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Home-based physical telerehabilitation in patients with multiple sclerosis: A pilot study

Joseph Finkelstein, MD, PhD;[1–2*] Oleg Lapshin, MD, MPH;[2] Heather Castro, MS;[2] Eunme Cha, MPH;[2] Patricia G. Provance, PT, MSCS[2]

[1]Multiple Sclerosis Center of Excellence, Baltimore Department of Veterans Affairs Medical Center, Baltimore, MD; [2]Chronic Disease Informatics Group, Department of Epidemiology and Preventive Medicine, University of Maryland School of Medicine, Baltimore, MD

Abstract—This study assessed feasibility and patient acceptance and estimated the magnitude of the clinical impact of physical telerehabilitation in patients with multiple sclerosis (MS). We recruited 12 consecutive patients with a known diagnosis of MS. Each patient received a custom-tailored rehabilitative exercise program prescribed by a physical therapist during a clinic visit. The patients were guided by the home telecare units in following their individualized exercise plan. After the patients used the physical telerehabilitation system for 12 weeks, a statistically significant improvement was shown in a timed 25-foot walk (from 13.8 +/– 8.3 s to 11.3 +/– 5.4 s), 6-minute walk (from 683.3 +/– 463.8 ft to 806.5 +/– 415.0 ft), and Berg Balance Scale score (from 38.8 +/– 11.1 to 43.1 +/– 9.9) as compared with the baseline. (Values are shown as mean +/– standard deviation.) Patients were highly satisfied with the service. Home-based physical telerehabilitation can improve functional outcomes significantly in patients with MS.

Key words: disease management, e-health, multiple sclerosis, patient-centered care, patient satisfaction, patient self-care, physical therapy, rehabilitation, telemedicine, telerehabilitation.

INTRODUCTION

Multiple sclerosis (MS) is a chronic debilitating disease of the central nervous system that may result in significant damage of the neuromuscular system, vision, and affective and cognitive functions [1]. Approximately 400,000 persons in the United States have MS [2], including approximately 28,000 veterans [3]. The annual cost of MS in the United States was an estimated $6.8 billion, and a total estimated lifetime cost for each case was $2.2 million [4]. Lifelong rehabilitation measures, along with medication treatment, are the major components of patient management [5–6]. Physical exercises positively affect patients' quality of life (QOL) and their functional capacities [7–8]. Poor adherence to rehabilitation, limited patient education, and access to specialized care can be barriers to treatment [9–10].

Abbreviations: BBS = Berg Balance Scale, CSQ-8 = Client Satisfaction Questionnaire (8 items), HAT = Home Automated Telemanagement, MAS = Modified Ashworth Scale, MMSE = Mini-Mental State Examination, MOS = Medical Outcomes Study, MS = multiple sclerosis, MSQOL-54 = MS QOL (54-item scale), MSSE = MS Self-Efficacy Scale, MSWS-12 = 12-Item MS Walking Scale, PDDS = Patient-Determined Disease Steps, QOL = quality of life, T25FW = timed 25-foot walk, VA = Department of Veterans Affairs, VAMC = VA medical center.

***Address all correspondence to Joseph Finkelstein, MD, PhD; Chronic Disease Informatics Program, Johns Hopkins Medical Institutions, 2024 East Monument Street, Room 2-615, Baltimore, MD 21205; 410-558-0480; fax: 410-558-0470. Email: jfinkel9@jhmi.edu**

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The Department of Veterans Affairs (VA) MS Center of Excellence actively promotes use of medical informatics and telemedicine in helping veterans with MS and sets widespread implementation of telehealth technologies as one of its goals [11]. Telemedical approaches that use a chronic care model can be implemented on multiple levels for improving the quality of care of patients with MS [12]. In a recent article, Hatzakis et al. emphasized the importance of telehealth programs [12], which were defined as "the provision of healthcare and sharing of medical knowledge through telecommunications," for veterans. Hatzakis et al. indicated that veterans are often isolated because of their disability or location and telemedicine can significantly improve access to medical care for them. The VA introduced a care coordination program for veterans with the following objectives [13]:

1. "Help ensure veteran patients receive the right care in the right place at the right time.
2. Make their home (place of residence) the site where veteran patients receive care whenever this is appropriate.
3. Take away barriers of distance, time, and travel from veteran care."

