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Feasibility of an iterative rehabilitation intervention for stroke delivered remotely using mobile health technology

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Abstract

Background: Telehealth affords rehabilitation professionals opportunities to expand access to intervention for people in rural areas. Complex interventions have not been adapted for remote delivery using mobile health technologies. Strategy training is a complex intervention that teaches clients skills for identifying barriers and solutions to engagement in meaningful activities. Our goal was to adapt the delivery of strategy training for remote delivery using mobile health technology.

Methods: We conducted a sequential descriptive case series study (n=5) in which community-dwelling participants with chronic stroke and prior exposure to strategy training used the iADAPTS mobile health application for 5 weeks. Expert practitioners advised revisions to the intervention process. Safety was assessed via monitoring occurrence of adverse events and risk for adverse events. Acceptability was assessed via the Client Satisfaction Questionnaire-8 (CSQ-8) and the Patient-Provider Connection Short Form of the Healing Encounters and Attitudes Lists (HEAL PPC).

Results: Revisions to the intervention process supported the delivery of strategy training using mobile health technology after stroke. No adverse events occurred and risk for adverse events was managed through the intervention process. Acceptability was high (CSQ-8, 25 to 32; HEAL PPC, 59.9 to 72.5).

Conclusions: Strategy training can be adapted for delivery using mobile health technology, with careful consideration to methods for training participants on new technology and the intervention delivery. Future research should establish the efficacy and effectiveness of integrating mobile health in delivery of interventions that promote engagement in client-selected activities and community participation.

Keywords

mHealth; stroke rehabilitation; strategy training; community participation; CO-OP

Introduction

The advent of telehealth and its expansion into rehabilitation practice is promising to improve access to underserved populations and reduced healthcare costs in the United States [1]. Telehealth uses technology to facilitate communication between healthcare providers and patients who are not face-to-face [2, 3]. Among rehabilitation providers (physicians, occupational and physical therapists), these models have been used to connect people in rural regions with specialized rehabilitation professionals [4], engage people from rural areas in group-based intervention [5], and allowed for monitoring of adherence to exercise programs or health behaviors [6, 7]. These interventions represent a small subset of approaches to rehabilitation. Collectively, they demonstrated that clinical rehabilitation information and education can be transmitted between providers and patients using technology. Rehabilitation interventions range from simple (e.g., range of motion exercises) to complex (e.g., metacognitive approaches). Advancing telerehabilitation practice requires thoughtful adaptation to the delivery of complex interventions for remote delivery.

Metacognitive rehabilitation approaches are complex interventions that are used to develop patients' ability to problem solve within novel situations. *Strategy training* is one example of a metacognitive rehabilitation approach that shows promise for reducing disability after stroke [8, 9, 10]. During strategy training, patients learn to apply a four-step strategy (Goal-Plan-Do-Check) to any activity-based goal that the patient desires. For example, a patient may identify that his **goal** is to walk his dog in his neighborhood. Because his stroke led to weakness in his dominant hand and impaired balance, he makes a **plan** to practice walking the dog in his driveway using his cane for balance. He will ask his daughter to observe his practice sessions for safety. He will reassess his readiness to walk the family dog around the block after he can safely walk the dog to the end of his driveway. The patient proceeds to **do** this plan the next day. He then discusses what happened with his occupational therapist to **check** the results of the plan. During the check conversation, the patient commented that his dog pulled on the leash a little harder than expected and that he nearly lost his balance. His daughter was observing and together they decided to find a new harness that would not allow the dog to pull so hard. The patient decided to keep the same **goal**, and changed his **plan** to try walking the dog to the end of the driveway with a new harness. This process is repeated iteratively until the patient has established a new approach that allows him to safely walk his dog in his neighborhood. The patient also identified that he can sometimes change the tools that he uses (such as the dog's harness) to make activities that he wants to do safer after his stroke.

