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Preliminary findings describing participant experience with iSTEP, an mHealth intervention to increase physical activity and improve neurocognitive function in people living with HIV

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Abstract

We assessed the feasibility and acceptability of using text messages to monitor and encourage physical activity in the first 21 participants enrolled in an ongoing randomized controlled trial evaluating a 16-week Short Message Service/Multimedia Message Service (SMS/MMS) intervention (iSTEP) designed to increase moderate physical activity and improve neurocognition in persons with HIV-associated neurocognitive disorders (HAND; iSTEP, $n = 11$; control group, $n = 10$). Data were collected during the intervention and from interviews conducted at the 16-week post-intervention visits. Text message response rates for both iSTEP and control participants were high (89% and 85%, respectively). Pedometer self-monitoring, step count goals, and milestone achievement texts were reported to facilitate physical activity. All iSTEP participants (100%) and 70% of control participants indicated that they would recommend the study to other people living with HIV. The results indicate that it is feasible to administer an SMS/MMS physical activity intervention to persons with HAND.

Keywords

HIV; mHealth; neurocognition; physical activity

Approximately 30-60% of people living with HIV infection (PLWH) manifest some form of neurocognitive impairment, including deficits in executive function, attention, and memory collectively referred to as HIV-associated neurocognitive disorders (HAND; Antinori et al., 2007). HAND includes three categories: asymptomatic neurocognitive impairment (ANI), HIV-associated mild neurocognitive disorder (MND) defined by self-reported deficits in everyday functioning, and HIV-associated dementia (HAD; Antinori et al., 2007). HAD has

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declined in the combined antiretroviral treatment era, but ANI and MND, characterized by impaired performance in at least 2 cognitive domains, remain prevalent and occur in approximately 40% of PLWH (Heaton et al., 2010). Individuals with ANI do not self-report everyday functioning deficits, but they can exhibit functional impairment on objective performance-based tests (Blackstone et al., 2012b). Although less severe than HAND, mild to moderate neurocognitive impairment in ANI and MND represents a significant public health challenge and is associated with higher mortality, disruption in daily living, high risk of more significant cognitive decline, and poor quality of life (Moore et al., 2014). Despite the pervasive presence of HAND, few studies have examined ways to treat neurocognitive deficits or established evidence-based procedures for rehabilitation. Consequently, there is a significant unmet need to establish effective strategies that address HAND.

Physical activity provides many significant health benefits, including reducing cardiovascular disease risk and slowing cognitive decline in conditions such as stroke and Alzheimer's disease (Colcombe & Kramer, 2003). The mechanisms mediating beneficial physical activity effects on neurocognition have not been completely elucidated but may involve neurogenesis, improved cerebral blood flow, and reduced inflammation (Lista & Sorrentino, 2010). Aerobic exercise in particular is associated with improvement in multiple cognitive domains, including attention, memory, and executive function (Colcombe & Kramer, 2003). Early proposals have suggested that intense vigorous physical activity might be necessary to induce appreciable cognitive benefits, but recent low/moderate intensity walking interventions have demonstrated that relatively modest physical activity changes can improve cognitive performance in HIV-uninfected impaired populations (Kemoun et al., 2010). For example, increasing physical activity by as little as 500 steps per day improves performance in older adults on measures such as the Trail Making Test B (Rosenberg et al., 2012). A recent cross-sectional study indicated that PLWH with neurocognitive impairment ($n = 43$) exhibited significantly less moderate physical activity (weekly minutes of moderate-intensity physical activity reported on the International Physical Activity Questionnaire) compared to cognitively intact PLWH ($n = 57$; Fazeli et al., 2015); however, the effect of a physical activity intervention on HAND has not been assessed. In addition, physical activity interventions applied in the HIV population have typically required rigorous activity (e.g., running on a treadmill; O'Brien, Nixon, Tynan, & Glazier, 2010) and significant participant effort (traveling to a gym several times a week), which may not be feasible for many individuals.

Over the past few years, a dramatic increase in mobile phone use has expedited the application of mobile health (mHealth) interventions that effectively reduce smoking, promote weight loss, and stimulate physical activity in a variety of HIV-uninfected populations, including increasing moderate physical activity such as walking (Fjeldsoe, Marshall, & Miller, 2009). Other studies have illustrated that text message interventions can be effectively used to improve everyday function and goal-directed behavior in cognitively impaired populations such as patients with schizophrenia (Pijnenborg et al., 2010). Although Short Message Service (SMS) protocols have not been used to motivate physical activity in PLWH, text message reminders have been demonstrated to improve HIV medication adherence in several studies (Dowshen, Kuhns, Johnson, Holoyda, & Garofalo, 2012; Moore et al., 2013). Recent focus group data suggest that barriers limiting antiretroviral treatment

(ART) adherence may also apply to physical activity (e.g., poor motivation, depression); common facilitators (e.g., social support) could also sustain both behaviors (Montoya et al., 2014). Successful physical activity interventions that address these issues have been reported to incorporate self-monitoring, goal-setting, methods to overcome physical activity barriers, and approaches tailored to each participant (Fjeldsoe et al., 2009).

We are currently conducting an ongoing randomized controlled trial (RTC) evaluating iSTEP, a 16-week personalized, interactive Short Message Service/Multimedia Message Service (SMS/MMS) intervention designed to increase moderate physical activity and improve neurocognitive function in persons with HAND. The study has two primary aims: (a) to determine if iSTEP could significantly increase physical activity quantified by objective measures, such as pedometer and accelerometer counts; and (b) to evaluate the effect of iSTEP on a global indicator of neurocognitive performance and measures of everyday function. Here we report on the feasibility and participant acceptance of the iSTEP protocol used to monitor and motivate physical activity in a cognitively impaired population of people with HIV infection. Our objectives were to: (a) report participant preferences for personalized SMS/MMS options, (b) examine the responses to text messages and efficacy of data collection during the intervention, and (c) review qualitative feedback provided by iSTEP and control participants who completed the 16-week study. The rationale for reporting these preliminary findings is to expedite and inform the development of mHealth interventions that will improve health outcomes in PLWH and other vulnerable populations.

