Improving Quality of Life and Depression After Stroke Through Telerehabilitation

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MeSH TERMS

- depression
- exercise therapy
- quality of life
- robotics
- stroke
- telemedicine

OBJECTIVE. The aim of this study was to determine the effects of home-based robot-assisted rehabilitation coupled with a home exercise program compared with a home exercise program alone on depression and quality of life in people after stroke.

METHOD. A multisite randomized controlled clinical trial was completed with 99 people <6 mo after stroke who had limited access to formal therapy. Participants were randomized into one of two groups, (1) a home exercise program or (2) a robot-assisted therapy + home exercise program, and participated in an 8-wk home intervention.

RESULTS. We observed statistically significant changes in all but one domain on the Stroke Impact Scale and the Center for Epidemiologic Studies Depression Scale for both groups.

CONCLUSION. A robot-assisted intervention coupled with a home exercise program and a home exercise program alone administered using a telerehabilitation model may be valuable approaches to improving quality of life and depression in people after stroke.

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Stroke is a leading cause of long-term disability, necessitating a multidisciplinary rehabilitation approach to improve motor impairment and function (Go et al., 2014). Although the literature has emphasized motor rehabilitation therapies, the effect of therapy on quality of life (QOL) and depression has been less studied (Kutner, Zhang, Butler, Wolf, & Alberts, 2010). Nevertheless, outcomes that measure improved perception of QOL and improved mood are considered an important part of stroke rehabilitation (Graven, Brock, Hill, & Joubert, 2011).

A systematic review by Hackett, Yapa, Parag, and Anderson in 2005 reported that approximately one-third of all people with stroke display signs of depressive symptomatology, and more recent studies have reported an even greater incidence rate of 41%–52% (Jia et al., 2006; Wulsin et al., 2012). People with stroke who have depression exhibit greater utilization of health care services (Jia et al., 2006), ultimately resulting in significantly higher health care costs than for their counterparts without depression (Husaini et al., 2013). In addition, depression is a predictor of poor functional outcomes after stroke (Farner et al., 2010; Wulsin et al., 2012). Currently, limited evidence supports that poststroke rehabilitation designed to achieve functional recovery, minimize disability, and reintegrate people back into the community decreases the risk of depression and improves QOL in this population (Hou et al., 2013).

The American Heart Association has predicted an increase in the U.S. population who will experience a stroke and an increase in stroke-related health care costs over the upcoming decades (Ovbiagele et al., 2013), necessitating further research to determine effective, cost-efficient stroke rehabilitation. *Telerehabilitation* is an emerging method of rehabilitation that consists of the remote delivery and monitoring of rehabilitation services (McCue, Fairman, & Pramuka, 2010) and has the potential to provide health care services to underserved areas with potential cost and travel savings (Chumbler et al., 2010; Gamble, Savage, & Icenogle, 2004). Several studies have supported the efficacy of telerehabilitation in facilitating motor recovery and activities of daily living (ADL) performance after stroke (Chumbler et al., 2012; Lum, Uswatte, Taub, Hardin, & Mark, 2006; Rogante, Grigioni, Cordella, & Giacomozzi, 2010); however, the research devoted to telerehabilitation and QOL outcomes has been limited.

Robot-assisted therapy is a technological development designed to augment exercise training during stroke recovery (Kwakkel, Kollen, & Krebs, 2008). A robot-assisted device can provide repetitive, task-specific activities that can be graded to challenge the user to promote motor learning without the direct one-on-one oversight of a therapist (Kwakkel et al., 2008; Masiero et al., 2009; Matsuo et al., 2013). An emerging body of evidence has shown promising results with improved motor recovery and improvement on QOL measures with the use of robotic devices after stroke (Bovolenta, Sale, Dall'Armi, Clerici, & Franceschini, 2011; Page, Hill, & White, 2013; Posteraro et al., 2009). Page et al. (2013) found that after 24 sessions with an upper-extremity (UE) robot-assisted therapy device, people with chronic stroke made favorable gains in the ADL and Instrumental Activities of Daily Living (IADL), Hand Function, and Stroke Recovery domains of the Stroke Impact Scale (SIS; Duncan et al., 1999), a QOL measure used after stroke (Page et al., 2013). We previously reported significant improvements in several domains of the SIS after 30 hr of an in-clinic robot-assisted therapy intervention combined with 30 hr of repetitive task practice (Kutner et al., 2010).