As demonstrated in the above example, strategy training is a complex intervention that addresses patients' real-life activity-based goals. These activities occur in the community. To our knowledge, metacognitive interventions such as strategy training were not previously adapted for delivery via telerehabilitation. Mobile health (mHealth) is a specific subset of telehealth approaches in which smartphones, tablets, and associated software applications are used to deliver interventions. mHealth has been used to promote early post-stroke rehabilitation via tablets during acute hospital settings [11]. Because mHealth approaches allow patients to engage in interventions at any location of their choosing, these approaches may be particularly advantageous for the delivery of strategy training. Strategy training

specifically addresses goals that occur in the community. Strategy training delivered via mHealth affords patients an opportunity to receive support remotely from specialized therapists while completing activities in real-world community settings.

Recommendations for early phase development of complex intervention protocols, such as strategy training, include precise specification of intervention components and extensive pilot testing to assess feasibility and estimate effect sizes [12, 13]. Traditional face-to-face strategy training underwent this process prior to ongoing efficacy and effectiveness trials [8, 9, 10]. Translating strategy training from a face-to-face format to a remote delivery format requires return to intervention specification phases. This informs protocol adaptation and feasibility testing prior to definitive efficacy and effectiveness trials of mHealth approaches. These steps are particularly important to assure participant safety and rigor in intervention delivery when the therapist and patient are not in the same room. Thus, the objective of this paper is to describe lessons learned through adaptation of a complex intervention—strategy training—for delivery via mHealth technology.

Methods

To deliver strategy training via mobile health technology, we first needed a platform through which to deliver the intervention. The iADAPTS mobile health system was developed through collaboration with an interdisciplinary team. The resulting iADAPTS mobile health system is described in the supplement to this paper (available online). The iADAPTS mobile health system consists of 3 components: 1) iADAPTS mobile health application, 2) iADAPTS web-based clinician portal, and 3) real-time two-way communication that connects the iADAPTS mobile health application and the iADAPTS web-based clinician portal through a secure channel. Once the initial version of this system was developed, we utilized the system to deliver strategy training remotely.

Study Design

We conducted a descriptive case series ($n=5$) in which participants were recruited sequentially. Sequential enrollment allowed for feedback from participants and the treating therapist to be implemented. Adaptations to the intervention protocol both informed and were influenced by improvements to the system. The iADAPTS system is described in the supplement.

Participants

Participants were recruited from a sample of participants known to our research laboratory who had previously received the metacognitive strategy training intervention during face-to-face sessions. Our inclusion criteria were: 1) previous exposure to metacognitive strategy training conducted by therapists trained and supervised by our laboratory, 2) 6 months post-stroke, 3) ability to read words on a mobile device (reported by the participant), and 4) access to a personal mobile device (iOS or Android cellular smartphone or tablet) for the duration of the study. Participants were excluded from this study if they had poor self-awareness measured by a score of 2 on item 1 (awareness of current deficits) or 2 (awareness of how current deficits affect current activities) of the Self Awareness of Deficits

Inventory [14] or if they resided greater than 100 miles from Pittsburgh. Once participants were deemed eligible based on telephone screening, a research assistant (EK, an occupational therapist with expertise in metacognitive strategy training) visited their home to obtain written informed consent and initiate study procedures. If the participant provided written informed consent, the research assistant proceeded with pre-intervention assessments (Canadian Occupational Performance Measure, COPM, described below), assisted the participant to download the iADAPTS application onto his/her personal device, and initiated intervention. Participants then used the iADAPTS application for five weeks. Communication with the intervention therapist primarily occurred via the iADAPTS application and telephone during the five-week intervention period. At the conclusion of week 5, participants completed questionnaires over the telephone. Participants provided written informed consent and all intervention procedures were approved by the University of Pittsburgh Institutional Review Board.

Intervention

We adapted the strategy training protocol for remote delivery using the iADAPTS mobile health system. To adapt the intervention protocol for mHealth, we considered the therapist's approach to training the participant to use the iADAPTS system and the therapist's approach to guiding through the Goal-Plan-Do-Check process remotely.