Following this strategy, physical telerehabilitation can be a part of the integrated computerized system for veterans with MS and for veterans with other chronic conditions.

Telerehabilitation has been rapidly developing during the last decade [14] and is now moving from single-case, or small sample research, to controlled trials with larger samples [15]. The cost-effectiveness of telerehabilitation and its financing are being actively discussed [16–18]. However, even though the number of studies evaluating various interventions of telerehabilitation is growing [19], reports on using this potentially promising technology with MS are limited.

This study was designed to assess the feasibility and patient acceptance of home-based physical telerehabilitation in patients with MS and to estimate the magnitude of its clinical impact. Home Automated Telemanagement (HAT) system [20] was used to implement the physical telerehabilitation intervention. Although telemanagement may support multiple components of patient care [20–29], in this feasibility pilot study, we focused on a physical rehabilitation component that was based on an individualized exercise plan prescribed by a physical therapist. Our long-range goal is to improve functional status and QOL, promote adherence to individualized treatment plans, and advance patient education using a home telemanagement system in patients with MS. In this study, we hypothesized that a home telerehabilitation system guiding patients at home in following their exercise program combined with a computerized decision-support tool monitoring patient performance would be feasible for and acceptable to patients with MS and would improve functional status. In addition, we intended to collect feedback from the study participants regarding the system functionality so as to refine our program and better address possible cognitive [19], visual, and motor dysfunctions in this population. The affect of such a system on patient self-care behavior and disease-specific QOL was also estimated.

METHODS

System Design

The HAT system is an academic test bed designed to study how telemedicine could help healthcare practitioners treat and monitor their patients according to evidence-based guidelines and help patients in following individualized self-care plans [20–21]. HAT is based on Wagner's model of chronic disease care [22] and supports patient self-management, comprehensive patient-provider communication, and multidisciplinary care coordination. Care coordination using the HAT system has been successfully implemented in different chronic diseases. Evaluation studies in asthma [23–24], hypertension [25], inflammatory bowel disorder [26], and other conditions [27–28] showed increased patient adherence and improved clinical outcomes. A recent study demonstrated high acceptance of computer-mediated education by patients with MS [29].

The technical aspects of the HAT system design have been previously described [20]. Briefly, the HAT system consists of clinician HAT units, HAT server, and patient HAT units. The clinician units are used to set up and update individualized treatment plans, analyze patient self-testing results, and review computer-generated alerts. The HAT server implements computerized decision support based on individualized alert setup and real-time monitoring of patient self-testing data. A patient HAT Home Unit in this study was represented by a laptop communicating through a modem with the central HAT server from patient homes. The HAT Home Unit was programmed to guide the patients' exercise activities throughout the day by presenting the prescribed personalized exercise list; providing textual, audio, and video prompts for performing each exercise; collecting self-reported information after completion of each exercise; and sending the complete exercise log at the day's end to the HAT central server. The user interface was self-explanatory and did not require previous familiarity with computers. It used large fonts, allowed a limited number of messages to each screen, had straightforward navigation, and operated with only a few keyboard buttons.

Study Sample

We recruited 12 consecutive patients with a known diagnosis of MS from University of Maryland School of Medicine outpatient sites, including University of Maryland Medical Center, Kernan Rehabilitation Hospital, Kernan Physical Therapy Center in Timonium, and Baltimore VA Medical Center (VAMC). Subjects were eligible to participate in the study if they (1) were aged 18 to 65, (2) had a confirmed diagnosis of MS based on MacDonald criteria [30–31], and (3) had a functional disability in the 2 to 5 range as defined by the Patient-Determined Disease Steps (PDDS) [31–32]. Subjects were ineligible if they had (1) other musculoskeletal diagnoses or unstable cardiovascular, respiratory, metabolic, or other conditions that would interfere with this study; (2) one or more exacerbations in the preceding 3 months; (3) received a course of steroid (intravenous or oral) within 60 days of screening; or (4) presence of significant cognitive impairment based on a Mini-Mental State Examination (MMSE) score ≤23. The patients were also required to have a working telephone line in their home. Level of computer experience was not a criterion for patient enrollment.

