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Feasibility study of home telerehabilitation for physically inactive veterans

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Abstract—The aim of this study was to develop a system for and determine the feasibility of monitoring home exercise for physically inactive older adults using a Health Buddy (HB) text messaging device (Robert Bosch Healthcare; Palo Alto, California). Questions and messages related to exercise adherence are displayed on the HB screen and participants choose a response by pressing the corresponding button on the device. Responses are transmitted through a landline connection and high-risk responses are highlighted by the system for follow-up. We developed the questions and messages based on input from patient and clinician focus groups. We evaluated feasibility by administering the intervention to inpatient and outpatient adults aged 60 or older. We gave participants a choice of exercise monitoring by HB (n = 20) or telephone (n = 18). The results showed that home exercise monitoring by HB and telephone is safe, as evidenced by low adverse event rates. We saw a decline in exercise adherence rates to both the HB and telephone after 8 weeks, although adherence was better for HB than telephone. Taken together, the results demonstrate the feasibility of using text messaging to monitor home exercise adherence in physically inactive older adults.

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Key words: deconditioning, exercise, exercise adherence, exercise monitoring, Health Buddy, older adults, physical activity, telephone, telerehabilitation, text messaging.

INTRODUCTION

The *Healthy People 2010* guidelines recommend that all Americans engage in at least 30 minutes of moderate-intensity activity 5 days per week or at least 20 minutes of vigorous-intensity exercise 3 days per week [1]. In 2001, approximately 34 percent of adults in the general U.S. population achieved this level of activity. Even fewer older adults met these guidelines; among older adults aged 65 to 74, only 16 percent met the guidelines for moderate-intensity exercise and 13 percent met the guidelines for vigorous-intensity exercise [2]. Although U.S. veterans are more physically active than nonveterans across all age groups, many veterans also do not meet Federal recommendations for weekly moderate physical activity [3–4]. In an analysis of a national sample of veterans, Littman et al. found that 45.6 percent of veterans aged 50 to 59 and 40.7 percent of veterans ≥70 years met daily physical activity level recommendations [4]. Physical

Abbreviations: HB = Health Buddy, TEM = transtelephonic exercise monitoring, VA = Department of Veterans Affairs.

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activity levels were lower for veterans receiving care from the Department of Veterans Affairs (VA) than those who received healthcare in other settings [4].

Physical inactivity is an important problem to address for older veterans because continued inactivity may contribute toward the development of deconditioning, frailty, and disability. Deconditioning is clinically defined as "multiple changes in organ system physiology that are induced by inactivity and reversed by activity" [5]. In older adults, deconditioning may be a result of the aging process itself, disease, and inactivity such as bed rest or a sedentary lifestyle. Deconditioning may start at any time, may become worse during hospitalization, and may continue after discharge [5]. If left untreated, deconditioning may become chronic and lead to functional decline, institutionalization, and increased mortality [5].

Frailty in older adults is a new and emerging syndrome [6–9]. Geriatricians generally agree that frailty and disability are related, and both can result from decreased activity over time [10]. According to Fried et al., frailty is a consequence of disease and age-related changes and is defined as a "physiologic state of increased vulnerability to stressors that results from decreased physiologic reserves of multiple physiologic systems" [10]. Disability is related to frailty and is defined as "difficulty or dependency in carrying out activities essential to independent living, including essential roles, tasks needed for self-care and living independently in a home, and desired activities important to one's quality of life" [10]. These definitions have led to frailty being described as a continuum based on the presence or absence of clinical manifestations such as weakness, weight loss, slow walking speed, fatigue, and low levels of activity [10–12]. Its prevalence in the general U.S. population is estimated at 3 to 7 percent in those 65 to 75 years old and 32 percent in those ≥90 years old [6]. The prevalence of frailty in the veteran population may actually be higher. In a study of 985 veterans who were admitted to the VA Palo Alto Health Care System, 27 percent of those ≥65 years old were judged to be frail with a 1-year mortality rate of 45 percent [13]. Once an older adult becomes frail, he or she is at increased risk for events such as falls, injuries, adverse health outcomes, institutionalization, and mortality [14–15].