Experimental Design and Methods

Participants

Our target enrollment for the ongoing RCT is 25 participants in the iSTEP intervention and 25 participants in a control condition (50 total). To date, 21 participants have completed the intervention and their data are included in this report; 11 were administered the iSTEP intervention and 10 were randomly selected for the control group. These individuals were community-dwelling participants who had a confirmed diagnosis of both HIV and HAND based on recent medical and neuropsychological assessments conducted during ongoing studies of HIV infection at the HIV Neurobehavioral Research Program (HNRP). Participants were contacted on the phone by an HNRP recruiter who explained the purpose of the study. Potential participants were informed that findings from the study would be analyzed and reported. Inclusion criteria included: (a) the ability to provide informed consent; (b) HAND diagnosis of ANI or MND per Frascati guidelines (Antinori et al., 2007); (c) ages 18 and older; (d) physically capable of moderate physical activity by self-report and verification with the participant's primary care provider (PCP); (e) no significant physical activity in the previous 3 months, defined as reporting fewer than 3 hours of moderate physical activity per week; and (f) willingness to receive and respond to daily text messages. Exclusion criteria included physical conditions that might limit moderate physical activity (e.g., myocardial infarction, stroke), neurological disorders (e.g., brain injury, seizures), and psychotic disorders. Approval for this study was obtained from the University of California San Diego local institutional review board.

Prior to participation in this study, all participants had been administered a comprehensive neuropsychological battery at the HNRP that included testing in seven domains (i.e., speed of information processing [SIP], learning, delayed recall, executive function, verbal fluency, working memory, and motor function) typically used to assess HAND (Heaton et al., 2010). Neuropsychological tests included the Wechsler Adult Intelligence Scale (WAIS-III); Digit Symbol, Symbol Search and Trail Making Test A (SIP); Hopkins Verbal Learning Test-Revised and Brief Visuospatial Memory Test-Revised (learning and memory); Computerized Wisconsin Card Sorting Test-64 and Trail Making Test B (executive function); Controlled Oral Word Association Test and Category Fluency (verbal fluency); WAIS III Letter-Number Sequencing and Paced Auditory Serial Addition Task (working memory); and Grooved Pegboard Test (motor; Heaton et al., 2010). To assess cognitive impairment, raw scores for these domains were converted to T scores using demographically corrected norms adjusted for age, education, sex, and ethnicity. Following previously established protocols (Heaton et al., 2010), a deficit score was applied to T scores and a global deficit score (GDS) was computed that reflected the severity of deficits across the battery. Participants with neuropsychological clinical ratings of greater than mild impairment in at least two cognitive domains (Blackstone et al., 2012a) were considered to have ANI as specified by the Frascati criteria. Everyday function was also assessed with: (a) the Patient's Assessment of Own Functioning (PAOFI), a 41-item questionnaire reporting the degree of difficulties with various cognitive abilities (Troeman et al., 2011); and (b) Instrumental Activities of Daily Living (IADL), a modified version of the Lawton & Brody scale that includes 13 items detailing independent function in areas such as managing finances and medication (Jefferson et al., 2008). Participants were classified as MND if they met at least two out of the following three criteria: (a) worse current functioning (compared to their best ability) in two or more areas on the IADL form; (b) impaired function on the PAOFI (i.e., indicating *almost always*, *very often*, or *fairly often* for three or more cognitive difficulties such as poor memory or organization); (c) unemployed or impaired job performance due to cognitive problems (Blackstone et al., 2012b).

RCT Design

HIV-infected participants with HAND who were referred to our 16-week physical activity intervention attended a screening session to determine eligibility, including: (a) the Physical Activity Readiness Questionnaire, used to screen subjects for medical conditions that could preclude participation in moderate physical activity; (b) a physical activity questionnaire to ascertain physical activity over the prior 3 months; (c) consent to participate, including permission to contact his/her PCP; and (d) a decisional capacity assessment quiz to verify participant ability to provide informed consent for the study. Once initial participant eligibility was established, the PCP was contacted to verify the person's physical capacity and confirm it was medically acceptable for him/her to engage in specific types of physical activity. Enrolled participants were subsequently assigned to the iSTEP intervention or control condition via computer-based simple randomization (Table 1).

At the baseline visit conducted at the HNRP, all participants were administered: (a) the 7-Day Physical Activity Recall (7DPAR), a detailed interview that quantified physical activity over the previous 7-day period, providing a quantitative assessment of total physical activity

in caloric expenditure (kilocalories/kg/day); (b) assessment of physical activity barriers and facilitators, a form rating the intensity of barriers and motivating factors for physical activity on a 1 to 5 scale, including the identification of the top five barriers that made it most difficult for each individual to engage in physical activity; (c) neuropsychological testing with the 7-domain battery described above to assess neurocognitive function at baseline; (d) everyday function assessed with the PAOFI and IADL; (e) Diet History Questionnaire (DHQ); (f) the Actigraph GT3X accelerometer (ActiGraph, Pensacola, FL) for a 7-day baseline physical activity assessment (to be mailed back after a week); (g) the Omron HJ-321 pedometer to quantify daily step counts during the 16-week intervention; and (h) study orientation (reviewing the intervention plan and protocol, training to use the text message program, and setting personal preferences, such as when to receive messages). Participants were instructed to wear the pedometer on their waistband or belt during the study and the device was equipped with two clips (one on the back and one attached to a strap) to secure the unit. The accelerometer was attached to an elastic fabric band worn around the waist and participants were asked to situate the monitor on their right hip. The total time typically required to complete this assessment battery was 4-5 hours. Participants were allowed to take breaks as needed and were also provided with a free lunch and transportation if required. If a participant did not have a phone or his/her phone lacked SMS/MMS capability, we planned to provide a phone and cover voice/text costs, but all 21 participants in this cohort had their own mobile phones with text/picture message capability.