Participant Training on the iADAPTS Application—Participants were trained on navigation of the iADAPTS application during an in-person session. Training involved both demonstration and teach-back methods. If the participant was comfortable with trial-and-error, they were allowed to explore the application in this manner as well. Participants were allowed time to explore and ask questions until they verbalized that they were comfortable with the use of the iADAPTS application. They were then asked to navigate through the application during a teach-back process that allowed the therapist to assess the participant's understanding of the application. During this teach-back, the therapist provided any necessary clarification. Participants were also provided with a copy of the *iADAPTS User's Guide*, which included screenshots of the application and instructions for navigating the application.

Remotely Delivered Strategy Training—Participants had previously engaged in strategy training (NCT01934621), and so we expected that they would be familiar with the Goal-Plan-Do-Check process. To assure that these four steps were clear for all participants, we reviewed the Goal-Plan-Do-Check process during the in-person session. Participants then selected personally meaningful goals using the Canadian Occupational Performance Measure (COPM) [15]. The intervention therapist entered the selected goals from the COPM into the iADAPTS system via the clinician portal. The goals then appeared on the client's mobile application. During this in-person session, the therapist guided the participant to establish a plan for their first goal.

Strategy training was then delivered remotely. The intervention therapist monitored the clinician portal. When plans were submitted, the therapist reviewed the plan. If the plan was clearly described and had appropriate plans for safety and any assistance required, the

therapist approved the plan. This allowed the participant to continue with the do and check steps. If the therapist had questions about the plan, safety, or assistance, the therapist reached out to the participant via the messaging function of the mobile application to identify a time for a phone call. During this phone call, the therapist asked questions that guided the participant to clarify the plan, establish a clear plan for safety, and specify who would provide assistance if needed. Once the therapist and the participant agreed upon a plan, the participant updated the plan in the application. The participant then proceeded to complete the do and the check steps. This process was repeated iteratively for 5-weeks.

Given that the goal of this study was to establish an adapted intervention protocol that would be acceptable to participants, we asked participants to set their own routine for frequency of use. If participants asked what the expected amount of use was, we indicated that we anticipated approximately three times per week, but that was flexible based on their goals and preferences. During the 5-week period, if there was an extended period of inactivity on the therapist portal, we attempted to contact the participant via the messaging system embedded within the iADAPTS mobile health system. If the participant did not respond to the message within one to two days, the intervention therapist contacted the participant by telephone to assure participant safety and identify reasons that the participant was not accessing the iADAPTS application. During these calls, a plan was collaboratively established for the next point of contact with the intervention therapist. At the end of the 5-week intervention period, the intervention therapist contacted the participant by telephone to complete follow-up assessments, disassociate the clinician portal from the participant's device, and instruct the participant in application uninstallation procedures.

Outcomes

Data informing adaptation of the intervention process included detailed narrative intervention notes and a log of participant interactions. Narrative intervention notes included a description of the content of the session, barriers to engagement, observations related to participant understanding of materials and level of engagement in the intervention, and distractions that may have limited understanding or engagement. The participant interaction log described the mode (e.g., iADAPTS system messenger, telephone) and purpose (e.g., technology issues) of interactions that occurred remotely. In addition, conversations that occurred over the telephone were audio recorded when possible.

Safety was assessed by tracking adverse events. Adverse events were defined as a fall or injury to the client that occurred while carrying out a plan that had been approved by the therapist. We also monitored the number of times a plan was initially rejected by the therapist due to safety concerns, and then subsequently revised and carried out without the occurrence of an adverse event.

Acceptability of this approach was assessed using several assessments. Satisfaction with the intervention was assessed using the Client Satisfaction Questionnaire-8 (CSQ-8). The CSQ-8 is an 8-item questionnaire that asks participants to rate the degree to which their rehabilitation needs were met and their satisfaction with the quality and amount of the rehabilitation that was provided. Each item is ranked on a 1 to 4 Likert-type scale. The CSQ-8 demonstrates good reliability and validity [16].