A prefrail stage, in which one or two criteria are present, identifies a subset of individuals at high risk of progressing to the frailty stage [16]. The identification of a prefrail stage is significant because studies suggest that the effects of prefrailty may be reversible [7]. Gill et al. studied 754 community-dwelling adults ≥70 years old for transitions between stages of frailty [7]. They identified frailty based on weight loss, moderate to severe exhaustion, low physical activity based on kilocalories of physical activity expended each week, muscle weakness as related to body mass index and a handheld dynamometer test, and slow walking speed. They classified older adults as prefrail if they met one or two criteria and frail if they met three or more criteria. Of the total sample, they classified 51.2 percent as prefrail at the beginning of the study period. As the cohort aged, approximately 40 percent went from a nonfrail to a prefrail state at 18 months and 25 percent went from a prefrail to a frail state. Frailty was partially reversible, with 23 percent going from a frail to prefrail state and 11 percent going from a prefrail to nonfrail state at 18 months. No individuals went from a frail to nonfrail state, suggesting that once an individual reaches the frail state, he or she will always be at least somewhat frail. Collectively, these results suggest that if healthcare providers can intervene before a patient reaches the frail state, the potential exists for halting or reversing the condition.

Home Telehealth Monitoring

Telehome health programs have been implemented to support older adults in their homes [17–19]. In the VA, home telehealth programs have focused on monitoring chronic disease conditions. Early evaluation of these programs have shown improvements in functional status and cognitive status [17] and reductions in resource utilization [20]. Surveys have shown excellent patient, family/caretaker, and provider satisfaction [18].

Home telehealth programs have also been used to monitor exercise performance. Fletcher et al. established the efficacy and safety of transtelephonic electrocardiographic monitoring in patients with coronary artery disease who exercised at home [21]. In another study, Sparks et al. found significant improvement in cardiac function with no medical emergencies using transtelephonic exercise monitoring (TEM) [22]. The researchers concluded that TEM was an effective alternative for the rehabilitation of patients unable to attend a hospital-based exercise program.

Using Text Messaging to Promote Exercise Adherence

The early studies demonstrating high satisfaction and clinical effectiveness of text messaging suggest that text messaging may potentially be a useful tool to promote exercise behavior in older adults. Several text messaging devices are available for clinical monitoring, including the Health Buddy (HB) (Robert Bosch Healthcare; Palo Alto, California), ViTelCare Turtle 400 (ViTel Net; McLean, Virginia), Viterion 100 and 200 telehealth monitors (Viterion TeleHealthcare; Tarrytown, New York), and InLife XP Patient Monitor and LifeView Patient Station (American Telecare; Eden Prairie, Minnesota). These text messaging devices transmit messages using a telephone landline service compared with devices that use an Internet or wireless connection (e.g., cellular telephone or WiFi [wireless fidelity]).

Several advantages exist to using text messaging through a landline. First, these devices can be connected to peripheral measurement devices such as blood pressure instruments or weight scales [23]. Text messaging devices are simple to use for older patients because of the big buttons and large font sizes. Older adults are more likely to have a telephone landline than Internet or wireless connections. These advantages led us to convene a pilot study with the overall aims of developing and determining the feasibility of a text messaging program to monitor exercise behavior in the home for physically inactive older adults. Feasibility was assessed by (1) determining if a text messaging intervention administered through the HB targeted to physically inactive older veterans to monitor exercise behavior could be administered safely and with high patient satisfaction compared with a telephone monitoring group, (2) determining intervention adherence for the HB group (text messaging adherence) and the telephone group (telephone adherence), and (3) determining exercise adherence rates for the HB group compared with a telephone monitoring group.

METHODS

Development of Exercise Monitoring Intervention Using Text Messaging

A literature review of existing models of home exercise, as well as input from rehabilitation and technology experts and patients through focus group discussions, initiated the development of the text messaging intervention. The expert focus group consisted of five individuals selected for their expertise in home exercise for older adults, rehabilitation, and home telehealth technology. The two patient focus groups consisted of older individuals enrolled in a Care Coordination Home Telehealth Program for disease monitoring or who had been discharged from the acute hospital setting in the previous 6 months. We asked patients about their preferences regarding the use of technology for health monitoring (patient focus group 1), the kinds of exercise they do, how much exercise they do, what kinds of advice they were given about exercise while in the hospital, perceived barriers to exercise and what they do to overcome these barriers, factors affecting adherence to exercise, and desired exercise outcomes (patient focus group 2).

We combined information obtained from the focus groups with our clinical expertise to develop the home telehealth monitoring intervention using text messaging devices. We selected the HB, versions 1 and 2, for use in this exercise monitoring intervention because of its high satisfaction ratings from patients in the focus groups [24]. We already use these devices in our medical center to monitor patients with chronic diseases such as diabetes and hypertension and loaned them to our project for use with physically inactive patients. **Figure 1** shows the HB. The HB is powered through an electrical plug connected to a wall socket. The telephone is then plugged into the HB, and the HB is plugged into the telephone wall jack (**Figure 2**).

Feasibility Testing of Text Messaging Intervention

After developing the text messaging intervention, we determined its feasibility in monitoring home exercise on a sample of older veterans. We assigned study participants to either the HB or telephone monitoring group

Figure 1.
Health Buddy device.

