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RESEARCH PAPER

In home telerehabilitation for older adults after discharge from an acute hospital or rehabilitation unit: A proof-of-concept study and costs estimation

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Abstract

Purpose. The purpose of this study is to investigate rehabilitation through teletreatment as an alternative to a physical home-care visit to deliver services to individuals at home following discharge from an acute hospital or rehabilitation unit.

Method. Four community-living elderly people were recruited for telerehabilitation services prior being discharged from an acute-care hospital and a geriatric rehabilitation unit. Once the patient returned home, an appointment was made for the assessing therapist to take the clinical measurements (T1) in a face-to-face session. Four clinical variables were used (functional autonomy, balance, locomotor performance in walking and lower-body strength). Telerehabilitation sessions with the participants were conducted with trained personnel in the individual’s home. The system used to support telerehabilitation services for this proof of concept was built around network-attached remotely-controlled pan/tilt/zoom cameras with MJPEG compression, media displays and hands-free phones. Before the patient was discharged from the physiotherapy program, the same assessing therapist visited the subject again to take the T2 measurements in a face-to-face session. The satisfaction of the health-care professional was determined for each session with the homemade questionnaire. Costs related to telerehabilitation were compared to theoretically home visits.

Results. All four subjects improved on the four clinical variables. Mean costs for the telerehabilitation program, comprising 12 sessions over 4 weeks was $487.

Conclusion. Telerehabilitation seems to be a practical alternative for dispensing rehabilitation services after patients are discharged from an acute hospital or rehabilitation unit.

Keywords: Telehealth, rehabilitation, home care, older adults, cost, functional autonomy, health economics

Introduction

Transformation of the health care systems in Canada and Europe in the last decade [1,2] has reduced the length of stay in acute hospitals, increased the number of day surgeries and generally reoriented hospital centric care toward dispensation of health services in the community. While home-care rehabilitation services are viewed as a solution to ensure continuity of rehabilitation services in the community after patient discharge from hospital or rehabilitation unit [3], home-care budgets for implementing these changes have not been forthcoming [4] and discharged patients at home present greater disability [3,5–7]. One outcome has been increased numbers of users on waiting lists for these services [3]. Another key issue of home-care rehabilitation services is that they are not accessible in all regions, with rural areas [3] being particularly affected.

Recent changes in home-care policy statements attempt to address these issues generally by advocating an increase in the level of rehabilitation services and the promotion of alternatives to the home-care program in order to increase the level of rehabilitation services delivered, particularly in rural areas [8]. In this context, telehealth has been identified as a promising alternative for improving accessibility of health care and services in the rural and remote communities.

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communities [9]. Telerehabilitation, defined as an application of telehealth to rehabilitation, is an emerging and innovative way to deliver services [10]. Little, however, is known about the feasibility and costs of such services, especially for in-home geriatric rehabilitation.

Published studies on telerehabilitation are generally limited to patient assessments using video-conferencing between two institutions [11,12]. Only one study has investigated treatment by telerehabilitation compared to the usual services, but this occurred under controlled conditions using a local area network [13,14]. No studies have examined teletreatment under non-quality-of-service conditions like those typically found when using the Internet. In this context, the purpose of this study is to investigate rehabilitation through teletreatment as an alternative to a physical home-care visit to deliver services to individuals at home following discharge from an acute hospital or rehabilitation unit. The objectives for this proof-of-concept study were: (1) to assess the feasibility of using in-home telerehabilitation with geriatric patients and explore the ensuing changes in clinical outcomes, (2) to examine the acceptance of this modality of service by health care practitioners, and (3) to obtain cost estimates for the provision of such telerehabilitation services.

Materials and method

Population and sample

Community-living older adults were recruited for telerehabilitation services prior being discharged from two institutions (an acute-care hospital and a geriatric rehabilitation unit). The inclusion criterion was to be discharged at home with a prescription for a physiotherapy follow-up. Participants with cognitive or communication deficits interfering with collaboration during therapy were excluded using judgement from referring clinical staff.

Potential participants were first approached by their treating physician at either the acute hospital or rehabilitation unit to determine their interest in receiving information about a research project on in-home telerehabilitation after their discharge from the hospital. Positive responses from potential participants were followed up by a planned visit by a rehabilitation professional to formally explain the project. With the candidate's authorization, the availability of high speed Internet access from their home was checked with a regional Internet service provider (ISP). Once it was determined that broadband access was available, the candidate’s informed consent to participate in the study was obtained. Installation of Internet access and the telerehabilitation communication platform at the participant’s home was scheduled 3 days after the participant’s discharge from the hospital. The in-home visit by the ISP technician was scheduled to coincide with the visit by a research-team technician. The installation visits took around 2 h per site to complete. The equipment was picked up by research-team personnel at the end of the planned period of telerehabilitation services (i.e., 2 months).

