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# A text messaging-based intervention to increase physical activity among persons living in permanent supportive housing: Feasibility and acceptability findings from a pilot study

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## Abstract

**Objective**: Persons who have experienced homelessness and are living in permanent supportive housing experience high rates of health and mental health problems. Given that physical activity is associated with improved health outcomes and persons with homelessness histories report high rates of cell phone use, phone-based interventions to increase physical activity may be effective for improving health and wellbeing among persons in permanent supportive housing.

**Methods**: To understand the acceptability and feasibility of a cell phone-based physical activity intervention in this population, this 6-week pilot study enrolled 13 persons living in permanent supportive housing. Participants were eligible if they had completed their final, 12-month follow-up interview in a larger, longitudinal study of persons moving into permanent supportive housing in the Los Angeles area, spoke English, and reported comorbid chronic physical and mental health conditions. For the study duration, participants wore a pedometer, received multiple weekly motivational text messages on set days (at times selected by the participant), and responded via text to weekly depression screeners and requests to report their weekly step totals, as recorded by their pedometers. Follow-up interviews asked open-ended questions about study participation and satisfaction.

**Results:** Participants were 53 years old on average, most were female (54%), and most were African-American (62%). Changes to people's physical activity levels were limited, but participants reported increased quality of life during the intervention period. Interviews revealed that the intervention was well received and enjoyable for participants.

**Conclusions:** The efficacy of utilizing cell phones to improve health and wellbeing among adults living in permanent supportive housing requires further research, but these pilot findings suggest that such interventions are feasible and acceptable.

## Keywords

Exercise, pedometer, permanent supportive housing, text messaging, walking

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## Introduction

Persons who experience homelessness report high rates of chronic physical and mental health disorders,[1,2] and increased physical activity has been associated with improvements in a wide range of physical and mental health outcomes.[3,4] However, little research has examined physical activity among persons who have

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experienced homelessness and the small body of extant research has found mixed results on whether this population has higher or lower physical activity rates than the general population.[5–7] Permanent supportive housing (PSH) pairs non-time-limited housing with wrap-around supportive services and is the principal accepted intervention for ending homelessness in the United States (U.S.).[8,9] Persistent disparities in health among indigent populations call for improved access to appropriate healthcare as well as promotion of personal behaviors that can improve health. Safe and stable housing provides a foundation for health promotion; there is therefore a need for health promotion services that can be implemented within PSH. Given recent research findings of prevalent cell phone use among adults preparing to move into PSH,[10] cell phones may be an effective means for disseminating health interventions in this population.

Mobile health (mHealth) interventions, which utilize cell phones and other digital technology for health promotion or disease prevention, have been successful mechanisms for improving outcomes related to diet and exercise,[11,12] serious mental illness,[13] and other preventive health behavior[14] in the general population. The feasibility and acceptability of such interventions has not been examined among persons living in PSH, although some studies have used digital technology to intervene successfully with persons who have experienced homelessness. For example, phone-based motivational interviewing improved health behaviors among a small sample of persons experiencing homelessness in Australia,[15] and pilot studies in the U.S. have successfully used cell phone calls to improve medication adherence[16] and text messaging for appointment reminders[17] among persons experiencing homelessness.

Despite the success of these small-scale studies, adults with homelessness histories may still face unique challenges in adopting technology-based health interventions, particularly because health issues associated with aging occur an average of 20 years earlier among this population, as compared to their housed counterparts.[18] Aging-related health issues, particularly vision problems, cognitive impairment, and arthritis, may negatively impact the population's ability to engage effectively with technology-based interventions. Feasibility assessment of such programs for people in PSH is therefore an important first step.

In light of the need for effective health improvement interventions for persons in PSH and these concerns about the accessibility of such interventions, this paper presents feasibility and acceptability findings from a pilot study utilizing text messaging and pedometers to improve physical activity. To our knowledge this study is the first to introduce pedometers and text messaging as potential tools to monitor and improve physical activity among this population. We expected to find overall acceptance of this technology among persons in PSH due to their widespread use of cell phones.[10] We also expected to find challenges in utilization that should be acknowledged and addressed in developing and implementing such technology-based interventions.