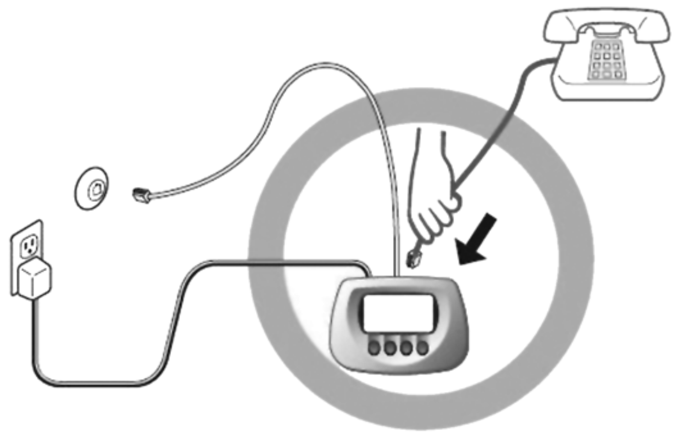

Figure 2.
Health Buddy setup with telephone.

based on their preference. We assessed feasibility by evaluating the safety, patient satisfaction, intervention adherence rates to the HB or telephone, and exercise adherence rates for the HB and telephone groups.

Participants

We recruited a convenience sample of 38 older veterans to participate in the study from both the inpatient and outpatient settings of a large urban academic VA hospital. The initial intent was to target physically inactive inpatients that were being discharged from the hospital. However, because inpatients had a high dropout rate from the feasibility study, we redirected our focus to physically inactive outpatients. We recruited potential participants through referrals from physicians, case managers, and social workers; participant recruitment fairs; and flyers posted around the hospital. We asked interested veterans to contact the research coordinator who would then describe the study in detail. We scheduled those veterans who wanted to participate in the study for an initial in-person visit at the hospital where the research coordinator would review and obtain written informed consent and screen the veteran for possible inclusion in the project. Inclusion criteria were as follows: ≥60 years old, patient report of acute decline in functional status while hospitalized (if recruited from the inpatient setting) or patient report of physical inactivity (if recruited from the outpatient setting) as indicated by answering “No” to the question “Do you exercise at least 3 days a week for 30 minutes or more for the purpose of improving or maintaining your health?,” ability to hear and communicate by telephone, ability to read a video or text monitor, ability to manually operate the technology, have a working telephone and power source, and willingness to use text messaging technology. Exclusion criteria were as follows: not fluent in English; poor cognitive functioning; nonambulatory; or stroke, myocardial infarction, hip fracture, or hip or knee replacement in the 6 months before study enrollment. We asked participants meeting screening criteria to select their preferred monitoring method, i.e., HB or telephone.

Interventions

We scheduled participants who selected HB monitoring for a home visit with the study coordinator within the first week after the initial session. The purpose of this home visit was to set up the HB and instruct the participant in its use. We programmed the HB to ask a series of daily questions using a branching logic related to exercise performance, walking, and experience of adverse events. The HB would remind the participant to answer the daily questions by providing a soft beeping sound approximately every 24 hours. The participant then initiated the daily questions by pressing any of the four buttons on the HB. The participant responded to the daily questions by pressing the button on the HB corresponding to the answer, and the data would be transmitted through a telephone landline to a computer server located at the hospital. A vendor-supplied software program automatically analyzed the data to facilitate viewing by research staff. In addition to providing raw data on participants’ responses, the program summarized the data by risk stratifying responses into “low risk” and “high risk” groups using a color-coding method. Research investigators predetermined the values for these groups during the development of the daily questions. The entire process of answering daily questions took about 5 minutes for the participant to complete. A research associate reviewed the transmitted information daily, then contacted the participant by telephone if there were any reported adverse events as denoted by positive responses to questions regarding chest pain, dizziness, and/or falling. If any of the above adverse events was confirmed, the study physician called the participant at home for appropriate triaging and clinical management. In addition, we interspersed motivational and educational messages between daily questions to encourage the participant to keep exercising. For example, one motivational message said, “Make sure you do your exercises today. Exercise will help you increase your daily activity level.”

In the telephone monitoring group, we asked participants to call the research coordinator on a daily basis. During the call, the research coordinator asked participants the same series of questions about exercise performance and safety as administered to the HB group. We gave participants the same response choices as the HB group. The research coordinator also provided the same educational and motivational messages as the HB to encourage the participant to exercise.

Measurements

We used the following measures to assess safety, text messaging adherence, exercise adherence, and patient satisfaction.