To control for the attention of the SMS program, both iSTEP and control participants received text messages 3 times a day throughout the 16 weeks of the study (1 message in the morning, afternoon, and evening), including text questions about HIV symptoms and mood (e.g., neuropathy symptoms, depression). During the first week, both groups received similar messages, including introductory texts (Welcome to the study, Save this number in your contacts so you know it is an iSTEP message) and reminders to wear the accelerometer. After the first week, control participants did not send or receive any SMS/MMS regarding physical activity but instead were sent random factoid messages (e.g., A newborn baby's head accounts for one-quarter of its weight). Participants in the control arm were requested to wear the pedometer and record their daily step counts in a paper diary but did not use the SMS program to report or receive feedback on step counts and did not set any step count or physical activity goals. In contrast, participants in the iSTEP intervention condition received the physical activity SMS/MMS protocol designed to increase physical activity, used SMS to report daily step counts, and received MMS feedback on weekly step counts. Because using a pedometer may itself influence physical activity, we chose to have control participants also wear the device to better determine the specific efficacy of the physical activity SMS/MMS paradigm. We selected a 4-month duration for the study based on evidence that: (a) neurocognitive improvement occurs within this period (Kemoun et al., 2010); and (b) participants, including PLWH, demonstrate a high level of adherence to SMS protocols over this time frame (Dowshen et al., 2012).

All participants received a payment of \$50 for completing the baseline visit and \$75 for attending the final visit at the end of 16 weeks. iSTEP and control participants were each contacted by phone at Weeks 6 and 11 to check their status and determine if they had any questions or concerns; participants who responded to phone contacts and remained in the

study were subsequently mailed a \$20 payment as an incentive for continued participation. All participants were also mailed an accelerometer to wear during the last (16th) week of the intervention and returned the device at the final visit, where they were administered the same comprehensive assessment battery as the baseline visit. Participant feedback about the study was obtained using a questionnaire that included Likert-type scales to rate intervention outcome and acceptability, evaluation of the protocol (e.g., number of preferred messages per day, appropriate step count goals), and feedback on potential future modifications to the design. Information obtained from the questionnaire was augmented by an interview with each participant about the experience, including soliciting comments on text messages and ideas for improving the intervention.

iSTEP Intervention Theory and Implementation

The intervention was based on elements of control theory, including goal-setting, self-monitoring, performance feedback, and intention formation (Carver & Scheier, 1981). A recent meta-analysis indicated that control theory techniques, self-monitoring and goal-setting in particular, have proven to be the most successful at improving physical activity and diet health behaviors (Michie, Abraham, Whittington, McAteer, & Gupta, 2009). The process we applied in our study consisted of goal review (establishing physical activity goals, reviewing effects of goal progress), intention formation (identification of participant intention to engage in physical activities), goal setting (establishing step count goals for walking), self-monitoring (reporting pedometer step counts via SMS), and goal feedback (weekly MMS graphs illustrating physical activity change over the course of the intervention).

Participants in the iSTEP intervention condition received a series of interactive and personalized daily text messages sent to their mobile phones that were designed to motivate moderate physical activity, including: (a) tips for increasing the amount of walking; (b) prompts to engage in other types of physical activity that they preferred doing; (c) suggestions to address the top five barriers to physical activity; (d) messages about the health benefits of physical activity; (e) a text message every evening that asked them to report daily pedometer step counts; and (f) milestone messages indicating how far, in total, they had walked during the study, e.g., Guess what! You have walked 21 miles, the closest distance between England and France across the English channel! Participants received three messages a day and novel texts were sent each week to minimize habituation. At the baseline visit, each iSTEP participant provided a list of his/her top five personal barriers that limited physical activity (fatigue, neuropathy, comorbid medical conditions, etc.); two moderate physical activity activities s/he preferred to perform (household chores, gardening, bicycle riding); two locations where s/he could engage in physical activity (e.g., parks, mall, local beach); when s/he wanted to receive text messages (e.g., 7 a.m. or 10 a.m.); the name of a support friend who could do physical activity with him/her; and personalized messages (reminders to check messages if they had not responded for 3 days). This information was used to construct personal messages for each participant, including reminders to perform [selected physical activity] at [specific physical activity location]. Beginning in the second week, iSTEP participants were sent two questions each week asking if they had engaged in physical activity either on that day or during that week, for example, Were you able to do at

least 30 minutes of physical activity today, either walking or some other form of physical activity? (Y/N) or Were you able to do [preferred physical activity activity] this week?; the percentage of *Yes*, *No* and *No Response* outcomes were quantified over 15 weeks.

Every Sunday each iSTEP participant received feedback about his/her mean daily step counts in the prior week, including an MMS graph showing the average number of weekly steps over the course of the study. The participant was sent a text message requesting that s/he meet a goal of increasing their steps by 10% during the next week, a benchmark used to successfully motivate walking (Michie et al., 2009). If the individual felt 10% was too difficult, s/he was allowed to select an alternate goal of increasing steps by 5%. To assist with this process of goal-setting, iSTEP participants were informed at the beginning of the study that they would be assigned “exercise ranks” based on how many points they earned for total steps completed and for responding to messages (1 point per step, 5,000 points for responding to all text prompts each week, and 25,000 points for meeting a 10% weekly step goal). All participants started as Level 1 *Beginner Walker* with 0 points. As points were accrued, they received milestone messages indicating goal achievement (e.g., Congrats! You have earned 150,000 points and reached the rank of Strong Walker!). There were a total of 17 ranks, including *Bronze*, *Silver*, and *Gold Walkers*, up to the highest rank of *Ultimate Walker* earned with 1.5 million points.

The SMS/MMS system used for our intervention was designed by the California Institute for Telecommunications and Information Technology (Calit2) and had four components: (a) a Web-based application (Case Management) that enrolled participants and set user preferences; (b) an MS-SQL database storing messages and intervention rules for how the system responded to participant responses; (c) a Java application that determined the appropriate message to send and processed the replies; and (d) an SMS delivery/reception program. Participants responded to messages by selecting single letter options or entering numbers (e.g., step counts), as shown by the example interactive message exchange in Table 3. Response content was evaluated to determine the appropriate reply from the system. Erroneous participant interaction was flagged by the system and alerted the staff to contact the participant and determine if there were problems. If a participant failed to respond to three texts in a row, s/he received a unique message (his/her own design) as a reminder to improve adherence; after five serial missed messages, the HNRP staff contacted the participant by phone to assess status.