## Methods

### Theoretical background

We designed the text messaging-based intervention in the present study based on self-regulation techniques derived from social cognitive theory (SCT).[19] These techniques are prompting self-monitoring and goal setting, and providing feedback on performance. SCT posits that a person can achieve self-regulation by observing the behavior, identifying attainable short- and long-term behavior changes, and receiving information about the recorded behavior. Meta-regression analyses of interventions to promote physical activity and healthy eating indicate that these self-regulation techniques are associated with positive outcomes.[20,21] Moreover, a pilot study found that providing guidance in self-regulation to urban, low-income, Latino adults via a voice and text-messaging physical activity intervention was feasible and accepted by participants.[22] The current intervention aimed to increase physical activity by encouraging walking via goal-setting and motivational text messaging, self-monitoring of walking behavior using pedometers, and providing ongoing feedback on walking performance. For the purposes of this study, pedometer use was a means for self-monitoring as well as a method for collecting physical activity outcomes. This intervention was designed to have a low-dose model of text-messaging frequency, as shown to be feasible and acceptable with other populations,[22] and because a low-dose model is likely to be low barrier for real-world implementation.

### Study sample and procedures

The participants ($n$=13) enrolled in this study had completed a 12-month follow-up interview in an ongoing longitudinal study of 421 adults who had experienced homelessness and were moving into PSH in Los Angeles. Participants were initially eligible if they had completed their final (12-month) interview in the longitudinal study, spoke English, and had lifetime diagnoses of comorbid chronic physical and mental health conditions. These potential participants were contacted to complete a second level of eligibility screening assessing whether they: 1) had a cell phone and

used/were willing to use text messaging, 2) planned to live in the Los Angeles area for the study duration, 3) were not currently using a cane, walker, crutches, or wheelchair to assist with their walking, and 4) were able to walk a flight of stairs without assistance. In total, 26 people were screened and 54% were eligible ($n$=14); all but one eligible person participated in the study. The most common reason for study ineligibility was requiring walking assistance (91.7%; $n$=11); the remaining person (8.3%) was ineligible because they did not use text messaging. All participants provided written informed consent.

At the beginning of the intervention, a 30-minute, in-person, interviewer-administered survey using the Qualtrics offline survey application (app) assessed participants' demographic characteristics and physical activity. Participants were given an electronic pedometer (Yamax Power Walker EX-510), which could be clipped to clothing or worn around the neck and provided weekly step totals. Study staff provided participants with detailed written and verbal instructions on pedometer use, and assisted participants with opting in to an online texting platform from their cell phones.[23] Participants were given one-on-one assistance with utilizing text messaging, as needed.

After the first week, interviewers contacted participants by phone to assess their step counts. Using a modified version of steps-per-day recommendations from Tudor-Locke and colleagues[24]—a method that provides guidelines for calculating target steps per day for older adults and those with limited mobility or endurance—interviewers calculated the weekly step goals for each participant. Step goals were intended to be moderate to ensure that inactive people would avoid injury, but still aimed to get participants as close as possible to recommended weekly numbers of steps. Goals increased each week. Calculations for our population based on the Tudor-Locke et al. method can be found in Table 1.

**Table 1.** Weekly step increase calculations based on week 1 steps.

| Week 1 steps | Weekly increase |
|---|---|
| <7000 | 14–30% per week |
| 7000–17,499 | Variable percentage to reach 38,500 steps by week 6 |
| 17,500–34,999 | Variable percentage to reach 49,700 steps by week 6 |
| 35,000–52,499 | Variable percentage to reach 70,000 steps by week 6 |
| 52,500+ | 8–10% per week |