Safety

We assessed each participant's in-home safety by the number of adverse events they reported during exercise. Specifically, we asked participants daily whether they experienced any chest tightness, pressure, or pain; dizziness; and/or trips, stumbles, or falls during the most recent exercise session. We administered the same questions to both the HB and telephone groups. For example, one question was, "Did you experience dizziness during your most recent exercises?" Response choices for each adverse event question were "No" and "Yes." If the participant responded "No," the HB would deliver the following message: "Very good! Continue with your daily exercises to keep you healthy." If the participant responded "Yes," the HB would deliver the following message: "Call your Care Coordinator if these problems are preventing you from continuing your daily exercises," followed by the contact information for the care coordinator, telecare nurse, and emergency 911.

Text Messaging or Telephone Adherence

We calculated text messaging or telephone adherence rates in two ways. First, we calculated a whole group text messaging or telephone adherence rate by dividing the number of response days of the HB or telephone by 77 days (e.g., 11 weeks) and multiplied by 100. This first calculation estimated the text messaging or telephone adherence rate with the full intervention period as the denominator regardless of participant dropout. We considered a participant a dropout if he completely stopped communicating through the HB or telephone before the end of the intervention period. We used 11 rather than 12 weeks in the denominator because subjects received their HB units sometime during the first week of study enrollment and may have missed some days during this first week. The second measure was a participant group text messaging or telephone adherence rate, which we calculated as the number of response days with the HB or telephone divided by the total number of days the subject participated in the study and multiplied by 100. For the telephone group, we defined telephone response as the number of days that a telephone call was made to the research staff divided by the total number of days participating in the program and multiplied by 100.

Exercise Adherence

We calculated exercise adherence rates in two ways. First, we calculated a whole group exercise adherence rate by dividing the total number of days that the participant reported exercising by 77 days (i.e., 11 weeks) and multiplying by 100. This first calculation estimated the exercise adherence rate with the full intervention period as the denominator regardless of participant dropout. We used 11 rather than 12 weeks in the denominator because subjects received their HB units sometime during the first week of study enrollment and may have missed some days during this first week. We calculated a second measure, the participant group exercise adherence rate, by dividing the total number of days that the subject reported exercising by the total number of days that the subject actually participated in the study and multiplied by 100. This latter calculation for both groups yielded a higher exercise adherence rate because we excluded days following dropout from the denominator.

Patient Satisfaction

We administered a patient satisfaction survey developed by the VA Office of Care Coordination to the HB group only. We administered this survey through the HB and asked participants to rate their satisfaction on seven items regarding the use of the technology, such as "I think the providers have a better understanding of my care issues than they would have with a regular telephone call." Participants rated items on a 5-point Likert scale from 1 (strongly agree) to 5 (strongly disagree). We summed item scores to obtain a total score ranging from 7 to 35, with a lower score indicating better satisfaction.

Data Collection Procedures

We abstracted demographic and health information, including age, sex, education, living arrangements, height, weight, last three blood pressure readings, medications, medical diagnoses, and documented geriatric medical conditions, from the Computerized Patient Record System of the VA hospital. Data on safety, patient satisfaction, text messaging adherence, and exercise adherence were transmitted directly through a landline for the HB group or recorded by the research associate during each telephone session for the telephone group.

Data Analysis

Statistical analyses included descriptive statistics to assess demographic and medical characteristics, safety, text messaging or telephone adherence, exercise adherence, and patient satisfaction. We used *t*-tests to determine significant differences between the HB and telephone groups (with inpatients and outpatients combined within each group). We conducted all analyses using SPSS version 14.0 for Windows (SPSS, Inc; Chicago, Illinois).

RESULTS

Characteristics

Table 1 displays demographic and clinical characteristics of the sample. All participants were male. Significant differences existed in age between the HB and telephone groups (inpatients and outpatients combined within groups, $p < 0.01$). Participants in the inpatient HB group were the oldest at 78.0 ± 4.7 years old (all values shown as mean ± standard deviation unless otherwise noted), and

Table 1.
Demographic and clinical characteristics of sample.

Variable	HB Group		Telephone Group	
	Inpatient	Outpatient	Inpatient	Outpatient
No. of Participants	4	16	3	15
Age (yr)*				
Mean ± SD	78.0 ± 4.7	69.9 ± 7.9	76.0 ± 7.5	65.0 ± 6.1
Range	74–83	61–89	69–84	60–83
Race/Ethnicity (%)				
White	25	56	67	33
Black	25	38	33	40
Asian/Pacific Islanders	0	6	0	0
Hispanic	25	0	0	20
Other	25	0	0	7
Education (%)				
<12 years	25	0	33	0
12 years	0	19	0	13
>12 years	75	81	67	87
Living Alone (%)	25	50	33	40
Body Mass Index				
Mean ± SD	24.3 ± 5.1	28.6 ± 5.9	24.5 ± 2.8	30.4 ± 4.3
Range	18.4–29.2	22.7–44.1	21.8–27.3	22.9–38.4
Medical Condition (%)				
Hypertension	75	75	100	53
Congestive Heart Failure	25	0	0	13
Coronary Artery Disease	0	38	33	20
Cancer	75	31	33	7
Past Stroke	0	6	33	7
Diabetes	25	31	0	33
Chronic Obstructive Pulmonary Disease	50	25	0	33
Osteoarthritis	25	44	0	20
Chronic Kidney Disease	25	13	0	7