Robot-assisted technology has been implemented in a research setting and, to a lesser extent, in the clinical setting; however, the concept of combining telerehabilitation and robot-assisted therapy is a novel approach in rehabilitation. To date, there are few case reports and small studies that have administered robot-assisted therapy in the home environment (Carey et al., 2007; Fluet & Deutsch, 2013; Reinkensmeyer, Pang, Nessler, & Painter, 2002; Zhang et al., 2011); however, none of these studies has reported outcomes on QOL or depression. Our recent case study found that the use of a robot-assisted device in association with remote monitoring in the home environment resulted in improvements in UE function, QOL, and depression in a person 22 wk poststroke, giving rise to the possibility that this intervention may have an impact on nonmotor outcomes (Linder, Reiss, et al., 2013).

To address the fundamental gap in understanding whether a telerehabilitation approach can effectively improve QOL and depressive symptomatology, we undertook a multisite randomized clinical trial. The purpose of this article is to report the nonmotor outcomes of two home-based rehabilitation interventions: (1) a home exercise program (HEP) and (2) robot-assisted therapy + HEP (robot + HEP). We hypothesized that participants randomized to the robot + HEP group would have significantly greater improvements in QOL and on depression measures than the HEP group.

Method

Design Overview

A prospective, multisite, single-blind, randomized controlled clinical trial was designed to assess the effectiveness of two home-based interventions on motor and nonmotor outcomes after stroke. Before the intervention, all participants signed an informed consent approved by the institutional review board of the Cleveland Clinic (Cleveland, OH) or Emory University (Atlanta, GA). Further information regarding the protocol and a full description of the robot-assisted device are provided in our previous publication (Linder, Rosenfeldt, et al., 2013).

Participants

Participants were recruited from the Cleveland, OH, and Atlanta, GA, geographic areas. Main criteria for eligibility included a unilateral ischemic or hemorrhagic stroke within the previous 6 mo with some UE voluntary movement as indicated by a score of 11–55 on the Fugl-Meyer Assessment (FMA; Gladstone, Danells, & Black, 2002), limited access to an organized stroke rehabilitation program, and preserved cognitive function. *Limited access* included logistical, financial, and geographical barriers such as lacking transportation, being uninsured or having limited insurance, being unable to fund insurance copayments, and living in a rural area. Participants with subacute stroke were targeted because rehabilitation interventions in the early phases of stroke recovery have been associated with improved functional outcomes (Rodin, Saliba, & Brummel-Smith, 2006).

Main exclusion criteria were lack of independence before the stroke (determined by a score >1 on the Modified Rankin Scale; Wilson et al., 2002) and antispasticity injection in the hemiparetic UE since stroke onset. Additional exclusion criteria to ensure whether potential participants could successfully complete study-related interventions without the direct supervision of a therapist included substantial peripersonal neglect, as determined by more than three errors on the Star Cancellation Test (Menon & Korner-Bitensky, 2004); sensory loss score ≥2 on the sensory item of the National Institutes of Health Stroke Scale (Lyden et al., 1999); and UE hypertonicity score ≥3 on the Modified Ashworth Scale (Bohannon & Smith, 1987).

Each participant was screened during a home visit by a physical therapist or occupational therapist. Of the 505 potential participants screened, 99 consented to participate.

Outcome Measures and Randomization

After meeting inclusion criteria, participants completed baseline evaluation. All evaluations were completed by a physical therapist or occupational therapist blinded to group assignment at baseline and end of treatment (EOT). The primary QOL outcomes were the SIS and the Center for Epidemiologic Studies Depression Scale (CES–D; Shinar et al., 1986).

Briefly, the SIS is a self-rated QOL questionnaire that addresses several domains after stroke: Physical Strength; Memory; Feelings and Emotions, or Mood; Communication; ADLs and IADLs; Mobility; Hand Function; and Meaningful Activities. It also addresses overall percentage of recovery from the stroke, which is categorized as a domain in this article. The SIS has been shown to be valid and reliable in people with stroke (Duncan et al., 1999).

The CES–D is a valid and reliable measure of depressive symptomatology after stroke (Shinar et al., 1986). A cutoff score of 16 has been found to have 100% specificity and 73% sensitivity for the diagnosis of depression; thus, a person after stroke who scores higher than 16 is likely to have a depressive disorder (Shinar et al., 1986).

After baseline testing, an adaptive treatment assignment procedure was used to balance sex, premorbid handedness, side of stroke, and level of function (FMA score above or below 33) within each of the two sites.

Intervention

A physical or occupational therapist completed a home visit to educate participants and their caregivers if indicated in their assigned intervention. To facilitate compliance, participants signed a behavior contract and were instructed to complete a daily exercise log. Each participant was asked to complete 3 hr of study-related interventions 5 days/wk for 8 wk total within a 12-wk period, thus allowing for life events such as illness or vacation that may have prevented study completion.