Study Objectives and Outcomes

The iSTEP intervention incorporated a variety of elements designed to motivate physical activity, including step count monitoring with a pedometer, text and MMS feedback of physical activity changes over time, message reminders tailored to each participant’s barriers and preferred activities, and weekly goal-setting. The overarching aims of the ongoing study are: (a) to determine if iSTEP would significantly increase physical activity as quantified by accelerometer, pedometer, and 7DPAR self-report (Week 1 compared to Week 16); and (b) to examine if iSTEP participants would exhibit improvement in global neurocognitive performance assessed by GDS and everyday function measured by IADL and PAOFI. We will also examine the relationship between changes in physical activity and GDS, IADL, and

PAOFI. The objective in this article has been to present preliminary findings that address the feasibility and acceptability of our protocol, including initial qualitative feedback from iSTEP and control participants who have completed the 16-week intervention. The descriptive results shown below include: (a) participant responses at the baseline session about physical activity barriers, facilitators, and preferred options for exercise locations and text message settings; (b) participant response rates to text messages during the study and self-reported frequency of physical activity; and (c) participant feedback at the final visit, including Likert-type scale assessment of satisfaction and self-perceived efficacy, preferred support options, and qualitative feedback from the post-intervention interview.

Results

Demographics and Sample Characteristics

As shown in Table 2, participants were primarily middle-age males with an average of 13 years of education (range 10-18 years), including 1 year of college. Approximately half of the sample met criteria for MND, two thirds of participants had AIDS, and 20% exhibited a detectable HIV viral load. Table 2 also lists the percentage of participants who identified various factors as one of their top five barriers to physical activity. The majority of both iSTEP and control participants listed fatigue and lack of motivation as a primary barrier, and about one third identified depression or not enough time as key factors that limited physical activity. Other physical activity barriers included financial limitations, feeling that physical activity was less important than other needs, not wanting to exercise alone, and lack of access to transportation. These responses were indicated by one to three participants in each arm. Participants were also asked to identify general reasons for choosing to engage in physical activity. The majority indicated that concern about heart disease and a desire for more energy were very important motives for physical activity, while self-esteem and improved mood were also emphasized.

Participant Responses During the Intervention

Participants were given several options to personalize the text messages they received, including setting the time for messages and choosing if each message would arrive at the same time each day (e.g., 9 a.m.) or vary within a range (e.g., between 9 and 11 a.m.). All control participants requested an exact time for message delivery and half of iSTEP participants wanted a variable time range for their texts (Table 3). In the iSTEP group, the majority of participants selected a local park or gym/YMCA as a physical activity location; a few individuals listed other specific options such as a beach, hiking trail, or bowling alley. Preferred physical activity activities, beside walking, tended to include bicycling, swimming, or volunteer work.

iSTEP and control participants both exhibited a high rate of responding to all text messages during the 16-week intervention (Table 3; 89% and 85%, respectively). iSTEP participants also reported the vast majority of daily step counts (92%); controls showed a similar level of adherence by writing daily steps in a paper diary collected from each participant at the final visit (92%). As part of the SMS protocol, participants were: (a) asked twice during the first week if they were wearing their accelerometer, (b) received three questions about HIV-

related symptoms and two questions about medication effects over the course of the 16-week study, and (c) were sent two questions every week (Week 2 through Week 16) about performing physical activity. Almost all participants reported that they were wearing the accelerometer when prompted with this question during the first week of the study. Over the course of the 16 weeks, participants indicated ongoing HIV-related symptoms about one third of the time; approximately one quarter of the entire participant sample indicated problematic medication effects at least once. When asked if they engaged in physical activity that day or during the week, iSTEP participants reported *Yes* two thirds of the time.

Questionnaire Feedback After the Intervention

All 21 participants completed the study and attended the final visit after 16 weeks. At the last visit, all participants completed a feedback questionnaire with Likert-type scales to rate their experiences with the study (Table 4). Eighty percent of control and 90% of iSTEP participants indicated that they were either *satisfied* or *very satisfied* with the study. While 7 iSTEP participants *strongly agreed* that the intervention increased their physical activity, only 1 control participant chose this option. All individuals in the iSTEP condition either *strongly agreed* or *somewhat agreed* that the intervention increased physical activity and none selected a *neutral* or *disagree* response. Five or six of the control participants reported that they *somewhat* or *strongly agreed* that the intervention improved their cognitive function, quality of life, and mood. Approximately two thirds of the iSTEP group gave similar responses. When asked how many text messages they would prefer to receive per day, both groups were evenly split between 2 and 3 messages; 3 of the entire participant cohort opted for only one daily text and no one wanted 4 or more messages per day. The group consensus was also divided on the optimal length of the study, with 40% of controls and 60% of iSTEP subjects agreeing that we should plan a longer (6-12 month) intervention. Of note, all iSTEP participants would *strongly agree* ($n = 8$) or *somewhat agree* ($n = 3$) to recommend this intervention for other PLWH; in contrast, 3 of the controls choose the *neutral/no opinion* option on this question.