This study was approved by the Ethics Committee of the Sherbrooke Geriatric University Institute.

Technological infrastructure for telerehabilitation services

The system used to support telerehabilitation services for this proof of concept (see Figure 1) was built around network-attached remotely-controlled pan/tilt/zoom (PTZ) cameras with MJPEG compression (Sony RZ30), media displays (i.e., televisions with embedded Linux computers) and hands-free phones. Video signals from the PTZ cameras were transmitted to and from the clinical site and the participant’s home through dual TCP/IP links (T1 lines) with a bidirectional (upload and download) connection bandwidth of 1.5 megabits/s. Images at both sites were sampled at 15 frames/s with a CIF resolution of $280 \times 340$. Images were compressed as MJPEG files and then uploaded to the remote location for decoding and display in full-screen mode on the clinician’s computer or the participant’s media display. Audio signals were transmitted through regular phone connections using hand-free phones. A software program with intuitive interfaces was developed to control PTZ functions for both cameras, establish communication with the media display and provide an electronic patient record system based on database architecture. Cameras functions at both sites were controlled by the clinician through a point-and-click or a zoom-and-click action with a computer mouse on a video display containing both image sources. Automated measures (user log and bandwidth log) were integrated into the program to document network conditions and user actions. Once phone contact was established, the participant initiated the video feed from the in-home networked PTZ camera with the media display remote control.

Outcome measures

One of the major goals of the rehabilitation intervention for older persons after discharge from an acute hospital or rehabilitation unit is to improve the individual’s independence. The principal outcome measure in this study was functional autonomy measured with the standardized instrument Functional Autonomy Measurement System (SMAF)
Figure 1. Technological infrastructure for telerehabilitation services.
This instrument is a 29-item scale based on the WHO first classification of disabilities (WHO, 1980). It measures functional ability in five areas: activities of daily living (ADL) (seven items), mobility (six items), communication (three items), mental functions (five items) and instrumental activities of daily living (IADL) (eight items). Each item is scored on a five-point scale from 0 (dependent) to 5 (independent) to 0.5, 1, 2 and 3 as a gradient of disability leading to dependency for a maximum total score of 87. The score is inversely proportional to functional ability. The SMAF’s reliability and validity have been tested in several studies [15,18]. A change of five or more points is considered to be metrically and clinically significant [19].

Others variables were measured in this feasibility study. These tests were chosen because they have been shown to be valid and reliable and easy and safe to administer in community setting [20]: (1) balance with the Berg Balance Scale [21–23]; (2) locomotor performance in walking with the ‘Timed Up-and-Go’ test [24–26]; and (3) lower-body strength with the ‘30-s chair-stand’ test [27]. Health professional satisfaction with the use and performance of the technology was assessed after completion of each telerehabilitation session (n = 40 total) using the following question: ‘In general, how would you rate your telerehabilitation experience for the duration of the session on a scale where “0” corresponds to “not satisfied at all” (i.e., unable to provide rehabilitation services) and “100” corresponds to very satisfied (i.e., able to meet my expectations).’

**Physiotherapy program used in telerehabilitation**

The goal of the physiotherapy program was to improve functional autonomy of the patient at home. To achieve this goal, a standardised program of exercises was structured to improve muscular weakness, range of motion, balance, transfers and walk. All these exercises are based on functional activities. The exercise program is in continuity with exercises given in the hospital with the difference that they are adapted to the progression to each patient according to this specific evolution of the clinical problem. Each session is 1 h long. Sessions are scheduled three times a week for 4 weeks.

**Data collection procedures**

Initial contact between the treating physiotherapist and the patient occurred either in the acute-care hospital or the geriatric rehabilitation unit before the patient was discharged. The patient was also taught the physiotherapy program at that time. Once the patient returned home, an appointment was made for the assessing therapist to take the clinical measurements (T1) in a face-to-face session.

As part of this proof-of-concept study, telerehabilitation sessions were conducted in the individual’s home by a trained physiotherapist. In order to ensure the participants safety, as requested by the institutional review board when they approved this research project, a research assistant was in the home of the subject for the telerehabilitation sessions. The physiotherapy program consisted of twelve 1-h sessions over a period of 4 weeks. Before the participant was discharged from the physiotherapy program, the same assessing therapist visited the participant again to take the T2 measurements in a face-to-face session. The satisfaction of the health-care professional was determined for each session with the homemade questionnaire.