*$p < 0.01$ on *t*-tests between HB and telephone groups (combined inpatients and outpatients).
HB = Health Buddy, SD = standard deviation.

participants in the outpatient telephone group were the youngest at 65.0 ± 6.1 years old. The majority of participants had >12 years of education. The percent of participants living alone ranged from 25 percent in the inpatient HB group to 50 percent in the outpatient HB group. We found the highest body mass index in the outpatient telephone group at 30.4 ± 4.3 percent. Hypertension was the most prevalent medical condition reported by participants in this sample.

Adherence Rates to Health Buddy Text Messaging or Telephone Calls

Table 2 displays HB and telephone adherence rates. Both whole group and participant adherence rates were significantly different between the HB and telephone groups (inpatients and outpatient combined within group, $p < 0.05$). Of the whole group adherence rates, the inpatient HB group was the highest at 70.1 percent (range: 40.3%–98.7%) and the outpatient telephone group the lowest at 36.3 percent (range: 2.6%–72.7%). Of the participant group adherence rates, the inpatient HB group had the highest adherence rate at 95.0 percent (range: 89.0%–100.0%). The lowest participant group adherence rate was found in the outpatient telephone group at 50.2 percent (range: 5.4%–87.5%).

Exercise Adherence Rates

Table 2 displays exercise adherence rates. The whole group exercise adherence rates were higher for the HB groups than the telephone groups ($p = 0.007$). The outpatient HB group had the highest whole group exercise adherence rate at 57.4 percent, and the outpatient telephone group had the lowest rate at 32.1 percent. Participant group exercise adherence rates ranged from 77.1 percent in the outpatient HB group to 81.4 percent in the inpatient HB group. These latter exercise adherence rates were not significantly different between the HB and telephone groups.

Safety

The overall adverse event rate was significantly different between HB and telephone groups (inpatients and outpatients combined, $p < 0.05$) (**Table 2**). The mean rates of adverse events were 11.9 ± 11.7 percent and 2.1 ± 2.9 percent for the inpatient and outpatient HB groups, respectively. The overall adverse event rates were lower overall for the telephone groups at 0.5 ± 0.9 percent for the inpatient telephone group and 0.1 ± 0.5 percent for the outpatient telephone group. Participants in the inpatient HB group had higher rates of each adverse event than the other three groups. The number of trips, stumbles, and/or falls and reports of dizziness were significantly different between HB and telephone groups (inpatients and outpatients combined, $p \leq 0.05$). The study physician evaluated all reported adverse events, and none of the events resulted in discontinuing participation from the study.

Patient Satisfaction

We measured patient satisfaction to text messaging for the HB groups only. Participants in the inpatient HB group had a mean satisfaction score at 12 weeks of 9.0 ± 2.8 on a scale of 7 to 35, with a lower score indicating greater satisfaction. The outpatient HB group had a mean satisfaction score at 12 weeks of 11.6 ± 3.7.

DISCUSSION

The primary aim of this study was to explore the feasibility of conducting a text messaging intervention to monitor exercise adherence. To do this, we assessed safety, intervention adherence, exercise adherence, and patient satisfaction for a text messaging intervention compared with a similar telephone intervention. Initially, we targeted the deconditioned older veteran inpatient population; however, we found that this population had a high dropout rate due to multiple comorbidities. We shifted our focus to the older physically inactive veteran outpatient population.

Our data suggest low overall adverse event rates for home exercise in both the HB and telephone intervention groups. The overall adverse event rate was higher for the inpatient HB group, and these participants reported more pain; dizziness; and trips, stumbles, and/or falls than the other groups. The reason for the increased adverse event rate for the inpatient HB group is not known, but it may have been related to their recent acute medical illness for which they were hospitalized, presence of cardiopulmonary disease, and/or the actual home exercise program.

Despite the higher adverse event rate, the inpatient HB group also had the highest intervention adherence rate (text messaging adherence) at 70.1 percent over 11 weeks and 95.0 percent during study participation compared with the other three groups (outpatient text messaging adherence or inpatient and outpatient telephone adherence).

Table 2.
Adherence and safety percentage rates for HB versus telephone group.