## Intervention procedures

Intervention procedures were designed to incorporate goal setting (number of steps per week), self-monitoring (wearing the pedometer), and feedback (responses from the team on step counts). Participants received 24 text messages over 6 weeks. Participants were able to choose the time of day they received their messages; all messages were sent on the same day of the week. There were four messages each week, two of which were knowledge-based and barriers-acknowledging statements about the positive benefits of physical activity on physical and mental health and meant to be motivational. The other two were assessment questions to which the participant was expected to respond. These included one item from the Center for Epidemiological Studies-Depression scale (CES-D) assessing depression in the past 7 days[25] and one text message asking the respondent to reply with their number of steps taken in the past week, as measured by their pedometer. If participants responded to the text message asking for weekly steps, study staff would provide text message feedback based on the calculated weekly step goals for the participant and their reported number of weekly steps. See Table 2 for text message examples. If participants did not respond to these items, they were still retained in the study.

At the conclusion of 6 weeks, participants completed a 45- to 60-minute follow-up interview during which they were asked the same questions as those in the first interview, along with qualitative, open-ended items assessing their experience with the intervention. To ensure that we received an accurate reporting of weekly step counts during the intervention, the interviewers logged weekly steps directly from the pedometers when they visited participants for the follow-up interview. These steps were used to calculate weekly and overall step changes. Specific measures are described below.

## Measures

### *Participant characteristics (assessed at first interview only).*

Participant characteristics included in this paper include demographics (age, gender, and race/ethnicity) assessed using items from the authors' previous research with persons who have experienced homelessness.[10] Participants were also asked total lifetime years spent in locations that constituted literal homelessness (temporary or emergency shelters, outside, abandoned building, garage or shed not meant for living in, indoor public place, vehicle, and public transportation).[26] Participant time in PSH was measured by calculating

the time between their move-in date and intervention start.

Several health, physical activity, and wellbeing items were adapted from existing measures to be relevant to the context of PSH and sensitive to persons with a history of experiencing homelessness. Using a question adapted from the National Health Interview Study,[27] participants were also asked about the types of chronic physical and mental health disorders they had been diagnosed with in their lifetime (original question asks "have you EVER been told by a doctor or other health professional that you had [CONDITION]" for each item; we adapted the question to assess the entire list of chronic conditions as a single "check all that apply" item). We also expanded the response options to include common conditions informed by research with adults experiencing homelessness;[27–29] separate count variables were created for the overall number of physical and mental chronic condition diagnoses.

*Quality of life, physical activity limitations, walking self-efficacy, and depressive symptoms (assessed at both interviews).* The 11-point quality of life scale was adopted from the RAND HIV Cost and Services Utilization Study.[30] We adapted two items from the 12-item Short-Form Survey (SF-12) to assess the impact of physical pain on usual physical activities (e.g. walking, climbing stairs) in the past week (original item asks how much pain interfered with "normal work;" we modified it to ask about interference with "usual physical activities").[31] A 16-item measure with a four-point Likert scale from "not at all confident" to "very confident" assessed participants' confidence in their ability to walk every day given several potential barriers (e.g. weather, pain, safety, stress, clothing) question text came directly from McAuley,[32] with response options adapted by the authors to the context of living in PSH. The 10-item CES-D questionnaire was used to assess frequency of depressive symptoms in the past week.[25]

*Qualitative perceptions of the intervention (assessed at follow-up only).* The follow-up questionnaire assessed experiences with technology, walking, and other aspects of the intervention; all measures were created or adopted from previous research by the authors. Participants rated their ease in receiving and replying to intervention text messages (seven-point scale: "extremely easy" to "extremely difficult") and their likelihood of recommending the intervention to others (five-point scale: "extremely likely" to "extremely unlikely"). Open-ended short answer items assessed why participants would or would not recommend the intervention, what they would change about the program, and other intervention experiences.

Other qualitative items assessed thoughts on the overall number of text messages, problems receiving messages, impressions about message content, and thoughts on using text messages to communicate with people about physical activity. Participants were also asked what they enjoy or dislike about walking, reasons why they did not walk when they should have, how study participation impacted their walking, and thoughts on setting walking goals, as well as experiences with the pedometer, including ease of use and how helpful a pedometer was in awareness of walking.