Questionnaire Feedback on Elements of the iSTEP Intervention

In addition to the feedback obtained from both groups, we also solicited responses from iSTEP participants about the utility of various aspects of the SMS/MMS intervention (Table 5). Self-monitoring with the pedometer was indicated to be *helpful* or *very helpful* to increase physical activity by all iSTEP participants, while 9 or 10 individuals indicated similar responses for setting step count goals and receiving milestone messages. The weekly MMS graphs and text tips for walking were deemed *helpful* or *very helpful* by about two thirds of the group, while 1 or 2 people responded that these options were unhelpful. Most participants (10/11) considered several of the tailored personal options as also *helpful* or *very helpful* to motivate physical activity, including setting their own text message time, using their Week 1 step count as a baseline, choosing their own types of physical activity, and being able to select a 5% or 10% weekly step count goal. Slightly fewer (two thirds) of the participants indicated that choosing their own locations for physical activity was helpful, while only about half indicated that their physical activity barrier messages were helpful. The most popular type of text message for iSTEP participants were the milestone messages. About half preferred to keep the 5% to 10% step count goal option, while 2 participants each

opted for either just 5% or 10% weekly step goals. Only one person wanted a 20% goal to increase step counts each week, while another individual desired the option to select a 5% to 20% range.

Qualitative Interview Feedback

In addition to the final visit questionnaires, participants were briefly interviewed by research staff and asked about their experiences. They were requested to indicate level of satisfaction, what aspects were most useful, what type of text messages were preferred, how easy or difficult it was to text (for iSTEP) or write down (for controls) step counts, how we could improve the intervention, and whether they would stay more physically active in the future, including performing more walking.

iSTEP participants uniformly described their experiences as *good, very satisfied, or helpful*, while one participant stated: “I enjoyed it. Overall, it was a ‘10’.” Control participants expressed positive statements about monitoring physical activity with a pedometer but also indicated that more support during the study was needed as illustrated by the following participant quotation: “It was pretty good, I needed more interaction and my partner had to motivate me ... I needed more in-person or motivational messages” (Control #8).

When asked to identify the most useful part of the study, eight iSTEP participants also mentioned self-monitoring with the pedometer, while seven individuals indicated a variety of elements as shown in two participant statements: “3 parts: graphs of step counts, physical activity messages about health benefits, milestone messages about levels” (iSTEP #5); and:

Milestone messages were useful, pedometer was motivating, wearing it every day I was able to track my mileage and set my own goal of walking three miles a day.

The pedometer was more accurate than a cell phone and exercise levels were motivating, earning points for answering questions. (iSTEP #7)

In regard to the type of text messages, five control participants expressed a desire to receive physical activity texts in addition to factoids: “Texts from an exercise partner would be optimal and much more meaningful” (Control #5); “I would have liked to see steps via texts and have step count goals each week” (Control #7).

iSTEP participants expressed a variety of opinions; some indicated that all text messages were useful, one person wanted fewer messages about physical activity benefits and another wanted more, while several individuals expressed positive feedback about the milestone messages: “I liked milestone messages and feedback about doing walking; they helped me to ‘get over the hump’ from intention to actually doing the activity” (iSTEP#7).

iSTEP and control participants indicated it was feasible to keep a record of step counts either via text or on paper, although four controls indicated that the memory function on the pedometer, which kept a record of the past 7 days of step counts, was quite useful: “With my poor memory, I sometimes skipped a day, then had to write entries for 2 days ... the memory function is a fabulous feature” (Control #6); “It was easy to write steps; I used the memory function 3 times to read past steps” (Control #7); “Easy to text, it was helpful to combine

messages with wearing pedometer every day” (iSTEP #7); and “Very easy to text step counts ... I always kept my pedometer by my cell phone” (iSTEP #11).

Participants provided a number of ideas about how to improve the study, including increasing the amount of phone contact, adding text messages about family-based activities, incorporating more messages about weather conditions, providing more explicit guidance about finding good physical activity locations, and including methods to reduce boredom (e.g., apps for listening to audio books). Two dominant themes were adding a diet/weight component and allowing participants to compare their physical activity with other individuals. Both control and iSTEP participants mentioned diet and weight loss as important factors: “Include diet/food messages in the middle of the day, like ‘remember to put down the chips’ ... a good idea to have a food log ... Weight loss was my motivating factor for participation” (Control #8); “I would like to see diet tips, recipe ideas ... Useful for other illnesses such as diabetes and cancer” (iSTEP #8); “I know people who could use this ... adding diet would be excellent, recipes, and combine with weight loss” (iSTEP #9).

Ten participants mentioned a preference for monitoring others’ physical activity and setting up a ranking system for competition, but some individuals also expressed concerns about this idea: “A bigger motivator for me would be to compare my progress with other people” (iSTEP #5); “Make it longer and set up competition with other people to rank their activity, this would be motivating rather than exercise levels” (iSTEP #6); “[Milestone messages were] not so interesting, it would be better to compare my performance to other participants ... have weekly rankings” (iSTEP #10); “Monitor what other people are doing ... possibly team with others, but I worry it could intimidate other people or they would be discouraged” (Control #7); and

It would be good to see others’ messages ... target those days when I am able to get physical activity and not the busy work days when this is less possible. I would feel irritated about getting messages that others are walking more if it was a workday when I just didn’t have the time. (Control #10)

Three participants offered suggestions on how to address potentially negative aspects of monitoring other people’s physical activity and/or introducing a competitive component: “It would be motivating to see other people’s steps anonymously, to show other people’s results at the beginning of the study to show expectations ... would help with goals” (Control #10) and

Allowing people the option to compare themselves to others would be good, but might be discouraging for some people ... One idea is to place people in groups based on their age range and existing physical activity and provide them with physical activity goals at the start of the study based on the performance of similarly fit participants. This would avoid discouraging an older person feeling like they could not compete with a 25-year old. (iSTEP #11)

When asked about their intent to remain more physically active in the future, all iSTEP participants ($n = 11$), and most control participants ($n = 8$), indicated they would do so and would continue to monitor their physical activity: “Yes, I started a new log book for steps ... looking at the numbers motivates me, my goal was a 5-6 pound loss” (Control #8); and “Yes,

I am still monitoring steps on my phone and keeping track on a spreadsheet at home” (iSTEP #11).