Participants' perspectives of the patient-provider connection were assessed using the Patient-Provider Connection Short Form from the Healing Encounters and Attitudes Lists (HEAL). The HEAL assessments were developed using rigorous methodology set forth by the Patient Reported Outcome Measures Information System (PROMIS). The Patient-Provider Connection Short Form consists of 7 statements in which participants are asked to rate the degree to which they feel the therapist understands and respects them, and provides them with enough information [17, 18]. Each item is ranked on a 1 to 5 Likert-type scale. Scores are summed and then converted to T-score (mean=50, SD=10). The Patient-Provider Connection Short Form was completed by the participant during a follow-up telephone call that was conducted by an independent assessor.

Participants' perspectives of their progress toward goal achievement was assessed using the Canadian Occupational Performance Measure (COPM). The COPM contains a structured interview in which participants are asked to identify activities that they are expected to, want to, or need to do. They are then asked to select the top three to five activities and rate their current performance in these activities on a 1 to 10 scale. The COPM demonstrates good validity and reliability for participant-reported goal attainment [15]. The COPM was completed during the in-person intervention session. At the end of the intervention period, participants were asked to rate their performance on the activities that they selected at the beginning of the study.

Analyses

Our goal in conducting a descriptive case series study was to allow for adaptation of the intervention process based on participant and therapist feedback in this first application of the iADAPTS mobile health system. Members of the study team who have clinical expertise (EAK, KG, ERS) reviewed intervention notes, logs, and audio recordings to identify themes that informed adaptations to the intervention process. We also explored comments from a study follow-up interview regarding the intervention approach. Scores on the CSQ-8, PROMIS Patient-Provider Connection, COPM, risk for and occurrence of adverse events, and the number of plans completed in the application were also examined.

Due to the variability of residual cognitive, motor, and affective deficits after stroke, we also examined these clinical variables within our sample. To assess these variables, we examined participants' scores from the 6-month post-stroke time point in the parent study, where they had previously been exposed to metacognitive strategy training (NCT01934621). Specifically, we examined cognitive scores on the Repeatable Battery for the Assessment of Neuropsychological Status [19] and Delis-Kaplan Executive Functions System Test of Trailmaking [20], motor function scores on the Chedoke-McMaster Stroke Assessment [21], and affective scores on the Patient Health Questionnaire-9 [22]. This allowed us to begin to consider future adaptations to the intervention process that may be important for successfully delivering remote intervention to people with specific types of impairments.

Results

Participants

We contacted 21 individuals who had previously participated in metacognitive strategy training intervention through our research laboratory. Ten individuals expressed interest and completed the telephone screen. Our telephone screening process was refined at the initiation of the study, to identify a strategy to ensure the safety of our participants while including those who may benefit from ongoing rehabilitation. Our initial safety criteria were conservative, and we excluded individuals with self-reported falls or loss of balance within the last year. Under this criteria, 2 participants were included. Eight participants were excluded due to falls or loss of balance (7), and no personal device (1). History of falls and loss of balance are common within the stroke population [23, 24, 25, 26]. Given that these individuals are part of the population who may benefit from ongoing rehabilitation services, we convened a panel of individuals with expertise in stroke rehabilitation to identify approaches to screen for safety during the intervention process. Our expert panel identified that participants with low self-awareness may be at greater risk to engage in unsafe activities during this intervention than those with high self-awareness. Our exclusion criteria were modified to exclude those with low self-awareness related to current impairments and daily activities (Self Awareness of Deficits Inventory – 2 on item #1 or item #2) [14], allowing those with a history of falls to participate. We contacted 3 of the participants who were previously deemed ineligible due to falls or loss of balance, and all 3 were deemed eligible for the study. No adverse events (such as falls) were reported during the study.

Participant characteristics are described in Table 1. Our participants ranged in age from 57 years to 81 years. Four were female. We had four participants with ischemic stroke and one with hemorrhagic stroke. Our sample had a combination of right (3), left (1), and bilateral (1) stroke at the cortical (2) and sub-cortical (3) level. Stroke chronicity ranged from 1.10 to 3.27 years post-stroke. Four participants were retired prior to their stroke and one had stopped working because of the stroke. Four participants resided with a family member, and one lived alone. Three participants identified that they had no caregiver, and 2 participants reported support from caregivers. No participants were currently participating in rehabilitation therapies.