Participants were paid US$20 for completing the baseline interview and US$20 for completing the follow-up, as well as compensated US$30 (US$5 per week) to offset any additional costs associated with text-messaging from their cell phones. To incentivize responses to text messages asking for depression scale scores and number of weekly steps, participants were paid an additional US$1 for each response to these text messages. All study protocols were approved by the authors' institutional review board.

*Data analysis.* All quantitative analyses are descriptive (i.e. *n*, percentages, means, and standard deviations) and were conducted in Stata Version 14.[33] Qualitative data were open-coded utilizing an inductive thematic coding process, wherein two staff read a portion of the open-ended responses and independently identified themes, then met to discuss emerging themes and patterns. This resulted in a codebook that was used by both staff to independently code all open-ended responses. After coding was complete, the staff compared each of the themes they had coded and any differences were resolved through consensus. Coded, qualitative responses were then sorted into thematic categories, as reported below. Reported themes are accompanied by illustrative quotes.

## Results

### Quantitative findings

*Study sample.* As shown in Table 3, participants in this study averaged 52.5 years of age, about half were female (54%), and most were African-American (62%). Their average lifetime duration of literal homelessness was 4.5 years, and they had been living in PSH for an average of 1.2 years when they participated in the intervention. Having comorbid chronic physical and mental health conditions was an eligibility criterion for this study; on average, participants had 3.5 chronic mental health conditions and 2.7 chronic physical health conditions. The most common physical health diagnoses reported by this sample included arthritis

**Table 2.** Text messages.

| |
|---|
| **Knowledge-based message examples** |
| Physical activity can help you manage stress and feel less tired. Once you become active, you're likely to have more energy than before. |
| Being active will help you get in shape and look good. Keep up your walking! |
| **Barriers-acknowledging message examples** |
| Feeling too lazy or tired to go on a walk? Plan on walking during times of the day when you tend to feel most energetic. |
| Schedule walking as you would schedule an important appointment. Block off these times in your schedule. |
| **Depression screener (CES-D)** |
| Over the past 7 days, how often have you been bothered by feeling down, depressed or hopeless? |
| **Steps assessment** |
| How many steps did you take last week? Review the weekly log on your pedometer and reply with the weekly number of steps. |
| **Steps feedback examples** |
| Great job! You're working hard to meet your goals. Now try increasing your daily steps to meet next week's goal. |
| Walking needs to be a regular habit to produce benefits. Make an effort to improve your walking in the next 7 days. |

CES-D: Center for Epidemiological Studies-Depression scale.

(50%), respiratory issues (42%), hypertension (33%), anemia (33%), and diabetes (25%).

*Response rates, step count changes, mental health and other characteristics.* As shown in Table 4, during the intervention the overall text message response rate, which includes all messages to which we asked the participant to respond, was nearly 76%. This rate includes responses to text messages asking for the previous week's step totals from the pedometer, as well as those requesting responses to the depressive symptom item. For the depressive symptom item, the response rate was 81.3% overall and the rate was 67.7% for the pedometer step totals. Over the 6 weeks of the intervention, overall response rates from participants varied, peaking at 85% in weeks 1 and 4, and reaching of a low of 69% in weeks 2 and 6.

**Table 3.** PSH walking pilot study demographic, homelessness, housing, and health characteristics ($n$=13).

| | %($n$)/mean (SD) |
|---|---|
| Age | 52.5 (5.6) |
| *Gender* | |
| Male | 46.2 (6) |
| Female | 53.9 (7) |
| *Race/Ethnicity* | |
| African-American/Black | 61.5 (8) |
| White | 23.1 (3) |
| Another race/ethnicity | 15.4 (2) |
| Lifetime duration of literal homelessness (years) | 4.5 (4.7) |
| Time in PSH (years) | 1.2 (0.2) |
| Number of chronic physical health conditions | 2.7 (1.7) |
| Number of chronic mental health conditions | 3.5 (1.9) |

PSH: permanent supportive housing.