Rate	HB Group		Telephone Group	
	Inpatient	Outpatient	Inpatient	Outpatient
No. of Participants	4	16	3	15
HB/Telephone Adherence				
Whole Group*†				
Mean ± SD	70.1 ± 26.3	64.7 ± 29.7	43.7 ± 25.8	36.3 ± 24.2
Range	40.3–98.7	1.3–98.7	14.3–62.3	2.6–72.7
Participant Group*‡				
Mean ± SD	95.0 ± 4.8	68.0 ± 28.2	63.9 ± 30.4	50.2 ± 29.6
Range	89.0–100.0	4.8–93.6	29.0–84.0	5.4–87.5
Exercise Adherence				
Whole Group*§				
Mean ± SD	56.2 ± 15.6	57.4 ± 24.9	35.1 ± 20.0	32.1 ± 22.7
Range	41.6–72.7	10.4–88.3	13.0–51.9	2.6–74.0
Participant Group¶				
Mean ± SD	81.4 ± 14.6	77.1 ± 15.3	78.2 ± 5.8	78.0 ± 13.3
Range	65.8–100.0	51.9–95.5	71.4–81.8	50.0–98.2
Overall Adverse Event***				
Mean ± SD	11.9 ± 11.7	2.1 ± 2.9	0.5 ± 0.9	0.1 ± 0.5
Range	0.0–23.4	0.0–8.9	0.0–1.6	0.0–1.8
Chest Tightness/Pressure/Pain				
No. of Occurrences (mean ± SD)	1.8 ± 2.4	0.6 ± 1.2	0.3 ± 0.6	0.1 ± 0.3
Range	0–5	0–4	0–1	0–1
Dizziness				
No. of Occurrences (mean ± SD)	3.8 ± 3.0	0.4 ± 0.7	0.0 ± 0.0	0.0 ± 0.0
Range	0–7	0–2	0–0	0–0
Trips/Stumble/Falls*				
No. of Occurrences (mean ± SD)	1.8 ± 2.9	0.8 ± 1.6	0.0 ± 0.0	0.0 ± 0.0
Range	0–6	0–5	0–0	0–0

*$p \leq 0.05$ on *t*-tests between HB and telephone groups (combined inpatients and outpatients).
†Whole Group HB/Telephone Adherence Rate: HB group = (number of days responding by HB/77 days) × 100. Telephone group = (number of days calling research office/77 days) × 100.
‡Participant Group HB/Telephone Adherence Rate: HB group = (number of days responding by HB/total number of days in program) × 100. Telephone group = (number of days calling research office/total number of days in program) × 100.
§Whole Group Exercise Adherence Rate = (number of days reported exercise/77 days) × 100. Adherence rate calculated over duration of intervention regardless of study dropout.
¶Participant Group Exercise Adherence Rate = (number of days reported exercising/number of days participating in study) × 100. Adherence rate accounting for dropout.
**Adverse Event Rate = [(number of chest tightness, pressure, or pain events) + (number of dizziness events) + (number of trips, stumbles, or falls)]/(total number of days in study) × 100.
HB = Health Buddy, SD = standard deviation.

The high text messaging adherence rates could have been influenced by the desire to quickly recover from the recent hospitalization. The outpatient HB group and inpatient telephone group had participant adherence rates of 68.0 and 63.9 percent, respectively. Both HB and telephone intervention groups had a drop off in intervention adherence rates after 8 weeks. A possible explanation, and one that has been verified by our clinical staff, is boredom after 8 weeks of daily text messaging or telephone questions and messages. This would indicate that if text messaging is used to monitor exercise adherence for the outpatient veteran, the text messaging intervention should be augmented to make it more interesting for a longer period of time. Conversely, the frequency of text messaging reminders could be decreased after the initial intense daily reminder period once subjects have acquired a healthier exercise habit.

Intervention adherence rates in our study ranged from 36.3 percent for the outpatient telephone group over 11 weeks, to 95.0 percent for the inpatient HB group during study participation. Other studies using the HB have reported varying adherence rates depending on the method used to calculate them, the condition being monitored, and the length of follow-up [25–27]. For example, Cherry et al. reported 12-month adherence rates ranging from 64 to 83 percent for patients with congestive heart failure, chronic obstructive pulmonary disease, diabetes mellitus, hypertension, and coronary artery disease [26]. They calculated compliance as the number of sessions taken by the patient divided by the total number of available sessions. However, they did not report how they handled dropouts or how they defined “available sessions.” Bigelow et al. reported a compliance rate of over 80 percent for a group of 68 patients with congestive heart failure followed for a mean of 7.4 months [27]. They calculated the compliance rate only for patients completing the study [27].