Cognitive, motor, and affective impairments were also examined. These scores reflect participants' function at 6-months post-stroke (data collected at follow-up during initial study, NCT01934621). Cognitive impairments were varied, with a range of impairments in executive functions (DKEFS Trail Making Condition 4 vs. DKEFS Trail Making Condition 5 scaled scores, range 5 to 12), attention (RBANS Attention Index Score, range 49 to 91), and visuospatial skills (RBANS Visuospatial Index Score, range 58 to 100). All participants had intact language (RBANS Language Index Score, range 85 to 101). Most participants had intact immediate and delayed memory, however, one participant had marked impairment in these domains (RBANS Immediate Memory Index Score, range 61 to 106, RBANS Delayed Memory Index Score, range 48 to 110). Our sample had low depressive symptoms (PHQ-9, range 1 to 4), and a range of motor impairment (Chedoke McMaster Stroke Assessment, range 16 to 36).

Outcomes

Case 1: Role of technology in client's life and scope of goals—The participant involved in case #1 was 81 years old and used his personal iPad daily to complete “brain games.” During the COPM, this participant identified bookwork and cleaning out filing cabinets as his goal for intervention. The participant completed 2 plans in the application during the initial training session and did not engage in using the application following this. The intervention therapist communicated with the participant via the telephone weekly. During these calls, it was identified that we should reconsider the scope of the goals that are entered into the application. Goals should be large enough to allow for iterations, yet focused enough that the participant could identify an appropriate time to *Check* his progress, and then choose to either repeat or revise the goal. The participant also indicated that he did not update his progress in the application because it took time away from actually completing the plan. During the study follow-up interview, this participant noted that the role of mobile technology in his life was concrete and finite (i.e., to play games for a specified time each day). The iADAPTS application was intended for tracking activities and progress, which required the integration of technology throughout his daily life in routine that he was not interested in establishing at this time.

Case 2: Refined goal setting and familiarity with specific mobile device—The participant involved in case #2 was 67 years old and used her personal e-reader (not Android or iOS-based) daily for reading and to play games. Because her device was not compatible with the iADAPTS mobile health system, but she had familiarity with mobile technology, she used a laboratory-owned mobile device for the duration of her participation in the study. This participant completed 14 plans in the application. During the COPM, the participant identified that she was preparing to move and set a goal to clean out specific areas of her home. Given experience from case #1 with goals of this nature, the participant was guided to select a specific strategy for cleaning, and a frequency in which she would *Check* her goal to assure it was progressing as expected in the application. By planning to keep, toss, and donate one item per day, and to *Check* her progress weekly in the application, the participant maintained momentum toward achieving her goal. This participant required frequent reminders to complete the *Check* process and then to proceed with revising or repeating her plan, as the application did not clearly direct her to the next step in the Goal-Plan-Do-Check process.

This participant encountered barriers related to technology that required frequent lengthy telephone conversations and one additional in-person meeting to resolve. We learned that, although a participant may have familiarity with their personal mobile technology, new devices may require additional orientation and training time. Gauging the participant's comfort level with the new technology may be important when determining the training needs of the participant.

Case 3: Comfort level with technology and accountability to complete plans—The participant involved in case #3 was 69 years old and used her Android-based smartphone and tablet frequently within her daily life. This participant also noted that, prior to her stroke, she was employed in a setting that demanded she become comfortable with

learning new technology. Although this participant completed only 4 plans in the application, she indicated that typing out her plans held her accountable to complete the plans that she set forth. Safety concerns were successfully navigated within the context of the participant's plans for painting her bathroom, walking for leisure, and sorting/cleaning boxes. The participant identified a friend or relative who could provide support for safety within each activity. No adverse events (e.g., fall) were reported.

This participant provided further insight into the variety of training approaches that may occur when introducing technology. This participant verbalized that her prior use of technology helped her to feel comfortable exploring that application using a trial-and-error approach to learn about specific functions of the application. In addition, this participant used her own personal device during this process, which she was already familiar and comfortable with.