We calculated mean daily steps by dividing each participant's weekly total steps by seven (also presented in Table 4). During week 1, the average mean daily step count across participants was 4,636 (SD=3,442), and this count fluctuated over the intervention, ending on a high of 5,770 (SD=4,895) mean daily steps in week 6. Given that mean daily step counts across all participants may mask individual-level changes—particularly given the large standard deviations in this sample—we have also presented percentage increases and decreases in steps over the study. During the first week of study participation, 75% of participants increased their weekly steps; however, the proportion of respondents continuing to increase steps went down in subsequent weeks (see Figure 1). Looking at overall changes in the number of weekly steps from the beginning to the end of the intervention, slightly more than half (54%) of participants increased their weekly steps. Among those who increased their overall number of steps, the increase averaged about 54% over their steps in week 1.

Also shown in Table 4, the self-reported quality of life score increased from 6.2 at baseline to 7.5 at follow up; this represents an improvement for more than half of study participants (62%). Depressive symptom scores also improved, decreasing from 13.8 at baseline

**Table 4.** PSH walking pilot study response rates, step changes, and quantitative outcomes ($n$=13).

| | %($n$)/mean (SD) |
|---|---|
| *Text message response rates* | |
| Overall text response rate (range: 25.0–100.0%) | 75.6 |
| Response rate to mental health items (range: 69.2–100.0%) | 81.3 |
| Response rate to step counts requests (range: 53.9–76.9%) | 67.7 |
| *Text message response rate by week* | |
| Week 1 | 84.6 |
| Week 2 | 69.2 |
| Week 3 | 76.9 |
| Week 4 | 84.6 |
| Week 5 | 76.9 |
| Week 6 | 69.2 |
| *Steps* | |
| Mean daily steps by week | |
| Week 1 (range: 748–11,732) | 4636 (3442) |
| Week 2 (range: 529–8395) | 3681 (3106) |
| Week 3 (range: 968–8143) | 4525 (2880) |
| Week 4 (range: 464–10,962) | 3972 (4717) |
| Week 5 (range: 358–12,334) | 4635 (4274) |
| Week 6 (range: 390–13,000) | 5770 (4895) |
| Overall step changes | |
| Increase | 53.9 (7) |
| Decrease | 46.2 (6) |
| % change among those with step increases | 153 (123) |
| % change among those with step decreases | 63 (41) |
| Quality of life mean score (higher = better quality of life; range: 1–11) | |
| First interview | 6.2 (2.5) |
| Follow up | 7.5 (2.5) |
| Improved | 61.5 (8) |
| No change | 23.1 (3) |
| Worsened | 15.4 (2) |
| Pain | |
| Lessened | 30.8 (4) |
| No change | 30.8 (4) |
| Worsened | 38.5 (5) |
| Barriers to walking | |
| Decreased | 66.7 (8) |
| Increased | 33.3 (4) |
| CES-D mean score (lower = less depression; range: 5–25) | |
| First interview | 13.8 (5.9) |
| Follow up | 12.6 (6.7) |
| Decreased | 50.0 (6) |
| No change | 8.3 (1) |
| Increased | 41.7 (5) |
| Found it extremely or moderately easy to: | |
| Receive study texts | 92.3 (12) |
| Reply to study texts | 69.2 (9) |
| Extremely likely/likely to recommend program | 92.3 (12) |

CES-D: Center for Epidemiological Studies-Depression scale; PSH: permanent supportive housing.

to 12.6 at follow up, which represents an overall decrease in symptoms for 50% of the sample. Barriers to walking decreased for two-thirds (67%) of respondents. However, pain levels worsened for nearly 40% of participants during the intervention.