**Costs of the telerehabilitation program**

For the purposes of this proof-of-concept study, the cost estimation was based on market prices. The duration of services for each of the 12 sessions in the rehabilitation program was recorded (mean of 59 min). This was used with the mean hourly salary for physiotherapists in our organization ($28.42) to establish the costs for professional services in delivering the telerehabilitation program to each subject. We voluntarily omitted taking into consideration the indirect time related to the organization of care, charting and administration. The cost for Internet service was based on the ISP rates at the time of the study for monthly high-speed Internet service without a long-term commitment ($48 per month for high-speed Internet services and $102.35 for initial activation and installation).

To theoretically compare telerehabilitation services with home visits, we applied direct time for telerehabilitation sessions to theoretical visits at home by a physiotherapist. Indeed, the direct time for home visits is quite similar, as determined on another study [28]. Accordingly, there should be no differences in direct times between the two service delivery modes. On the other hand, the duration of home visits must be increased to account for the traveling time to the home. We used the time and motion analysis from a previous study [29,30] to estimate the travel time for rural areas (20 min per visit). These times were applied as a constant to each theoretical home visit. In calculating costs, we used the government allowance for travel with a personal car ($0.37 per km) and a conservative travel distance of 30 km.

Therefore, the only differences in this theoretical comparison should be encountered in time related to Internet services (for telerehabilitation) and travel time (for home visits).
Results

Four subjects were recruited for this pilot study. The two first subjects were discharged from a rehabilitation unit: (1) a female (82 years old) with a below-knee (trans-tibial) amputation (SMAF: 22/87) and (2) a female (65 years old) with a diagnosis of stroke (SMAF: 11/87). Two others subject were discharged from an acute hospital: (1) a male (60 years old) receiving aftercare for hip replacement (SMAF: 7/87) and (2) a male (76 years old) with a knee replacement (SMAF: 20/87). All four subjects were living with their spouses.

The mean length of sessions for all four subjects was 59.2 min, with 19% of the time for assessment and 81% for the treatment plan. Some technical problems were identified during five of the 48 sessions. These five sessions were delayed a maximum of 30 min (ranging from 5 to 30 min) because of communication problems between the clinical site and the participant’s home (i.e., internet connection at the participant’s home was down or IP addresses changed). While these problem were addressed as they occurred, one of these five session was conducted only by telephone (no video transmission between the two sites), and one session was given without video transmission of the clinician image to the patient’s site.

Effect of telerehabilitation program

Table I shows the effect of the telerehabilitation program on the four clinical variables selected as outcome measures. All four subjects improved their functional autonomy status (ranging from 44 to 91%). The stroke subject showed little improvement in locomotor performance in walking (9% compared to 48–67% for the other three subjects). The knee replacement subject evidenced a 125% improvement in lower-limb strength compared to 18 and 43% for the stroke and hip subjects, respectively. All subjects showed improved balance, ranging from 15% (stroke) to 60% (hip replacement).

Health professional satisfaction with use of the technology was a mean of over 70% for all subjects for the 12 sessions.

No incidents or falls were documented in providing telerehabilitation interventions to the participants. However, the on-site presence of a person seems to be a prerequisite for safe delivery. This person could be an individuals living with the patient.

Costs of telerehabilitation

Table II shows costs for the therapist salary, travelling costs and communication costs when applicable for the two alternative of delivery of

<table>
<thead>
<tr>
<th>Table I. Clinical outcomes measures and health professional satisfaction related of telerehabilitation program.</th>
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<tbody>
<tr>
<td><strong>Functional autonomy – SMAF (/87)</strong></td>
</tr>
<tr>
<td>Below-knee amputee</td>
</tr>
<tr>
<td>T1 21.5</td>
</tr>
<tr>
<td>T2 12</td>
</tr>
<tr>
<td>Difference T2−T1</td>
</tr>
<tr>
<td>% of improvementa</td>
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<tr>
<td><strong>Locomotor performance in walking – Timed up &amp; go (s)</strong></td>
</tr>
<tr>
<td>T1 52</td>
</tr>
<tr>
<td>T2 27</td>
</tr>
<tr>
<td>Difference T2−T1</td>
</tr>
<tr>
<td>% of improvementb</td>
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<tr>
<td><strong>Lower-limb strength – 30-s chair-stand test (s)</strong></td>
</tr>
<tr>
<td>T1 Not performedc</td>
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<tr>
<td>T2 Not performedc</td>
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<tr>
<td>Difference T2−T1</td>
</tr>
<tr>
<td>% of improvement</td>
</tr>
<tr>
<td><strong>Balance – Berg (/56)</strong></td>
</tr>
<tr>
<td>T1 22</td>
</tr>
<tr>
<td>T2 29</td>
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<tr>
<td>Difference T2−T1</td>
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<td>% of improvement</td>
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<tr>
<td><strong>Health professional satisfaction with the use of technology</strong></td>
</tr>
<tr>
<td>Global appreciation (/100)</td>
</tr>
<tr>
<td>Below-knee amputee</td>
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<tr>
<td>70</td>
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<tr>
<td>Mean of the 12 sessions</td>
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</tbody>
</table>

*a A minus sign means improvement in functional autonomy.

