only open on weekdays and participants felt more compelled to change their behavior at the intervention site where they were more likely to be exposed to positive peer influence and support for reducing sedentary behavior. Fitzsimons et al. previously found that an individualized intervention for older adults significantly reduced weekend, but not weekday, sedentary behavior [7]. These findings suggest that mode of delivery may significantly impact the potential for behavior change and future research should compare various modes of delivery and their impact on intervention effectiveness.

Additionally, this intervention was theoretically grounded in a dual-process framework that targeted both reflective and automatic motivational processes shown previously to predict older adults' sedentary behavior [10]. Intervention content focused on disrupting sedentary behavior habits (i.e., an automatic process) via action planning in addition to enhancing self-efficacy, intentions, and plans to limit sedentary behavior via educational content, practicing interrupting

sedentary behavior, and developing action plans (i.e., reflective processes). Previous interventions have relied on determinants of physical activity, primarily reflective motivational determinants, to develop intervention content [5, 6, 8]. The intervention effects in this study may be the result of increased emphasis on targeting and disrupting the automatic motivational processes (e.g., habits) that maintain older adults' sedentary behavior. Future research should expand on intervention content designed to target other automatic processes such as automatic evaluations or self-schemas [13, 26].

Other reasons for the reduction in sedentary behavior may be attributable to the timing and mode of assessment. The short follow-up period may have inflated the intervention effects regarding reductions in sedentary behavior. Now that it is clear that this intervention is feasible and accepted by older adults, future research can evaluate the intervention's efficacy for reducing sedentary behavior over longer periods. It is also possible that this study inflated intervention effects due to the self-report measure of sedentary behavior or demand effects. Future research should include short recall periods or objective measures of sedentary behavior to reduce recall biases [27].

Results from this study point to possible domain-specific targets for intervention. Specifically, weekday sedentary behavior while watching TV and reading may be particularly amenable to change as these domains saw significant decreases in sedentary time among participants in the intervention group. Watching TV has previously been associated with a variety of negative health consequences in older adults including greater depressive symptoms and poorer cognitive functioning, which suggests that it is a worthwhile behavioral target in these types of interventions [28, 29, 30, 31]. However, results are equivocal regarding other domains of sedentary behavior, such a reading, and their association with aspects of physical and mental health [29, 31]. Considering intervention content that targets specific domains of sedentary behavior based on their implications for health is an important direction for future research. In the comparison group, significant changes in domain-specific, but not total, sedentary behavior, suggested a reallocation of time across domains.

This intervention was developed in collaboration with community stakeholders. Collaborations with engaged stakeholders largely focused on making sure the content was (1) devoid of jargon and (2) contained information and examples that were relevant to older adults. This tailoring is likely applicable to the majority of older adults; however, it is possible that depending on the area, patrons, or resources of a senior center content may need to be altered to better suit the needs of patrons and the centers.

All senior center managers approached about participating granted permission for the program to be implemented, suggesting high potential for adoption. Potential reach was difficult to ascertain because (1) the number of potential participants at senior centers was not known and (2) passive recruitment strategies were used, leaving it unclear how many senior center patrons were aware of the program. Future research should attempt to identify differences between older adults who choose to participate in such a program and those who do not to better understand the reach of this program. It was encouraging to find that four of the five centers had meaningful recruitment. In participating centers, high attendance and measurement completion suggest that participants were interested in the program. Participants' ratings of the program and its relevance in their

daily lives further supported its acceptability. Adverse events could be easily resolved by recommending that short bouts of light-intensity activity be incorporated into action plans to reduce sedentary behavior. Future evaluations of this intervention should include potential adverse consequences other than safety (e.g., fatigue) and assess adverse events over a longer period of time.

Finally, a major strength of this intervention was the focus on rural communities which have many aging adults and often face challenges in accessing health care professionals and health promotion programs [32]. In this intervention, video segments contain expert-informed intervention content and senior center managers or other program champions are tasked with facilitating group discussions and activities. Therefore, this intervention capitalizes on existing resources and social networks within rural communities to deliver a low-cost health promotion program that could easily be implemented within organizations were older adults are already gathering. As research on this intervention extends beyond initial questions about feasibility, it will be important to stay engaged with center managers and other paraprofessionals who were originally intended to deliver the intervention. It is currently unclear what type and the amount of training paraprofessionals need to feel comfortable facilitating this program; however, it is likely that this training would be minimal because all of the intervention content is included in the video segments and scripts with discussion questions and talking points have been developed. Once a sufficient evidence based has been established, this healthy aging program is intended to be publicly available for groups or organizations working with older adults.

This study had several limitations. The sample in this study largely consisted of white, women who tended to be highly sedentary. While these sample characteristics reflect the population demographics in many small, rural communities, future research should evaluate this intervention in urban and diverse settings. As previously noted, findings from this study may have been inflated due to the self-report measure of behavior or demand effects. Future research examining the efficacy of this intervention should incorporate objective measures of sedentary behavior or self-report measures with shorter recall periods (e.g., daily). Additionally, because of the short duration of this study, it is difficult to gauge the long-term efficacy of this intervention. Future research should incorporate follow-up assessments beyond the 1-week postintervention period. This intervention targeted intraindividual determinants of behavior. Broader influences, such as the built environment or social processes, could be incorporated to develop a more comprehensive intervention. Furthermore, cluster-level randomization was used to contain the threat of experimental contamination within the centers and because it was practical for a small feasibility study. However, data were analyzed at the individual level (i.e., treating the individual as the unit of randomization instead of the center). There is the potential for biased estimates if dependencies exist within clusters [33]. Having established the feasibility of this intervention in the present study, future research using cluster randomization should evaluate effects at the cluster rather than individual level. Additionally, the small sample size in this study limits confidence in estimated effect sizes.

In conclusion, this psychoeducational intervention capitalizes on widely available video technology and group discussions to deliver an acceptable and likely efficacious intervention to reduce sedentary behavior in older adults. Participants evaluated the intervention favorably, complied with intervention procedures, and had minimal safety issues. This study provides an

innovative healthy aging intervention with potential for broad dissemination at limited cost to target a largely overlooked health threat prevalent in the fastest growing segment of the population.

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Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflicts of interest.

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