The vast majority of study respondents (92%) found it moderately or extremely easy to receive study texts, whereas 70% found it moderately or extremely easy to

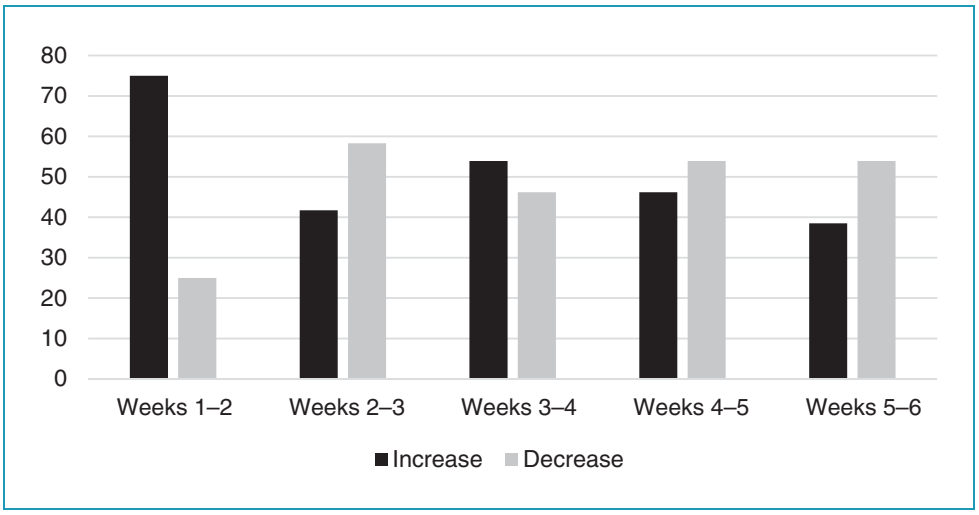


**Figure 1.** Weekly step changes (%).

reply to those texts, and 92% would recommend this intervention to others.

*Qualitative findings.* Two overarching themes emerged based on the coding of open-ended responses from the follow-up interviews. One theme pertained to technology utilization (i.e. text messaging, pedometers), and the other reflected thoughts and experiences surrounding the physical activity of walking.

### *Technology utilization*

Setting up the texting program. Some participants encountered technical difficulties setting up their phones to receive text messages from the third-party text-messaging service. Three of 13 participants (23%) were unable to receive text messages through the online messaging system because their cell phone carrier blocked messages sent from "short code" (i.e. phone numbers fewer than 10 digits). One participant was able to contact their carrier and have this remedied, although the other two were unable to correct this issue and their text messages had to be sent manually via email to text. We also had two respondents change phone numbers during the study. Both respondents contacted the study team to provide their new phone numbers, but one of those numbers could not receive the short code-based messages. One participant also accidentally opted out of the text messages and had difficulty opting back in.

Receiving and responding to text messages. Most participants reported positive or neutral experiences with receiving motivational texts and responding to question texts during the study. We provided detailed instructions and technical support during the first interview, and participants reported appreciating this support ("[The interviewer] helped me learn exactly what I was doing with that phone. So I felt confident to do it").

Most respondents (69.2%) reported that they thought the number of texts they received each week was the right amount, and three people (23.1%) would have liked to receive more text messages.

Participants reported three major aspects of the study texts that they felt were positive: 1) they conveyed *important information* ("They were informative. I learned some things"); 2) the texts *made them feel cared for* ("It helped me know there was someone there and they cared"); and 3) they *provided motivation for walking* ("It was encouraging").

Participants also reported some negative feelings surrounding the text messages. These fell into two major categories: 1) *feeling unsure about which messages they were supposed to respond to*, and 2) being *discouraged or feeling anxiety when they did not meet their walking goals*.

The technical aspects of text messaging were particularly difficult for one study participant. This participant reported feeling overwhelmed by the number of texts, and being fearful of giving the wrong answer and causing problems for the study. He expressed confusion about which texts he was supposed to respond to, and reported that sometimes his fear of sending the wrong response would keep him from sending anything. This respondent also had his phone turned off toward the end of the study because he did not have money to pay the bill. During his follow-up interview the respondent told the interviewer that he hoped he did not "mess up the study" or was not a "bad participant."