Discussion

Over the past 5 years mobile phone text messaging has emerged as a tool for the management of chronic disease (Hamine, Gerth-Guyette, Faulx, Green, & Ginsburg, 2015). The development of this nascent technology has been marked by a period of trial and error as some but not all intervention protocols have been effective at improving health outcomes (van Velthoven, Brusamento, Majeed, & Car, 2013). SMS has been applied to promote HIV prevention, clinic appointment reminders, and ART medication adherence (Mbuagbaw et al., 2015). Intervention efficacy appears to be maximized by: (a) minimizing message frequency to reduce fatigue, (b) using interactive message scripts rather than “one-way” reminders, (c) tailoring individual message content, and (d) matching the text message delivery to the time of the encouraged activity (Finitsis, Pellowski, & Johnson, 2014). Our group has recently demonstrated the feasibility of using SMS to monitor and promote ART adherence in difficult-to-treat populations such as PLWH with comorbid methamphetamine use or bipolar disorder (Moore et al., 2013; Moore et al., 2015). The present study extends this work by reporting on participant responses to an SMS/MMS intervention promoting physical activity in PLWH with HAND. Our initial cohort of participants exhibited a high response rate to all text messages (85%-89%), including miscellaneous questions about health, mood, and physical activity. They were able to report step counts via SMS or write down step counts in a diary more than 90% of the time. A majority of persons receiving iSTEP (63.6%) reported that they *strongly agreed* the study successfully increased physical activity, an opinion expressed by only one participant in the control group. While the current sample size was not powered for statistical group comparisons, the data collected to date suggest that combining SMS/MMS with pedometer self-monitoring may be a useful method to encourage physical activity in this population. Two thirds of iSTEP participants and half of control participants reported a self-perceived improvement in cognitive function. In response to biweekly questions about performing physical activity, iSTEP participants reported engaging in physical activity about two thirds of the time, with a low rate (11%) of non-response. In addition to providing positive feedback about the experience, participants who completed the 4-month intervention also submitted a variety of thoughtful suggestions about how we could improve the protocol. In summary, preliminary results show that these PLWH exhibited a high rate of response to iSTEP and remained engaged in the study.

Structured exercise regimens are indicated to improve a number of health-related outcomes in PLWH, including cardiovascular fitness, body composition, and psychological status (O'Brien et al., 2010), yet little is documented about everyday physical activity in this population. Webel et al. (2015) recently published one of the first exercise surveys of HIV-infected adults. The findings indicated that the most prevalent type of physical activity was walking (in 97% of participants), followed by climbing stairs (55%), and stretching (38%). Fewer than 5% of their participants indicated participation in sports or cardiovascular exercises. These results are reasonably congruent with data from our own sample showing that most participants selected walking as a preferred physical activity. A minority also opted for swimming or bicycling, while only a couple of participants chose other activities

such as roller skating. The findings suggest that specifically augmenting walking activity, common to virtually all PLWH and feasible even for frail persons, represents a good target for mHealth physical activity interventions. The virtual ubiquity of cell phones in the general population also appears to extend to our PLWH sample as all participants, to date, had their own mobile devices capable of SMS and experience with texting. After going through the study, control and iSTEP participants were evenly divided on the optimal number of messages per day (2 vs. 3), with few individuals advocating one message a day and none proposing four or more. These data indicate that 2-to-3 texts a day represents a reasonable “dose” for a physical activity study that involves daily monitoring of physical activity.

One of our key questions of interest was determining the value of using a pedometer by itself relative to combining this device with an SMS/MMS support system that included physical activity feedback and goal setting. Several studies have indicated that simply wearing a pedometer and self-monitoring steps with paper diaries was sufficient to stimulate physical activity (Tudor-Locke & Bassett, 2004), but more data are needed to assess the efficacy of a combined SMS/pedometer approach. While we will report quantitative physical activity changes and statistical analyses of group differences at the conclusion of the larger study, preliminary participant feedback indicated that all individuals felt the pedometer was useful, but controls expressed a need for more motivational support. They also endorsed the idea of receiving physical activity text message content. When queried about which iSTEP element was most effective at increasing physical activity, the majority of iSTEP participants indicated that setting step count goals and receiving milestone messages were very helpful in addition to self-monitoring with the pedometer. Weekly graph feedback, text message tips for walking, and personal physical activity barrier tips were endorsed as very helpful by only one third of the participants. Two thirds of the iSTEP group reported that the ability to set the time for messages was also very helpful for their physical activity, while about half responded similarly for the other personal options (own types of physical activity, physical activity locations). Milestone messages were the most preferred type of text message, while 80% of iSTEP participants favored having a 5%, 10%, or flexible 5-10% step count goal each week. These results suggest that the process of setting goals and, importantly, providing goal feedback in the form of meaningful milestone achievements, represented the most useful part of the intervention for these individuals. Personal control over study settings, such as determining text message timing, was also a key factor.

When asked to provide ideas about how to improve the intervention, a number of participants suggested we incorporate diet text messages to facilitate health and weight loss objectives. Several others proposed a competition/ranking system to enable physical activity comparison with other PLWH. Combined physical activity plus diet interventions are reported to be more successful than physical activity alone at improving metabolic indices of health (Jakicic, Wing, & Winters-Hart, 2002). Diet has also been proposed as a lifestyle intervention to address the significant problem of lipodystrophy and dyslipidemia in ART-treated individuals, factors also implicated in cognitive decline (McCutchan et al., 2012); therefore, we will consider inclusion of diet in future modifications of the iSTEP protocol. Although our current focus was on self-monitoring and self-established goals, competition, either at an individual or team level, has been applied to successfully motivate physical activity in workplace, community, and statewide intervention studies (Leahey et al., 2010).

Our participant feedback included excellent suggestions about how to circumvent some of the negative implications of including a competitive element (i.e., intimidation or discouragement), including: (a) providing anonymous rankings rather than describing participants by name; (b) focusing on days/periods selected by the individual so as to accommodate life/work limitations (e.g., a busy work schedule); and (c) placing participants in groups and setting physical activity goals based on current age and physical activity to avoid concerns about competing with others in far better physical shape or much younger in age. Based on this feedback, we will consider the inclusion of competitive-based physical activity goals in subsequent development of iSTEP, although the protocol for the ongoing RCT will not be altered.