*b A minus sign means improvement in performance in walking.

*c This test was not performed because of the pain at T1.
physiotherapy treatment. The mean costs for the 12 sessions over 4 weeks were $487 for the telerehabilitation group and $587 for the theoretical home visit. A comparison with the theoretical home visit shows that telerehabilitation could be less expensive.

### Discussion

The objective of this proof-of-concept study was to investigate the feasibility of delivering rehabilitation services using the Internet between a patient’s home and a clinical site at an institution. To our knowledge, this is the first study that illustrates the feasibility of carrying out a complete rehabilitation program, including specific therapeutic exercises and evaluations, remotely at the homes of geriatric patients. While the very small number of subjects involved in this study makes it difficult to draw clear conclusions, certain observations about the feasibility of telerehabilitation for patients referred for physiotherapy after discharge from an acute hospital or rehabilitation unit can be made: (1) telerehabilitation services in a geriatric patient population are feasible contingent upon the presence of a third party in the patient’s home to ensure patient safety, (2) telerehabilitation services can deliver basic treatment in order to increase functional autonomy, strength, balance and walking, and (3) health-care professionals appear satisfied with the service-delivery mode without a face-to-face session.

There are no published studies specific to real life use of in home telerehabilitation in the context of telentreatment. However, one study simulated this context of use using a local area network and webcams to deliver from a separate location treatment to patient with knee arthroplasty [13,14]. Our results are consistent with those of this study as both groups of patients were treated by telerehabilitation, patients and professionals expressed satisfaction with this way of delivering rehabilitation services and finally, patients improved their physical capacities.

In consideration of the pilot nature of this study and in compliance with the recommendations of the institutional review board, we choose to send a member of our staff to the home of the patient during the telerehabilitation session in order to ensure the safety of the participant. While no adverse incident happened during the delivery of the telerehabilitation services and the physiotherapy program used is based on safe exercises adapted to each individual, our experience leads us to propose that a non-professional person should be present at home to facilitate and optimize some of interactions between the clinician and the participants. A person in the home can help position things in the environment as needed (i.e., walking aids, ball or other small equipment used in the therapy) thus speeding up the transition between the exercises. This person could be an individual living with the patient (spouse, child, etc.). This prerequisite should be easy to meet because is a common condition when an older disabled person returns home after being discharged from a hospital or rehabilitation unit.

A key point of our study was the success of program delivery for this type of patient. The physiotherapist can watch the patient, provide specific instructions and feedback, and maintain a good patient–therapist relationship. As in the case of home visits, the treatment plan is based on basic exercises requiring no special device or equipment in this regard, telerehabilitation and home visits have the same limitations.

One point not addressed in our proof-of-concept study is whether real-time assessment can be performed properly during the telerehabilitation session. The patient assessments reported on were conducted at T1 and T2 by an independent physiotherapist using direct observation. The treating therapist followed up patient condition during the telerehabilitation session in real time. Our experience indicates that patient physical condition can be reliably assessed with the usual outcome measures for such patients and conditions, such as functional autonomy, strength, walking and balance. While some compromises are required due to camera angle and position, the physiotherapist appears satisfied with overall assessment.

Telerehabilitation treatment was effective as evidenced by improvement in physical function across the board. We cannot, however, attribute the improvement to the telerehabilitation treatment, since natural recovery and other variables were not
controlled in this pilot project. Future research should compare two alternatives of treatment, such as telerehabilitation and home visits.

As for our hypothesis, the cost of telerehabilitation treatment could be less than that of home visits based on our theoretical comparison. Indeed, the travel time required for home visits may increase their costs. If this is true, the cost savings could be used to increase the number of treatments for each patient or to increase the number of patients treated.

Conclusion

Telerehabilitation seems to be a practical alternative for dispensing rehabilitation services after patients are discharged from an acute hospital or rehabilitation unit. Indeed, this virtual way of giving treatment remains a compromise as the benefits of in person therapy outweighs any virtual visit. However, factors such as distance of institution providing care, burden to the family associated with visits to clinic, poor accessibility of home care are key points favouring use this 'good compromise' of delivery for physiotherapy services. Moreover, the cost savings yielded by telerehabilitation may provide means to increase accessibility in rural area and to increase the level of rehabilitation services. Nevertheless, future research is needed with a randomized controlled trial to measure the efficiency of this novel way of delivering rehabilitation services.

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