The PDDS scale is a self administered 8-point disability assessment for people with MS [31]. In a validation study conducted by Schwartz et al. [32], the PDDS showed high test-retest and internal consistency reliabilities. Correlational analyses performed in this study supported the construct validity of the PDDS. MMSE is an 11-question scale that measures cognitive functional areas of orientation, registration, attention and calculation, recall, constructions, and language. The maximum score is 30, and a score of 23 or lower may indicate cognitive impairment [33–34]. Since MMSE is not sensitive enough to assess complex changes in the mental functioning of the patients with MS and no firmly established cutoff point exists, we used the MMSE score only as an inclusion-exclusion criterion in this study.

The baseline characteristics of the study sample are presented in **Table 1**. Of the 12 consecutive patients with

Table 1.
Baseline characteristics of 12 study sample subjects with multiple sclerosis (MS). Values expressed as mean ± standard deviation or number (%) of patients.

Variable	Value
Age (Full Years)	52 ± 4
MS Duration (yr)	13 ± 7
Sex, Females	10 (83.3)
Race	
White	10 (83.3)
African American	2 (16.7)
Income Level ($k)	
<20	1 (8.3)
20–30	3 (25.0)
30–40	1 (8.4)
40–50	1 (8.3)
50–70	3 (25.0)
70–90	0 (0.0)
>90	2 (16.7)
Education (Full Years)	15 ± 2
Severity of MS (Self-Reported)	
Mild	2 (16.7)
Moderate	9 (75.0)
Severe	1 (8.3)
Job	
None	11 (91.7)
Temporary/Part-Time	1 (8.3)
Full-Time	0 (0.0)
Internet Use	
Never	0 (0.0)
Once a Month or Less	0 (0.0)
Once a Week	2 (16.7)
Once a Day	10 (83.3)
Computer Use	
Never	0 (0.0)
Once a Month or Less	0 (0.0)
Once a Week	1 (8.3)
Once a Day	11 (91.7)
No. of MS Exacerbations for Last Year	
0	6 (50.0)
1	3 (25.0)
>1	3 (25.0)
Disease Steps	3.7 ± 1.1
2	2 (16.7)
3	3 (25.0)
4	4 (33.3)
5	3 (25.0)
Control of MS (Self-Reported)	
Not Controlled	1 (8.3)
Somewhat Controlled	10 (83.4)
Completely Controlled	1 (8.3)

MS, 17 percent (2) were males and 83 percent (10) were females. The mean age was 52 ± 4, and education (in years) was 15 ± 2. Study subjects had had MS for an average of 13 ± 7 years, and 75 percent (9) reported that the severity of MS was moderate. (Values are expressed as mean ± standard deviation unless otherwise indicated.) Of the enrolled patients, 83.3 percent (10) claimed that they used the internet once a day and 91.7 percent (11) stated they used the computer once a day. One hundred percent of the patients self-reported that they had good or excellent knowledge about MS and that their English proficiency was excellent or good.

Intervention

The patients received a comprehensive baseline evaluation conducted by a physical therapist who specialized in the treatment of patients with MS. Based on the evaluation, each patient received a custom-tailored rehabilitative exercise program and was trained by the therapist during a clinic visit on how to perform the exercises. The physical therapist set up the individualized exercise plan for each patient at the designated HAT Web site. This site allowed personalized prescription of exercises tailored to particular functional impairments diagnosed by the physical therapist during the initial evaluation. The individualized exercise plan was loaded to a patient HAT Home Unit. After the baseline evaluation, the HAT Home Unit was installed in the homes of the patients to support them in following their exercise plans. Each patient was instructed on how to use the equipment during the 30- to 40-minute home installation visit. The HAT central server analyzed the exercise logs in real time. If a patient did not adhere to the exercise program, the physical therapist was notified by the HAT system. The therapist could then contact the patient by telephone to review exercise barriers and motivate the patient to participate in the exercise program. If necessary, the therapist could change exercise settings, such as intensity or duration, and add or remove a particular exercise from a patient's exercise list through the HAT Web site and have a new updated exercise plan uploaded to the patient unit. The patients also received educational information about MS and the importance of exercise rehabilitation through "tips of the day."