It is appropriate to note several limitations to our study. The data reported here are descriptive self-report findings from a small sample of participants who have completed an ongoing RCT. It is possible that subject expectancy effects (e.g., a participant feels compelled to endorse the intervention to please the investigator) may have impacted our findings; yet, we note that a number of control subjects did indicate *no opinion* or *disagree* when asked to report their satisfaction and self-efficacy. They were also willing to indicate that more physical activity support was needed during the final visit interview. All participants to date also had their own cell phone with SMS/MMS capability, so the protocol has not been tested with participants who required study-provided cell phones or who lacked experience with texting. Overall, participant feedback was positive and has provided novel findings regarding the feasibility of a text message physical activity intervention.

Conclusion

Our results indicate that it is feasible to administer iSTEP to PLWH with HAND as demonstrated by a high text message response rate and positive participant feedback. Use of SMS/MMS technology represents a cost-effective strategy designed to accommodate individuals who may have socioeconomic or physical activity constraints that would limit participation in physically rigorous or resource-intensive intervention protocols. Future adaptations to iSTEP, after the conclusion of the current RCT, may include: (a) combining diet and physical activity elements to maximize health outcomes, and (b) incorporating competition-based physical activity goals tailored to the capabilities and needs of PLWH.

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Key Considerations

- PLWH continue to exhibit high rates of HIV-associated neurocognitive disorders (HAND) despite the efficacy of antiretroviral treatment.
- Physical activity is known to improve neurocognitive function affected by aging or dementia, but the effect of physical activity interventions on HAND has not been documented.
- Combining pedometer use with physical activity self-monitoring/goal-setting text messages may be a useful method to enhance physical activity in PLWH with HAND.

Table 1
Schedule for the 4-Month iSTEP Intervention

Screening Visit: Determine eligibility, obtain consent from participant and primary care physician		
Assignment: Randomly assign participants to Control or Intervention group		
	Control	iSTEP Intervention
Baseline Visit 1	7DPAR, physical activity barriers, neuropsychological testing, everyday functioning, DHQ, training for SMS, pedometer and accelerometer for Week 1 physical activity assessment	7DPAR, physical activity barriers, neuropsychological testing, everyday functioning, DHQ, training for SMS, pedometer and accelerometer for Week 1 physical activity assessment
During the Intervention	Generic factoid text messages and SMS questions on HIV symptoms and mood, recording pedometer step counts in diary, no physical activity SMS messages	Personalized physical activity text messages, setting physical activity goals, reporting steps counts via SMS, weekly MMS graphs showing step count progress, participant feedback on intervention
Week 6	\$20 Incentive payment for participant	\$20 Incentive payment for participant
Week 11	\$20 Incentive payment for participant	\$20 Incentive payment for participant
Final Visit 2 after 16 weeks	7DPAR, neuropsychological testing, everyday functioning, accelerometer data for Week 16 physical activity assessment, study feedback	7DPAR, neuropsychological testing, everyday functioning, accelerometer data for Week 16 physical activity assessment, study feedback

Note. Use 7DPAR = 7-Day Physical Activity Recall; DHQ = Diet History Questionnaire; MMS = Multimedia Message Service; SMS = Short Message Service.

Table 2**Participant Demographic and Physical Activity Characteristics at the Baseline Visit**

Parameter	Control (n = 10)	iSTEP (n = 11)
Demographics and HIV Description		
Mean ± SEM		
Age	49.6 ± 3.2	51.8 ± 2.6
Education	13.1 ± 0.8	13.5 ± 0.7
Gender (male/female)	9/1	9/2
Ethnicity (Caucasian)	6	7
Number of participants with ANI/MND	5/5	5/6
CD4+ T cell Count at Baseline Visit	703 ± 127	536 ± 57
CD4+ T cell Nadir	272 ± 101	176 ± 39
HIV RNA plasma (log copies per ml)	1.68 ± 0.06	1.62 ± 0.02
HIV RNA plasma (% detectable)	20.0%	18.2%
Number of participants with AIDS	7	7
Duration since first positive HIV test (years)	10.9 ± 2.9	16.3 ± 3.2
Daily energy expenditure 7 days prior to baseline (kilocalories/kg/day)	33.8 ± 0.8	33.7 ± 0.6
Top five physical activity barriers identified at baseline		
Number of participants who listed the following reasons as top physical activity barriers:		
Fatigue or lack of energy	6	7
Lack of motivation	6	6
Depression	3	4
Not enough time	2	4
Medical conditions (e.g., neuropathy)	2	4
Too busy with other obligations	4	1
Financial limitations	1	3
Physical activity less important than other concerns (e.g., housing or food insecurity)	1	3
Not wanting to exercise alone	0	3
Sleeping problems	1	2
Embarrassed about how I look when I exercise	1	1
More interested in computer activity or television	0	2
Physical activity is boring	1	1
Lack of access to transportation	0	2
Concern about safety or risk of injury	0	1
Hard to care about physical activity with seeing immediate benefits	0	1
Being overweight	0	1
Physical activity motivating factors		
Number of participants who described the following factors as a “very important” reason for them to perform physical activity:		
Reduce heart disease	7	5

Parameter	Control (<i>n</i> = 10)	iSTEP (<i>n</i> = 11)
To get more energy	6	5
To feel better about myself (self-esteem)	6	3
To get stronger	5	4
To improve mood/reduce depression	5	4

Note. ASI = asymptomatic neurocognitive impairment; MND = mild neurocognitive disorder

Table 3
Participant Text Message Selections and Responses During the 4-Month iSTEP Intervention