Home Exercise Program Group

Participants were instructed in a customized UE HEP prescribed by the therapist from a pool of exercises and activities created before study initiation (Linder, Rosenfeldt, et al., 2013). Participants were asked to complete the prescribed activities and exercises using their affected UE for a total of 3 hr/day, 5 days/wk. The repertoire of UE exercises and activities was organized under the following categories: (1) range-of-motion (ROM) activities, (2) weight-bearing activities, (3) active-assistive exercises, (4) active exercises, and (5) ADLs and functional activities incorporating the affected UE. Because of the importance of functional, task-specific activities in promoting motor recovery, the therapist highlighted the need to incorporate the affected UE into tasks throughout the day (Birkenmeier, Prager, & Lang, 2010). The therapist customized each program for the person's impairments and goals to ensure sufficiently challenging tasks.

During weekly phone calls, the prescribed HEP was progressed as indicated to increase movement demands and to transition to increasingly complex functional tasks. In addition, participants were educated in strategies to incorporate the more affected UE into daily tasks such as opening and closing the refrigerator, turning light switches on and off, and grooming and bathing activities. Each participant was provided with an exercise book, which contained diagrams, written instructions, and dosage of each exercise.

Hand Mentor Pro™ Robotic Device and Home Exercise Program Group

The robot + HEP group was prescribed an identical dosage of therapeutic intervention—a total of 3 hr of use of the more affected UE, 5 days/wk (Lum et al., 2006). However, these participants were asked to use the Hand Mentor Pro (Kinetic Muscles Inc., Tempe, AZ) robot-assisted device for 2 hr and perform a prescribed HEP for 1 hr. The UE activities prescribed by the therapist used the same methods as described for the HEP group.

The Hand Mentor Pro robot-assisted device uses a pneumatic pump to facilitate active-assisted movement of the wrist and fingers. The device consists of three components: a computer control box, an arm unit and data collection device, and a communications module. Briefly, the arm unit stabilizes the forearm so the user is able to isolate wrist and finger movement with the assistance of the pneumatic pump, and the computer control box provides targeted goals with corresponding visual and auditory feedback.

The device has various training modules; one focuses on spasticity reduction, and the others focus on various aspects of improving motor control. The spasticity reduction program provides a prolonged isometric stretch of the wrist flexors while providing visual feedback to the participant encouraging active relaxation of the wrist and finger flexors. The motor training modules are designed to promote active control of the wrist. The programs use function-based games in which the goal is to move the hand to a target within a specified time. Advanced motor control games incorporate velocity and grading of force by showcasing dynamic targets and varying speeds. For example, during the "balloon game," the participant controls a hot air balloon and must use graded flexion and extension with precision to avoid hitting objects such as airplanes and birds, which scroll across the screen in random positions.

In the motor control games, if the client does not achieve the goal within the specified time, the air muscle actuates to assist the client through the desired ROM. If the client is successful in achieving the goal on 80% of the trials, the difficulty level programmatically increases by 1 level (10 levels total for each program). With each advancing level, the flexion ROM target increases by 1.5° and the active extension ROM target increases by 3°. Conversely, if the client is successful on less than 20% of the trials, the level is decreased.

Each time a client completes a program, the summary for that session is displayed on screen and stored in that client's coded electronic database. The data collection and communication module records the following variables: overall time of use, time of use in each module, number of attempted and successful repetitions, wrist angle, and pneumatic pressure. These data are encrypted and transmitted via landline telephone, Internet, or cellular connection to the Mentor Home™ website (http://dev.kineticmuscles.net/) where the therapist can remotely monitor the client's progress.

Telerehabilitation Monitoring

The therapist made weekly calls to each participant, which served several purposes. First, compliance with the prescribed intervention was facilitated by ensuring the participant was held accountable for his or her exercise program over the previous week. The participant relayed his or her daily exercise compliance from the exercise log to the therapist, and barriers to compliance were discussed. Second, the therapist advanced the HEP as participants' UE function improved by modifying, changing, or adding exercises and activities and educating the participant in approaches to incorporate the more involved UE into functional activities and ADLs.

Data from the robot-assisted device were transmitted to the Mentor Home website, allowing the therapist to work with participants to modify settings and grade the activity as needed. The therapist was provided with objective data from the device, including time spent performing each module and number of repetitions completed, and compared these data with the participant's subjective report.

Statistical Analysis

Data were double entered into a customized Microsoft Access database. Internal consistency of scales was estimated using Cronbach's α. Baseline demographic and clinical characteristics of the two groups were compared using independent-samples t tests for continuous variables and χ^2 or Fisher's exact tests for categorical variables.