Case 4: Directive application allowed for focus on goals and safety during intervention—The participant involved in case #4 was 57 years old. Her family had recently purchased an iOS tablet to share, although her prior experience with technology and current use of this new device was unclear. Following an initial overview of the iADAPTS application during the in-person session, the participant was able to navigate the application independently to apply Goal-Plan-Do-Check to her goals. This participant completed 12 plans in the application during the intervention period. Due to the participant's residual motor impairments (upper and lower extremity), safety was carefully considered by the therapist when assessing each plan for approval. This triggered 3 additional telephone calls to better understand the participant's plans for assistance while walking at the mall and preparing food in the kitchen. Each time, the participant was able to describe an appropriate plan that accounted for safety and was approved by the therapist. The participant successfully completed these plans and no adverse events were reported.

Case 5: Role of residual memory impairments in learning new technology—The participant involved in case #5 was 67 years old and owned 2 Android-based tablet devices, which she used to play games and check her email. She had previously worked in the technology industry. This participant had a high level of amnesic memory impairment that became the primary barrier to effectively using the iADAPTS application for intervention. Despite her familiarity with the device and prior use of technology, it was difficult for the participant to use the application. With step-by-step guidance from the therapist, she completed 2 plans in the application during the intervention period. Because the name of the application (iADAPTS) was unfamiliar to the participant, she required direct verbal cues to open the appropriate application. Simplified written instructions were provided to the participant to support her ability to access the application. Due to the participant's difficulty accessing the application independently, the focus of intervention shifted to understanding strategies that might be necessary to support this participant's ability to learn to use a new application. Two telephone intervention sessions were conducted under this new focus. Each session involved a step-by-step walk-through of one specific function on the application (e.g., sending a message to the therapist). During the 2nd session, the participant demonstrated the ability to locate the message function on the

application without cues. Further consideration should be given to the use of new technology among individuals with post-stroke cognitive impairments.

Goals during remotely delivered intervention—We examined the types of goals that participants set during intervention (Table 2). Household management goals were the most common, followed by personal care goals. Participants also identified community management and active recreation goals. Based on feedback from early participants, the intervention therapist collaborated with participants to break down large goals (e.g., clean out file cabinets from the past 20 years) into small goals. This allowed the iterative nature of the Goal-Plan-Do-Check process to be applied frequently during the intervention period. The iADAPTS mobile health system is designed to allow the therapist to review participants' Plan prior to providing approval for the participant to proceed through the Do-Check process.

Safety during remotely delivered intervention—No adverse events (e.g. falls) occurred during the course of participants' participation in this study. Of the 34 total activity trials completed during the study, the intervention therapist contacted participants via in-application messaging or telephone to discuss 7 plans prior to approving them. In each case, participants identified that they had a safe plan in place that was not reflected in the plan that they entered in the application. Additional details related to the participant's safe plan were subsequently entered into the application by the participant. Each of these 7 plans was subsequently carried out safely.

Acceptability of the iADAPTS Mobile Health System to participants—Scores on the CSQ-8 ranged from 25 to 32 (of a possible 32), indicating overall high satisfaction with this approach to intervention. Despite the remotely delivered nature of the intervention, participants scored the degree to which they felt understood and respected by the intervention therapist to be high (59.9 to 72.5 on HEAL Patient-Provider Connection). Pre-intervention to post-intervention change scores on goals set using the COPM varied in both direction and magnitude (Table 3).

Acceptability of delivering a remotely delivered metacognitive intervention via mobile health technology to therapists—Although we did not empirically measure the acceptability of this system among therapists, anecdotal evidence suggests that this approach may be acceptable to therapists. Occupational therapists that were involved in the initial design and implementation of the iADAPTS mobile health system were sensitive to the need for safety controls that would support this approach. This led to the implementation of therapist controls that allowed for rejection and revision of unsafe plans. During the intervention process, this option led to robust conversations surrounding safety that allowed both the therapist and the participant to feel confident in the safety of the established plan. In addition, therapists expressed a preference for receiving an alert to activity in the iADAPTS Clinician Portal, rather than scanning the portal each day to identify new activity. This led to the addition of an email alert sent to the intervention therapist each time the participant entered information into the iADAPTS Mobile Health Application. Therapists identified that

this provided an efficient approach to monitoring current participants that fit within the flow of their workday.