Participants had several suggestions for improving the text messaging component of the study, including wanting to respond to all texts, getting notifications or

reminders about meeting their walking goals, and wanting tips on calories and/or nutrition.

Using the pedometer. Participants reported generally positive experiences using the pedometer and seemed to enjoy having a *visual representation* of how much they were walking ("I wouldn't recognize all the walking I was doing without the pedometer").

Although the majority of the respondents felt the pedometer was *easy to wear and use* (61.5%), others had *trouble checking for the previous week's steps* ("Had a difficult time navigating through the menus and understanding what the abbreviations stood for"), *forgot the pedometer*, or had *difficulty wearing it* ("At times [the pedometer] was in the way. If I had my sunglasses and earphones the pedometer would interfere").

Of note, one participant had her pedometer stolen after the first week of study participation; we replaced the pedometer and she continued in the study.

Participants had several suggestions for improving the pedometer experience, including having a *wrist-worn design* ("Attach to my wrist like a watch") or a *different way to attach to clothing* ("The clip should have been stronger like a dental grip. It fell off me when I tried to run"), and having *additional features*, such as a heartbeat monitor and calorie count.

Physical activity. Participants reported many positive aspects of walking and physical activity, most commonly those related to improved motivation and mental health outcomes. Respondents discussed motivation in several ways, including 1) *general motivation for walking* ("It has made me change some of my routes to walk a little longer instead of shortcuts"); 2) motivation related to *meeting or beating their walking goals* ("I seem to be more interested in taking my walks and like watching the numbers change [on the pedometer]"); and, 3) *feeling motivated and productive in general* ("I've spent more days dressed during these 6 weeks, getting my hair done, opening the house, so I can be ready to get out than I had in the past before this study").

Participants described walking as having a *positive impact on their mood, stress, and other aspects of their mental health*:

> "It clears my head and reduces my stress."

> "Especially with me being depressed, the study motivated me and it does keep me in a better spirit."

Participants reported that walking allowed them to *enjoy the outdoors* ("Fresh air. Seeing the birds. Seeing people"), *walk their pets* ("I get to be with my dogs and they look forward to it, which makes me like it"), *interact with family* ("My son was very involved and he consistently checked how many miles I walked daily. I even called my mother to let her know"), and *commute* ("I enjoy walking. It's the only way I can get around since I don't have a car"). Participants also stated that walking made them *feel more normal and less isolated* ("Gets me out of my apartment and makes me feel like a normal member of society").

When discussing the negative aspects of walking, participants mentioned both internal and external factors that impacted their ability to walk or their enjoyment of walking. The most common internal factors that impeded walking or made participants think negatively about walking were 1) *mental health, including social anxiety and depression* ("I wasn't feeling good emotionally. All kinds of doubt and panic and dread. Fear people will start conversations. Anything I can do to avoid people I do."; "Feeling depressed makes it hard to get moving"), 2) *physical pain* ("My knees hurt when I walk"), and, 3) *lacking motivation* ("I was too lazy to get up from watching TV").

Less common internal factors included *forgetting to walk*, having *family obligations* that interfered with walking, feeling *like goals were unrealistic*, feeling that they were already *active enough*, and *disliking walking* in general.

External factors that limited participants' ability or desire to walk were primarily *bad weather or air quality* ("The weather was too hot") and *not having an appealing location in which to walk*:

> "Need to walk far to see something interesting. In NYC you could walk a block and see so many things and people. Skid Row is so blighted. The expensive high rises have people that won't even look at you. What is there to see?"

> "Creepy people in my neighborhood that I have to walk past."

## General study suggestions

Participants had several general suggestions about possible improvements for future intervention programs, including a longer study period, including nutrition tips and information, giving larger incentives, having a diary portion, using a phone app rather than texting, having competitions with other users, and incorporating interesting destinations ("I wish I had a goal to reach, like a treasure hunt. Like go to local museums to make it more exciting and asking how many steps did you take to get there. Give people choice[s] to walk somewhere beyond their neighborhood").