The results indicated that if targeted to the right population, the text messaging method can be an extremely efficient mode of monitoring home exercise. VA researchers estimate a total cost of $1,600 per patient per year for the HB intervention, which includes the cost of the equipment [28]. We estimate the cost of monitoring a patient by telephone to be $6,500 per year. The HB system has the capacity to monitor a large number of patients simultaneously and automatically identify and risk-stratify responses that require direct clinician intervention. In clinical practice, one practitioner would be able to monitor many patients simultaneously by reviewing data generated through the HB. In contrast, the telephone intervention requires more manpower to attend to each telephone call and is therefore not as efficient in monitoring home exercise.

CONCLUSIONS

The data from this study indicate that it is feasible to monitor home exercise adherence for older deconditioned/physically inactive veterans using a text messaging device or telephone. Both monitoring methods are safe, as indicated by low adverse event rates. However, our data suggest higher intervention adherence and higher exercise adherence using the text messaging device than the telephone method. Lower adherence and adverse event rates in the telephone group than the text messaging group could be influenced by intervention design, e.g., veterans in the telephone group had to initiate calls on their own to report exercise behavior whereas veterans in the HB group were prompted by the system to report exercise. We designed the telephone intervention in this way because, in practice, daily telephone calls initiated by a clinician to each participant would be resource intensive.

Limitations of this study are that we developed the HB intervention on a male veteran population; therefore, this intervention may not be generalizable to other population groups. Direct comparisons between the HB and telephone groups are not conclusive since we formed the two groups based on the participant’s preference and not using randomization. Exercise adherence was based on participants’ self-reports through the HB or telephone but not verified through any objective methods. We conducted the study on a small convenience sample. Finally, we did not collect any qualitative information from the participants at the end of the intervention period to ascertain their experiences with the HB.

The source of participant recruitment for a text messaging intervention, e.g., inpatient or outpatient setting, deserves careful consideration because of the differential dropout and adverse event rates between inpatients and outpatients. Therefore, future text messaging studies should develop criteria to target those older adults most likely to adhere to the intervention. In addition, adherence declined after 8 weeks of text messaging, indicating the need for the intervention to be modified to improve the intervention adherence rate. Future work should include qualitative studies to obtain participants’ preferences on ways to modify text messages to make them more appealing. In addition, the intervention should be tested on larger sample sizes using a randomized controlled design.

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REFERENCES

1. U.S. Department of Health and Human Services. Healthy people 2010. McLean (VA): International Medical Publishing, Inc; 2000.
2. U.S. Department of Health and Human Services. Physical activity and health: A report of the Surgeon General. Atlanta (GA): U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion; 1996.
3. Selim AJ, Berlowitz DR, Fincke G, Cong Z, Rogers W, Haffer SC, Ren XS, Lee A, Qian SX, Miller DR, Spiro A 3rd, Selim BJ, Kazis LE. The health status of elderly veteran enrollees in the Veterans Health Administration. J Am Geriatr Soc. 2004;52(8):1271–76. [PMID: 15271113] DOI:10.1111/j.1532-5415.2004.52355.x
4. Littman AJ, Forsberg CW, Koepsell TD. Physical activity in a national sample of veterans. Med Sci Sports Exerc. 2009; 41(5):1006–13. [PMID: 19346987] DOI:10.1249/MSS.0b013e3181943826
5. Siebens H. Deconditioning. In: Kemp B, Brummel-Smith K, Ramsdell J, editors. Geriatric rehabilitation. Boston (MA): Little Brown; 1990. p. 177–91.
6. Ahmed N, Mandel R, Fain MJ. Frailty: An emerging geriatric syndrome. Am J Med. 2007;120(9):748–53. [PMID: 17765039] DOI:10.1016/j.amjmed.2006.10.018
7. Gill TM, Gahbauer EA, Allore HG, Han L. Transitions between frailty states among community-living older persons. Arch Intern Med. 2006;166(4):418–23. [PMID: 16505261] DOI:10.1001/.418
8. Levers MJ, Estabrooks CA, Ross Kerr JC. Factors contributing to frailty: Literature review. J Adv Nurs. 2006;56(3): 282–91. [PMID: 17042807] DOI:10.1111/j.1365-2648.2006.04021.x
9. Markle-Reid M, Browne G. Conceptualizations of frailty in relation to older adults. J Adv Nurs. 2003;44(1):58–68. [PMID: 12956670] DOI:10.1046/j.1365-2648.2003.02767.x
10. Fried LP, Ferrucci L, Darer J, Williamson JD, Anderson G. Untangling the concepts of disability, frailty, and comorbidity: Implications for improved targeting and care. J Gerontol A Biol Sci Med Sci. 2004;59(3):255–63. [PMID: 15031310]
11. Vitagliano G, Curtis JP, Concato J, Feinstein AR, Radford MJ, Krumholz HM. Association between functional status and use and effectiveness of beta-blocker prophylaxis in elderly survivors of acute myocardial infarction. J Am Geriatr Soc. 2004;52(4):495–501. [PMID: 15066062] DOI:10.1111/j.1532-5415.2004.52153.x
12. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, Seeman T, Tracy R, Kop WJ, Burke G, McBurnie MA; Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: Evidence for a phenotype. J Gerentol A Biol Sci Med Sci. 2001;56(3): M146–56. [PMID: 11253156]
13. Winograd CH, Gerety MB, Chung M, Goldstein MK, Domingues F Jr, Vallone R. Screening for frailty: Criteria and predictors of outcomes. J Am Geriatr Soc. 1991;39(8): 778–84. [PMID: 1906492]
14. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, Scherr PA, Wallace RB. A short physical performance battery assessing lower extremity function: Association with self-reported disability and prediction of mortality and nursing home admission. J Gerontol. 1994; 49(2):M85–94. [PMID: 8126356]
15. Buchman AS, Wilson RS, Boyle PA, Bienias JL, Bennett DA. Change in motor function and risk of mortality in older persons. J Am Geriatr Soc. 2007;55(1):11–19. [PMID: 17233680] DOI:10.1111/j.1532-5415.2006.01032.x
16. Fried LP, Hadley EC, Walston JD, Newman AB, Guralnik JM, Studenski S, Harris TB, Ershler WB, Ferrucci L. From bedside to bench: Research agenda for frailty. Sci Aging Knowl Environ. 2005;3(31):pe24. [PMID: 16079413] DOI:10.1126/sageke.2005.31.pe24
17. Chumbler NR, Mann WC, Wu S, Schmid A, Kobb R. The association of home-telehealth use and care coordination with improvement of functional and cognitive functioning in frail elderly men. Telemed J E Health. 2004;10(2):129–37.