Discussion

This descriptive case series resulted in the adaptation of the metacognitive strategy training protocol for remote intervention delivery using the iADAPTS mobile health system. The adaptations made to our intervention approach highlight the careful consideration that must be given to goal setting and training for technology when applying mobile health technologies to complex interventions. Following these adaptations, we identified that it may be feasible to adapt the strategy training protocol for delivery using mobile health technology.

Breadth of individualized goals

Distinct from previous mHealth applications, the iADAPTS mobile health system provides a platform for client-therapist collaboration focused on the client-selected goals rather than prescribed goals (e.g., medication adherence, exercise, health monitoring) [6, 27, 28]. Individualized goal-setting is an important component of stroke rehabilitation across the range of settings (inpatient to community-based) [29, 30]. Several researchers suggest that individualized goals become of greater importance in chronic phases of stroke recovery relative to acute and sub-acute phases [31, 32]. We learned that the scope of individualized goals that can be accomplished during metacognitive strategy training delivered remotely must be carefully considered. Too broad of a goal may leave the client without clear direction on what the next step should be. Too small of a goal may be accomplished in one iteration, leaving little opportunity to practice the Goal-Plan-Do-Check process and apply lessons learned in future iterations. The intervention therapist must guide the client to find the appropriate balance in the breadth of goals pursued via remote intervention, accounting for the remote nature of this intervention. Future use of the iADAPTS mobile health system in research settings may help to delineate this balance more clearly.

Learning processes for adoption of mobile health technology after stroke

Consistent with studies of older adults' adoption of technology, our sample had variability in past experiences with mobile health technology, approaches to current device use, and comfort level learning new technologies [33, 34]. The environment surrounding technology adoption, including both the therapist approach to training and features embedded within the mobile health application, may influence this learning process [34, 35, 36]. In addition, we observed that residual cognitive impairments can also influence this learning process and should be given further consideration.

The intervention therapist plays a key role in identifying the approach to learning that the client may respond to best when learning a new technology. Our participants preferred either step-by-step directions or a trial-and-error approach. While all participants were provided with a written user's manual, none reported relying on the user's manual to learn the application. These three approaches to support older adults' adoption of technology are consistent with the literature [33]. Further studies examining the therapist process should

identify specific characteristics of clients who would benefit from one approach versus others. It is also likely that integrating this technology into an intervention program that spans multiple face-to-face intervention sessions followed by ongoing remote intervention may allow the client time to practice using the technology independently and resolve technology challenges before remote intervention.

Although our participants' adoption of technology paralleled that of older adults, we must remain mindful of potential differences associated with residual deficits post-stroke. Our participants had a range of residual cognitive, affective, and motor impairments. Impairments in cognition are common after stroke [37]. Depending on the domain of cognition affected, these impairments can influence learning in a variety of ways. Individuals with memory, language, visuospatial, and/or attentional impairments may require additional adaptations to the learning process that were beyond the scope of this work. Further studies examining adoption of mobile health technologies for rehabilitation should give careful consideration to approaches that may promote learning among clients with a range of cognitive deficits.

Limitations

We are mindful that this work carries several limitations. Our small sample size and descriptive case series design limit the generalizability of this approach beyond our sample. We used this study design to refine the intervention protocol that would support the intervention process and assess the safety of delivering metacognitive strategy training remotely. This system is intended to be integrated into a metacognitive strategy training approach that spans face-to-face and remote intervention processes. Future work should identify optimal models for this integration. Finally, this study did not examine the efficacy or effectiveness of the intervention. Our goal was to describe the adaptation and early phase implementation of the intervention process delivered using the iADAPTS mobile health system. Thus, before broad-scale implementation may occur, future comparative effectiveness trials should be conducted to explore the outcomes of the integration of mobile health relative to traditional face-to-face intervention.