## Limitations

Because this is a small pilot study focused on feasibility and acceptability, we are not able to present data on efficacy or make claims about statistically significant behavior changes. Some participants also experienced technical difficulties with the text-messaging system and their pedometers; this provided us with valuable feedback about the feasibility of this program, but also reduced the number of useable observations. Future studies would benefit from recruiting a larger sample, such that more extensive analyses can be conducted even when responses and data may be limited by technical difficulties. Further, given that these participants were chosen because they had already completed 12 months of participation in a longitudinal study, they may have demonstrated higher adherence to this intervention than would a general population of those living in PSH. Studies or interventions may be able to mitigate potentially lower "real world" levels of adherence by providing technical training, as well as budgeting time and resources for in-person visits with participants to help troubleshoot technical difficulties. This study did not specifically assess for incident illnesses or hospitalizations during intervention participation, which may have impacted the step counts of some participants in ways that we cannot address. Finally, given our desire to make the intervention short (only 6 weeks in total) and focus primarily on feasibility, we did not include a true baseline measure of participant steps (steps prior to study participation), but rather measured steps during the first week of study participation. Future research may identify larger changes in physical activity by including true baseline data collection.

## Discussion

This study of a pedometer- and texting-based intervention to promote physical activity (i.e., walking) is the first to be conducted among adults living in PSH. Our investigation of feasibility, acceptability, and preliminary evidence of behavior change through intervention will inform future, innovative efforts to improve the health of persons who have experienced homelessness and are now living in housing.

Given findings that PSH residents enjoyed being part of this intervention and suggestive evidence of change in walking behavior and particularly quality of life, technology-based interventions likely hold promise for improving PSH residents' health and wellbeing. Systematic reviews have demonstrated that physical activity can reduce symptomology among persons with serious mental illness[4] and can decrease the risk of obesity, coronary heart disease, type 2 diabetes mellitus, Alzheimer's disease and dementia.[3] As such, mHealth interventions focused on physical activity may also prove effective in reducing costlier use of health services and improving quality of life in PSH.

There are some limitations that should be considered when designing future programs. Cell phone-based interventions that rely on text-message delivery from a short code sender may not be the most effective, as 31% of participants throughout the study could not receive such messages. Many persons who have experienced homelessness report having smartphones;[10] thus, a smartphone app might prove more accessible and feasible for this type of intervention. However, some limitations of smartphone apps should be considered, including high cost of app design and the need to make the app available on multiple phone operating systems. Technological beta-testing of future interventions, including testing of phone loss and change procedures, message content, and pedometer use, may be vital for intervention efficacy. Further, the frequency of walking (number of steps) appeared to decline after the first two weeks, suggesting that in addition to potential modifications in the technology, future interventions may need to incorporate motivational interviewing[34] or behavioral activation[35] protocols to promote continued participation and thus efficacy. The finding that many participants reported increased pain over the intervention is troubling, and future interventions should consider screening for pain prior to participation, ongoing monitoring of pain symptoms, and encouragement of tailored physical activity alternatives aimed at reducing and managing pain. Screening for and tailoring activities to specific chronic health condition diagnoses (e.g. arthritis) may also help in managing pain for this population.

Finally, that participation in this intervention appeared to be associated with quality of life (both quantitatively and qualitatively) is of value in its own right. Quality of life in PSH has received less attention than outcomes related to housing retention and physical health, yet it is a universally desired and fundamental aspect of human existence recognized by the World Health Organization.[36] Improvements in quality of life should be considered important outcomes alongside more traditional measures of health within PSH.

Overall, this research identified text messaging and the use of pedometers as a feasible and promising option for improving health and wellbeing among those in PSH. Most participants enjoyed being a part of the technology-based intervention, were able to successfully interact via text messaging, and saw positive improvements in walking behavior and/or quality of life. Alongside these promising findings are potential concerns, including varying levels of ability to interface with technology. Future research is needed to fully

understand the efficacy of this type of intervention, but this pilot work suggests that providers should be considering technology-based interventions as feasible and acceptable for improving health and wellbeing among adults in PSH

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