The intervention consisted of a program of exercises customized for each participant following his or her initial evaluation. These exercises included functional strengthening, stretching, and balance activities. Each participant was taught the exercises during the evaluation session, and then the program was downloaded to the home computer, which contained exercise drawings, written descriptions, and a video of the therapist performing the exercise. The number of repetitions varied according to participant tolerance, but the physical therapist recommended that the participants perform them throughout the day instead of in a single session to manage energy better. They were told to avoid undue fatigue but to exercise at the level that was "a challenge but not a struggle." Support was available on request from the technical or the therapy staff either by telephone or email, but only a few participants had occasional problems or concerns requiring modification. Each participant had his or her exercise program updated or revised following the 6-week reevaluation. The Institutional Review Board of University of Maryland School of Medicine and Baltimore VAMC approved the study.

Outcome Measures

We evaluated the patients at baseline, 6 weeks, and 12 weeks. Each evaluation consisted of two parts: (1) a functional status evaluation performed by a physical therapist in an outpatient clinic followed by (2) a patient home visit, during which research assistants administered study questionnaires.

The clinical impact of the MS HAT system was measured in three major domains: (1) functional status, (2) patient QOL, and (3) behavioral and psychosocial domain. The primary outcome was improvement in scores assessing patient functional status. The functional status was assessed with a timed 25-foot walk (T25FW), 6-minute walk, Berg Balance Scale (BBS), 12-Item MS Walking Scale (MSWS-12), and Modified Ashworth Scale (MAS) in an MS clinic. For the T25FW, the patient was instructed to walk 25 feet as fast as safely possible. Then the patient repeated the task by walking back to the starting point. If necessary, assistive devices were allowed to be used. We measured the amount of time (in seconds) that the patient took to walk 25 feet [35]. We performed a similar task for the 6-minute walk by measuring how far (in feet) the patient walked within the 6-minute period. The BBS, which consists of 14 movements common in daily life, was designed to measure balance in a clinical setting. The subject was asked to sustain a given position for a specific time. Points were deducted if the subject did not fulfill the time or distance requirements, touched an external support, or received assistance from the examiner. Each item ranged from 0 to

4, with 0 indicating the lowest level of function and 4 indicating the highest level of function. The total score sums to 56. A score of 45 implies that an individual can safely move or walk independently. The inter- and intrareliability estimates were 0.98 and 0.99, respectively, and internal consistency (Cronbach α) was 0.96 as reported in the previous studies [36–37]. MSWS-12 is a questionnaire that consists of 12 items that measure self-reported walking ability in individuals with MS. The MSWS-12 questions patients about walking limitations due to MS during the past 2 weeks. Each item ranges from 1 to 5, and the more severe the degree of limitation is, the higher the sum. According to the previously published data, the item test-retest reproducibility was 0.78 and reliability for the entire scale was 0.94 [38]. The MAS measures the resistance encountered during passive muscle stretching. Its scale ranges from 0 to 4:

- 0 = no increase in muscle tone.
- 1 = slight increase in tone with a catch and release.
- 1+ = slight increase in tone, manifested by a catch, followed by minimal resistance.
- 2 = marked increase in tone.
- 3 = considerable increase in tone.
- 4 = rigid in flexion or extension.

The interrater reliability (agreement between assessors) from the previous studies was 86.7 percent [39–40].

The disease-specific QOL was estimated with the use of the MS QOL (54-item) (MSQOL-54) scale. MSQOL-54 measures the QOL for patients with MS, including general health perceptions (5 items), social function (3 items), cognitive function (4 items), health distress (4 items), sexual function (4 items), change in health (1 item), satisfaction with sexual function (1 item), physical function (10 items), role limitations due to physical problems (4 items), role limitations due to emotional problems (3 items), pain (3 items), emotional well-being (5 items), energy/fatigue (5 items), and overall QOL (2 items). One can aggregate these items into physical and mental health composite scores by averaging the items belonging to each category and by transforming them linearly to a 0 to 100 scale. A higher score indicates a better QOL. According to the previous studies, internal consistency reliability for multi-item scales range from 0.75 to 0.96 and test-retest intraclass correlation coefficients range from 0.66 to 0.96 [41–42].