Parameter	Control (<i>n</i> = 10)	iSTEP (<i>n</i> = 11)
Preferred iSTEP settings		
Number of participants who selected exact time/or range of text delivery	10/0	6/5
Number of participants who selected the following physical activity locations		
Local park		8
Gym or YMCA		6
Walking around neighborhood		3
Mall		1
Beach		1
Hiking trail		1
Other (bowling center)		1
Number of iSTEP participants who selected the following physical activity options		
General Physical Activity (miscellaneous walking reminders)		8
Bicycling		4
Swimming		3
Volunteer work		2
Gardening/yard work		1
Housework/chores		1
Roller skating		1
Bowling		1
Responses during the intervention		
Participant response rate to all text messages	84.5%	89.0%
iSTEP participant response rate for step counts		91.9%
Control participant response rate for writing down steps in diary	92.4%	
Accelerometer wear in Week 1: % of "Yes" responses	90.0%	100.0%
Reported current HIV symptoms (e.g., neuropathy): % of "Yes" responses	43.1%	33.2%
Number of participants reporting any medication effects (e.g., fatigue, nausea)	3	2
Biweekly (twice a week) iSTEP participant report of engaging in physical activity:		
% of "YES" responses to physical activity:		67.0%
% of "NO" responses to physical activity:		21.8%
% of physical activity questions with no responses:		11.2%
Examples of Text Messages		
iSTEP message (8:00 am): Good news! U have increased your weekly step count by 12%!		
Can U keep going and increase steps by 10% again this week? (Y/N)		

Parameter	Control (n = 10)	iSTEP (n = 11)
<i>Participant response (8:02 am): N</i>		
iSTEP message (8:03 am): Can you tell me why? A = Fatigue, D = Pain in hands/feet, J = Lack of time, P = Other		
<i>Participant response (8:03 am): A</i>		
iSTEP message (8:04 am): Feeling too tired for a long walk or long period of exercise?		
Aim for short walks - even 10 minutes is helpful to your health.		
iSTEP message (4:00 pm): Howdy. Were you able to do at least 30 minutes of physical activity today, either walking or some other form of physical activity? (Y/N)		
<i>Participant response (4:03pm): Y</i>		
iSTEP message (10:00 pm): How many steps did you get in today? Txt back steps (####)		
<i>Participant response (10:03 pm): 8750</i>		
iSTEP message (10:04 pm): Excellent! Keep up the good work!		

Table 4
Participant Feedback on a Questionnaire Administered at the Final Study Visit

Question	Control (n = 10)	iSTEP (n = 11)
Satisfaction and Efficacy		
<i>Overall satisfaction with the study</i>		
very unsatisfied	0	0
unsatisfied	0	0
neither satisfied nor unsatisfied	2	1
satisfied	6	4
very satisfied	2	6
<i>Was the intervention successful at increasing physical activity?</i>		
strongly disagree	1	0
somewhat disagree	0	0
neutral/no opinion	3	0
somewhat agree	5	4
strongly agree	1	7
<i>Do you feel the intervention helped to improve your cognitive function?</i>		
strongly disagree	0	0
somewhat disagree	2	0
neutral/no opinion	3	4
somewhat agree	4	4
strongly agree	1	3
<i>Do you feel the intervention helped to improve your quality of life?</i>		
strongly disagree	0	0
somewhat disagree	2	0
neutral/no opinion	2	3
somewhat agree	4	3
strongly agree	2	5
<i>Do you feel the intervention helped to improve your mood or level of depression?</i>		
strongly disagree	0	0
somewhat disagree	1	0
neutral/no opinion	4	3
somewhat agree	4	5
strongly agree	1	3
Method and Future Direction		
<i>We sent 3 text messages a day. Would more or fewer be preferable?</i>		
3 messages a day is optimal	3	5
I would prefer only 1 message a day	2	1
I would prefer 2 messages a day	4	5
I would prefer 4 messages a day	0	0

Question	Control (n = 10)	iSTEP (n = 11)
I would prefer 5 or more messages a day	0	0
<i>This study was 4 months. Should we plan a longer study, 6 or 12 months, for example?</i>		
strongly disagree	0	1
somewhat disagree	1	2
neutral/no opinion	5	1
somewhat agree	3	6
strongly agree	1	1
<i>Would you recommend this intervention to other individuals with HIV?</i>		
strongly disagree	0	0
somewhat disagree	0	0
neutral/no opinion	3	0
somewhat agree	4	3
strongly agree	3	8

Table 5
iSTEP Participant Feedback on a Questionnaire About the Methods and Utility of the Study (n = 11)

Question						
<i>Did the following procedures help you to increase your physical activity?</i>						
	Self - monitorin g with pedometer	Setting step count goals	Weekly Graph feedback	Review goals each week	Text tips for walking or ither physical activity	Milestone Text messages
very unhelpful	0	1	0	1	0	0
unhelpful	0	0	1	1	2	0
no opinion	0	1	2	1	2	1
helpful	3	3	5	5	3	4
very helpful	8	6	3	3	4	6
<i>We included several personal choices in iSTEP. Did any of these options help you to increase your physical activity?</i>						
	Setting my own time to receive texts	My own types of physical activity	Personal locations for physical activity	Using my own step count as baseline	Option of 5% or 10% weekly step count goal	Personal barrier messages
very unhelpful	0	0	1	0	0	0
unhelpful	0	0	0	0	0	2
no opinion	1	1	2	1	1	4
helpful	3	4	3	4	4	2
very helpful	7	6	5	6	6	3
<i>What type of text message was most helpful to increase your physical activity? Number of iSTEP Participants:</i>						
Tips to increase walking						3
Reminders for other types of physical activity						0
Reminders to decrease sedentary behavior (reduce TV/computer sitting)						1
Messages to help with personal barriers to physical activity						0
Information about the benefits of physical activity						2
Milestone messages, e.g., reaching an exercise level						5
<i>What weekly step count goal would you recommend?</i>						
10% increase in step counts per week is optimal						2
I would prefer a 5% increase in step counts per week						2
Having flexibility to choose either 5% or 10% goal each week						5
15% increase per week						0
20% increase per week						1
Having flexibility to select a range from 5% to 20% each week						1
<i>We focused on five physical activity barriers. Should we concentrate on fewer or more barriers?</i>						
Sending messages to help with five physical activity barriers was effective						8
Better to spend more time and attention on fewer barriers (e.g., focus on top 3)						3
I prefer to receive text messages and tips for a larger number of barriers (e.g., 7-10)						0