[PMID: 15319042]
DOI:10.1089/tmj.2004.10.129
18. Johnston B, Wheeler L, Deuser J, Sousa KH. Outcomes of the Kaiser Permanente Tele-Home Health Research Project. Arch Fam Med. 2000;9(1):40–45. [PMID: 10664641] DOI:10.1001/archfami.9.1.40
19. Meyer M, Kobb R, Ryan P. Virtually healthy: Chronic disease management in the home. Dis Manag. 2002;5(2):87–94. DOI:10.1089/109350702320229186
20. Paré G, Jaana M, Sicotte C. Systematic review of home telemonitoring for chronic diseases: The evidence base. J Am Med Inform Assoc. 2007;14(3):269–77. [PMID: 17329725] DOI:10.1197/jamia.M2270
21. Fletcher GF, Chiaramida AJ, LeMay MR, Johnston BL, Thiel JE, Spratlin MC. Telephonically-monitored home exercise early after coronary artery bypass surgery. Chest. 1984;86(2):198–202. [PMID: 6611245] DOI:10.1378/chest.86.2.198
22. Sparks KE, Shaw DK, Eddy D, Hanigosky P, Vantrese J. Alternatives for cardiac rehabilitation patients unable to return to a hospital-based program. Heart Lung. 1993;22(4): 298–303. [PMID: 8360063]
23. Veterans discharging from service—Home telehealth [Internet]. Washington (DC): Department of Veterans Affairs; 2009 [updated 2009 Jan 27; cited 2009 Nov 16]. Available from: http://www.carecoordination.va.gov/telehealth/ccht/discharge/#03.
24. Health Buddy System [Internet]. Palo Alto (CA): Bosch Healthcare; 2010. Available from: http://www.healthbuddy.com/content/language1/html/55_ENU_XHTML.aspx.
25. Ryan P, Kobb R, Hilsen P. Making the right connection: Matching patients to technology. Telemed J E Health. 2003; 9(1):81–88. [PMID: 12699611] DOI:10.1089/153056203763317684
26. Cherry J, Dryden K, Kobb R, Hilsen P, Nedd N. Opening a window of opportunity through technology and coordination: A multisite case study. Telemed J E Health. 2003; 9(3):265–71. [PMID: 14611694] DOI:10.1089/153056203322502650
27. Bigelow J, Cretin S, Solomon M, Wu SY, Cherry JC, Cobb H, O'Connel M. Patient compliance with and attitudes towards Health Buddy. Santa Monica (CA): RAND; 2000.
28. Health Hero Network [Internet]. Palo Alto (CA): Health Hero Network; 2009 [cited 2009 Dec 2]. Available from: https://www.healthhero.com/press/press_releases/pr_01_23_09.html.

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