Other secondary outcomes from behavioral and psychosocial domain included MS Self-Efficacy Scale (MSSE), Medical Outcomes Study (MOS) Patient Adherence Measure, and 8-item Client Satisfaction Questionnaire (CSQ-8). MSSE is a 14-item questionnaire with a 6-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree). Self-efficacy is people's belief about their capabilities to carry out certain behavior, including managing a chronic condition. Total scores range from 14 to 84; a higher score indicates an elevated level of self-efficacy. The internal consistency was 0.81 (Cronbach α), and test-retest reliability was reported to be 0.81 [43]. We used MOS Patient Adherence Measure to assess a patient's tendency to adhere to a doctor's recommendations during the past 4 weeks. Each item has a 6-point Likert scale ranging from 1 (none of the time) to 6 (all of the time). The general adherence score was calculated through the averaging of all patient responses after reversing the items 1 and 3. The reversal of patient responses for the items 1 and 3 resulted in measurement of overall positive aspects of patient adherence. The internal consistency reliability of the scale was shown to be 0.81 (Cronbach α) [44]. CSQ-8, which measures client satisfaction with the service, is scored through the summing of the individual patient responses, with 1 indicating the lowest degree of satisfaction and 4 the highest. The total score ranges from 8 to 32. A higher score implies greater satisfaction. The internal consistency (Cronbach α) established previously was 0.93 [45].

In addition, patient acceptance of the MS HAT system was assessed at the study exit with the use of the attitudinal survey. The attitudinal survey was designed for determining a patient's overall attitude toward the MS HAT system. This measure was conducted according to the guidelines for evaluating telecommunications in healthcare [46] and used successfully in our previous studies [23–29]. Eighteen questions were graded from 1 to 4, including brief explanations for choices. The survey measured any difficulty the patients had using the computer and their acceptance of computer features, such as color on the screen, text size, audiovisual content, keyboard/mouse, and educational program.

Statistical Analysis

Wilcoxon signed rank test and Fisher exact *t*-test were performed on the outcomes between baseline evaluation and the 12-week follow-up. A <0.05 *p*-value was considered statistically significant. We performed all statistical analyses by using SAS version 9.1 (SAS Institute Inc; Cary, North Carolina).

RESULTS

The physical therapist identified a wide variety of problems in the group of participants at the baseline evaluation, including poor core stability, generalized balance issues, weakness, fatigue, limited endurance, spasticity, limited flexibility, and a variety of gait disorders. Based on this evaluation, the therapist prescribed an individualized exercise plan tailored to specific patient problems for each participant.

The T25FW, 6-minute walk, and BBS scores improved significantly from baseline to the 12-week follow-up (**Table 2**). The mean time that patients took to walk 25 feet decreased from 13.8 to 11.3 seconds, and the mean distance that patients walked in 6 minutes improved from 683.3 to 806.5 feet. The BBS score also increased from 38.8 to 43.1 over the 12-week period. Self-reported MSWS-12 did not improve significantly (**Table 2**). MAS improved in quadriceps left and right: for quadriceps left, the percentage of patients who scored 0 increased from 41.6 to 75.0 percent, and for quadriceps right, the percentage increased from 41.7 to 75.0 percent (**Table 3**).

Table 2.
Study outcomes at baseline and 6- and 12-week follow-ups of 12 subjects with multiple sclerosis (MS).

Variable	Baseline (Mean ± SD)	6-Wk Follow-Up (Mean ± SD)	12-Wk Follow-Up (Mean ± SD)	Baseline to Wk 12 (p-Value*)
T25FW (s)				
1 (First Attempt)	13.8 ± 8.1	13.4 ± 7.0	11.6 ± 5.7	0.05†
2 (Second Attempt)	13.8 ± 8.5	13.2 ± 8.3	11.0 ± 5.2	0.02†
Average of 1 and 2	13.8 ± 8.3	13.3 ± 7.6	11.3 ± 5.4	0.007†
z Score‡	0.4 ± 0.7	0.3 ± 0.7	0.2 ± 0.5	0.007†
6-Minute Walk (ft)	683.3 ± 463.8	779.0 ± 451.6	806.5 ± 415.0	0.02†
Berg Balance Scale	38.8 ± 11.1	42.0 ± 9.0	43.1 ± 9.9	<0.001†
MSWS-12	47.1 ± 9.0	39.8 ± 13.6	47.1 ± 12.0	0.84
Health Composite Scores of MSQOL-54				
Physical	43.9 ± 11.9	43.8 ± 15.0	44.7 ± 14.2	0.85
Mental	66.7 ± 17.9	65.3 ± 18.0	60.0 ± 24.7	0.20
MSSE	47.7 ± 6.2	47.4 ± 6.8	47.0 ± 8.0	0.69
MOS Patient Adherence Measure	4.1 ± 0.8	4.6 ± 0.6	4.4 ± 1.0	0.30
MMSE	27.8 ± 2.0	—	—	—
CSQ-8	—	—	30.1 ± 2.0	—