Despite these limitations, these findings highlight the need to precisely specify intervention protocols when adapting complex behavioral interventions for remote delivery. To our knowledge, this work represents the first attempt to adapt a complex metacognitive rehabilitation approach for remote intervention using mobile health technology. The lessons we learned may inform the adaptation of other individualized behavioral interventions for remote delivery via mobile health technology.

Conclusion

This work represents a first step toward delivery of metacognitive strategy training through an integrated intervention program using the iADAPTS mobile health system. The current study demonstrated that metacognitive strategy training can be adapted for safe and acceptable delivery using this system. Adaptations to the goal-setting process supported the intervention delivery. In addition to future trials exploring the efficacy and effectiveness of

this approach, service delivery models and systems must be developed that support translation to clinical practice [38]. This includes exploration of cost-effectiveness, reimbursement models, state and national licensure laws, and accessibility to technology [39, 40]. Understanding these factors will inform advocacy efforts among state and national organizations to establish sustainable and reimbursable models for telerehabilitation delivery [41, 42]. Successful navigation of these next steps holds promise to expand the reach of stroke rehabilitation, and enhance participation outcomes that are of high value to clients and their families.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Implications for Rehabilitation

- Translating the strategy training intervention from face-to-face to remote delivery required thoughtful adaptation of the intervention protocol.
- Strategies for training clients to use mobile health technology during intervention may be important when designing remotely delivered mHealth intervention protocols.
- Client safety should be considered within the design of the intervention protocol for a complex intervention designed to be delivered remotely.
- Future studies should examine the efficacy of complex rehabilitation interventions such as strategy training on clinical outcomes (e.g., community participation).

Table 1.

Participant Characteristics

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Age	81	67	69	57	67
Gender	M	F	F	F	F
Race	White	White	White	Black	White
Education	Bachelors	High School	Associates	High School	Bachelors
Occupation	*Auditor	*Receptionist	*Customer service	**Customer service	*Project manager
Residential Status	Spouse	Adult child	Adult child	Spouse	Alone
Social Support	No caregiver	No caregiver	No caregiver	Full-time caregiver	Part-time caregiver
Stroke Type	Ischemic	Ischemic	Ischemic	Hemorrhagic	Ischemic
Stroke Hemisphere	Right	Left	Right	Right	Bilateral
Chronicity (Years)	2.36	2.91	1.10	2.31	3.27
Mood (PHQ-9) ^d	1	4	2	2	3
Executive Functions (DKEFS) ^b	9	5	11	10	12
Language (RBANS) ^c	85	101	101	90	92
Attention (RBANS) ^c	91	88	82	60	49
Immediate Memory (RBANS) ^c	100	90	100	106	61
Delayed Memory (RBANS) ^c	110	102	106	99	48
Visuospatial (RBANS) ^c	58	78	100	58	64
Motor Function (CMA) ^d	33	36	28	16	23

* Retired;

** No longer working, Social Security Disability Income

^a Range is 0 to 27, low scores are low depressive symptoms;^b Mean=10, SD=3;^c Mean=100, SD=15;^d Range is 6 to 42. Low scores are more impaired motor function.

Table 2.

Goals set during intervention

Goal	COPM Category
Put on socks	Personal Care
Button jeans	
Get dressed	
Walk outside	Community Management
Catch up on paperwork	
Pack to move	
Prepare sewing room	Household Management
Clean out filing cabinets	
Buy a house	
Paint the bathroom	
Clean out the basement	
Downsize my home	Active Recreation
Meal preparation	
Gardening	
Be more physically active	

Table 3.

Outcomes

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
Client Satisfaction Questionnaire-8 (8–32)	25	32	30	30	28
Patient-Provider Connection*	59.9	72.5	72.5	59.9	72.5
Number of Activity Trials Completed During Intervention	2	14	4	12	2
Canadian Occupational Performance Measure-Performance	Pre: 7.00 Post: 5.00	Pre: 7.33 Post: 6.67	Pre: 4.00 Post: 6.00	Pre: 3.20 Post: 3.80	Pre: 5.75 Post: 4.50

*
T-scores, mean=50, SD=10