Note: MMSE was measured at baseline and CSQ-8 was measured at exit interview only.
*Wilcoxon signed rank test.
†$p < 0.05$.
‡z score = (mean T25FW – 9.5353)/11.4058.
CSQ-8 = Client Satisfaction Questionnaire (8 items), MMSE = Mini-Mental State Examination, MOS = Medical Outcomes Study, MSQOL-54 = MS Quality of Life (54-item scale), MSSE = MS Self-Efficacy Scale, MSWS-12 = 12-Item MS Walking Scale, SD = standard deviation, T25FW = timed 25-foot walk.

Table 3.
Percentage of 12 subjects with multiple sclerosis at each Modified Ashworth Scale level at baseline and follow-up.

Variable	Grade of Resistance to Passive Movement (%)						p-Value*
	0	1	1+	2	3	4	
Quadriceps Left							
Baseline	41.6	25.0	16.7	16.7	0.0	0.0	—
12-Week Follow-Up	75.0	0.0	0.0	8.3	16.7	0.0	0.006†
Quadriceps Right							
Baseline	41.7	8.3	50.0	0.0	0.0	0.0	—
12-Week Follow-Up	75.0	8.3	16.7	0.0	0.0	0.0	0.48

*Fisher exact test was used to compare difference in grade distribution between baseline and 12-week intervention.
†$p < 0.05$.

In the MSQOL-54 (**Table 2**), the mean physical health composite score slightly increased and the mental health composite score decreased with no statistical significance. The mean score of MSSE remained about the same at baseline and the 12-week evaluation. MOS Patient Adherence Measure increased over the 12-week period, although the increase was not statistically significant. In MMSE, all patients scored over 23; thus our sample had no signs of cognitive impairment. The CSQ-8 score was 30.1 ± 2.0. Considering that the maximum score is 32, we found that the patients appeared to be highly satisfied with the service.

From the attitudinal survey (**Table 4**), 83 percent of the patients reported that computer use was not complicated and 67 percent claimed that reading the text from the computer screen was not difficult. About 83 percent reported that they liked the colors on the screen and the audiovisual content. One hundred percent of the patients had no unknown words that were not explained by the computer and found that the sentences used in the educational materials were not difficult. Over 80 percent of the patients expressed interest in probable use of the telerehabilitation program in the future, and 100 percent of the patients would recommend the program to other patients. Overall, 75 percent of the patients graded the intervention program as good or excellent.

DISCUSSION

This study explored the impact of an MS physical telerehabilitation system on patient functional status and assessed patient acceptance. The main functional outcomes, such as T25FW, 6-minute walk, and BBS, improved significantly after the intervention. Some other outcome measures, such as self-reported MSWS-12 and the MSSE, did not change significantly. The patients were highly satisfied with the provided service. According to their exit interviews, the patients found the computer system easy to use. Most patients evaluated the computer system and the program design, including ways of providing textual and audiovisual information, as good or excellent and were positive about the impact of the system on their self-care. Most patients claimed that they would like to use such a system in the future and would advise other patients to use it.

The functional outcomes in this study measured balance and timed walk. The significant improvement in these outcomes corresponds with previous studies of home-based MS rehabilitation [47]. In a recent randomized trial, short-term inpatient rehabilitation combined with 6 months of outpatient rehabilitation was successful in improving upper-limb endurance. Brief moderate physical exercise improved physical fitness in the study by Bjarnadottir et al. [48]. We can conclude that the results from our study corroborate previous reports that demonstrated functional status improved in patients with MS resulting from rehabilitation programs.

The data on the dynamics of the QOL in our study were inconclusive. The small sample size may attribute to absence of significant improvement in QOL. However, another study showed similar results when better functional outcomes coincided with no significant improvement in health-related QOL [49]. Evidently, QOL is a complex measure comprising many factors that may not be significantly affected by physical rehabilitation only.

Using telemedicine applications is one of the advanced technological approaches to healthcare that has been on VA's agenda for the last decade [50]. The VA Care Coordination Home Telehealth program was successfully implemented for veterans with different chronic health conditions [51], including patients with stroke [52] and diabetes [53]. Telehealth support systems for other patient groups, including MS, are near implementation. Our study provides additional evidence of the great potential home telecare systems have in improving patients' self-management.

Although physical telerehabilitation systems are actively used in treating patients with other neurological conditions, such as stroke [54–56] or spinal cord injuries [57–58], experience using them in treating patients with MS is limited. One approach described by Egner et al. uses videoconferencing or conventional telephone calls [59]. In their study, a rehabilitation nurse called the patient once a week for 5 weeks and then once every 2 weeks for 1 month. One call lasted for about 30 to 40 minutes and included a structured review of symptoms, psychosocial problems, and measures needed to be undertaken, which included referrals to other health professionals. At the 2-year follow-up, the video group had a significantly better health-related QOL and lower depression and fatigue than the usual care and telephone telecare groups. Evidently, using video calls has many advantages: the technique is simple and easy to understand, is relatively inexpensive, and provides live personal contact with socially isolated patients. Using this technique, patients can better adhere to an exercise program

Table 4.
Results of attitudinal survey of 12 subjects with multiple sclerosis (% of patients selecting each option).

Question	Score (%)			
	1	2	3	4
1. How complicated was it to use the computer?				
Very complicated	8.3	—	—	—
Moderately complicated	—	0	—	—
Slightly complicated	—	—	8.3	—
Not complicated at all	—	—	—	83.4
2. Did you have any difficulty in moving from one screen to another?				
Not at all	66.7	—	—	—
Very rarely	—	8.3	—	—
Frequently	—	—	25.0	—
All the time	—	—	—	0
3. How difficult was it to use the keyboard/mouse?				
Very difficult	0	—	—	—
Moderately difficult	—	8.3	—	—
Slightly difficult	—	—	25.0	—
Not difficult at all	—	—	—	66.7
4. Did you have any difficulties in reading text from the computer screen?				
Not at all	66.7	—	—	—
Very rarely	—	25.0	—	—
Frequently	—	—	8.3	—
All the time	—	—	—	0
5. Was the size of the text presented on the screen sufficient?				
Fully sufficient	75.0	—	—	—
Sufficient almost all the time	—	8.4	—	—
Sufficient some of the time	—	—	8.3	—
Not sufficient at all	—	—	—	8.3
6. Did you like the colors used on the computer screen?				
Certainly yes	58.4	—	—	—
To a large extent	—	25.0	—	—
To some extent	—	—	8.3	—
No	—	—	—	8.3
7. Did you like the audiovisual content provided by the computer?				
Certainly yes	66.7	—	—	—
To a large extent	—	16.7	—	—
To some extent	—	—	16.6	—
No	—	—	—	0
8. Did you get all the necessary information about using the computer during initial practice session?				
All information	75.0	—	—	—
Partial information	—	16.7	—	—
Very limited information	—	—	8.3	—
9. Did you come across any unknown words which were not explained by the computer?				
Very significant	0	—	—	—
Considerable	—	0	—	—
A few	—	—	0	—
None	—	—	—	100.0
10. How difficult were the sentences used in the educational materials?				
Very difficult	0	—	—	—
Moderately difficult	—	0	—	—

Table 4. (Continued)
Results of attitudinal survey of 12 subjects with multiple sclerosis (% of patients selecting each option).

Question	Score (%)			
	1	2	3	4
Slightly difficult	—	—	0	—
Not difficult at all	—	—	—	100.0
11. How much new information did you get using the computer?				
Very significant amount	16.7	—	—	—
Considerable	—	25.0	—	—
Little	—	—	41.7	—
Very little	—	—	—	16.6
12. Did you get any feedback from computer about your training progress?				
All the time	50.0	—	—	—
Occasionally	—	8.3	—	—
Very rarely	—	—	33.4	—
Never	—	—	—	8.3
13. How frequently did you find the information confusing?				
Very frequently	0	—	—	—
Occasionally	—	16.7	—	—
Very rarely	—	—	33.3	—
Never	—	—	—	50.0
14. How frequently did you find educational contents difficult to understand?				
Very frequently	0	—	—	—
Occasionally	—	8.3	—	—
Very rarely	—	—	16.7	—
Never	—	—	—	75.0
15. Did you have to wait for new information to come up on the screen?				
All the time	0	—	—	—
Occasionally	—	25.0	—	—
Very rarely	—	—	25.0	—
Never	—	—	—	50.0
16. Would you like to use this educational program in the future?				
Certainly yes	66.7	—	—	—
Maybe	—	16.7	—	—
Unlikely	—	—	16.6	—
No	—	—	—	0
17. Would you advise other patients to use this educational program?				
Certainly yes	83.3	—	—	—
Maybe	—	16.7	—	—
Unlikely	—	—	0	—
No	—	—	—	0
18. Overall how would you grade this educational program?				
Needs serious improvement	8.3	—	—	—
Needs some improvement	—	16.7	—	—
Good	—	—	41.7	—
Excellent	—	—	—	33.3

than other kinds of medical care. The intervention also allows a lot of flexibility. Widespread use of video calls for disease management may have certain limitations. First, it requires significant staffing with experienced nurses. For each 40 to 60 patients, only one full-time rehabilitation nurse is needed to make calls. Second, patients should ideally follow many aspects of rehabilitation and medical care daily because they both enhance adherence and detail patients' progress. Third, detailed instructions and daily follow-up of efficacy and safety of physical exercise conducted throughout the day are difficult, although not completely impossible, to provide through teleconferencing.

The technological approach used in this study includes a personal home telecare unit communicating with a central server and providing decision support and management of an individualized treatment plan. The patient uses the computer daily to receive interactive guidance in following an individually tailored program of physical rehabilitation, to report his or her health status and adherence to the exercise plan, to learn about the disease, and to communicate with a multidisciplinary care management team. Instead of contacting the patient regularly, the care management team contacts the patients only when alerts are generated. This action allows optimized workflow and focuses on patients who need attention. Serious problems with the patients are promptly reported to their health providers and resolved either during an outpatient visit or by telephone. This system may be used to follow a significant number of patients, including patients in remote areas, which is especially important for VAMC. An additional advantage is an opportunity to plan interventions for large numbers of patients in real time, since the information sent to the central service is immediately analyzed and alerts are created for patients who need attention.

Rogante et al. proposed a promising physical telerehabilitation model [60]. In addition to the central server and the patient station, it includes a patient motor-activity desk (allowing execution of occupational therapy and active physical training) and a videoconferencing module. Although not yet tested, this comprehensive model can significantly enhance the possibility for rehabilitation.

We conducted this study as a pilot project to test the feasibility of a physical telerehabilitation system in patients with MS before this model is implemented in a large clinical trial. Therefore, it has some restrictions inherent to pilot studies: a small sample size, relatively short follow-up time, and absence of a control group. Nevertheless, even in a small study sample with a short follow-up period, we demonstrated significantly improved functional status indicators and very high participant support of home-based physical telerehabilitation. Based on our analysis of previous literature [54–60], the magnitude of change demonstrated in our study after a 12-week follow-up apparently exceeds previously reported potential practice effects. To convincingly and objectively document the clinical benefits of physical telerehabilitation and to avoid possible biases, researchers should use a randomized controlled trial design. Our feasibility pilot study provided evidence that such a clinical trial is warranted. A randomized clinical trial with an intervention and control arms should address limitations of this study. The follow-up period in the future study should be at least 6 months. Our results provide necessary information for sample size estimation for such a study.

CONCLUSIONS

Home-based physical telerehabilitation is feasible in patients with MS, and it can potentially improve patient functional status significantly. The participants of the study demonstrated a very high level of support for the home-based physical telerehabilitation program. Further studies are warranted.

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