Changes in SIS subscale and CES–D scores from baseline to EOT were analyzed using a mixed-model approach, with random effects for participant scores. For the purposes of this intent-to-treat analysis, data were assumed to be missing at random. The mixed analysis approach was used, with no ad hoc imputation (Bell, Kenward, Fairclough, & Horton, 2013; Chakraborty & Gu, 2009). The estimate of primary interest was the time (baseline, EOT) × treatment (HEP, robot + HEP) interaction. Outcome scores were adjusted for participants' age at enrollment, time between stroke and enrollment, baseline CES–D score, and baseline FMA score. The Breslow–Day test was used to assess homogeneity of odds ratios for changes in clinical depression threshold. A p value of .05 was used as the criterion for statistical significance. Analyses were performed using IBM SPSS Statistics (Version 22; IBM Corporation, Armonk, NY).

Results

All domains of the SIS had adequate reliability during both measurement periods ($\alpha > .75$), except the Strength scale at baseline ($\alpha = .62$). For the CES–D, α exceeded .85 for both measurements. Demographic and clinical characteristics did not differ significantly at baseline for the two intervention groups (Table 1).

Total time spent engaging in the therapeutic intervention was calculated using self-reported time spent performing the prescribed HEP for participants in the HEP group (mean = 8,369 min, standard deviation = 3,373 min) and self-reported time spent performing the prescribed HEP + device-recorded robot use time for those in the robot + HEP group (mean = 8,052 min, standard deviation = 4,042 min, $p = .68$). Five participants (10.4%) in the HEP group and 3 (5.9%) in the robot + HEP group did not complete all outcome measures (SIS subscales and the CES–D) at both visits. Those who did not complete the full battery of scales at both visits did not differ significantly from those who completed all scales on any of the SIS subscales or CES–D measured at baseline (data not shown).

Mean SIS and CES–D scores and standard deviations for participants in the two groups at baseline and EOT

Table 1. Demographics

Variable	HEP Group (n = 48), M (SD) or n (%)	Robot + HEP Group (n = 51), M (SD) or n (%)	p
Baseline FMA score	33.3 (11.7)	34.1 (12.1)	.74
Male	33 (68.8)	31 (60.8)	.53
Race			.21
White	20 (41.7)	28 (54.9)	
African-American	26 (54.2)	22 (43.1)	
Other	2 (4.2)	1 (2.0)	
Age at enrollment, yr	55.5 (12.6)	59.4 (13.6)	.14
Days since stroke	125.6 (47.2)	117.0 (50.9)	.39
Right side affected	26 (54.2)	23 (45.1)	.42
Withdrew after baseline visit	3 (6.3)	4 (7.8)	.76
Incomplete SIS data	1 (2.1)	2 (5.9)	.59
Incomplete CES–D data	8 (16.7)	6 (11.8)	.48

Note. CES–D = Center for Epidemiologic Studies Depression Scale; FMA = Fugl-Meyer Assessment; HEP = home exercise program; M = mean, SD = standard deviation; SIS = Stroke Impact Scale.

are provided in Figure 1. Exact values for means and confidence intervals are presented in Supplemental Table 1 (available online at http://otjournal.net; navigate to this article, and click on "Supplemental"). Baseline SIS scores did not differ significantly across groups for any of the SIS domains. Preliminary analyses were conducted to assess the potential effect of site (Cleveland Clinic, Emory University) on change in SIS domain scores using a triple interaction term (Site × Group × Visit). None of these interactions was significant (data not shown), so data were collapsed across sites. Changes in SIS domain scores from baseline to EOT did not differ significantly across the two groups (p values for the interaction are shown in Table 2). However, participants in both groups improved significantly on the CES–D and SIS domain scores, except Memory and Mood (Table 2).

Eighty-five participants (40 in the HEP group and 45 in the robot + HEP group) completed the CES–D both at baseline and EOT. At baseline, 11 of the HEP participants (27.5%) and 12 of the robot + HEP participants (26.7%) scored >16. At EOT, 3 of the HEP participants (7.5%) and 6 of the robot + HEP participants (13.3%) reported scores >16. Within-subject changes were significant for the HEP group (p = .021) but not for the robot + HEP group (p = .07). A test for the homogeneity of odds ratios indicated that the interaction (Time × Group) was not significant (p = .447).

Discussion

Both interventions were effective in improving QOL and depression outcomes for participants <6 mo after stroke. Contrary to our hypothesis, the robot + HEP group did not produce superior results to the HEP group in nonmotor outcomes, and we found no significant interaction between the groups. Both groups improved in all but one domain of the SIS. In addition to the motor domains of the SIS, both groups improved on nonmotor domains. This finding is consistent with a large randomized controlled trial involving repetitive UE tasks that found expected improvements in motor domains such as UE function and also improvements in nonmotor domains such as Meaningful Activities and Mood (Studenski et al., 2005).

The similarities in change between the groups are similar to the results of several studies using robot-assisted

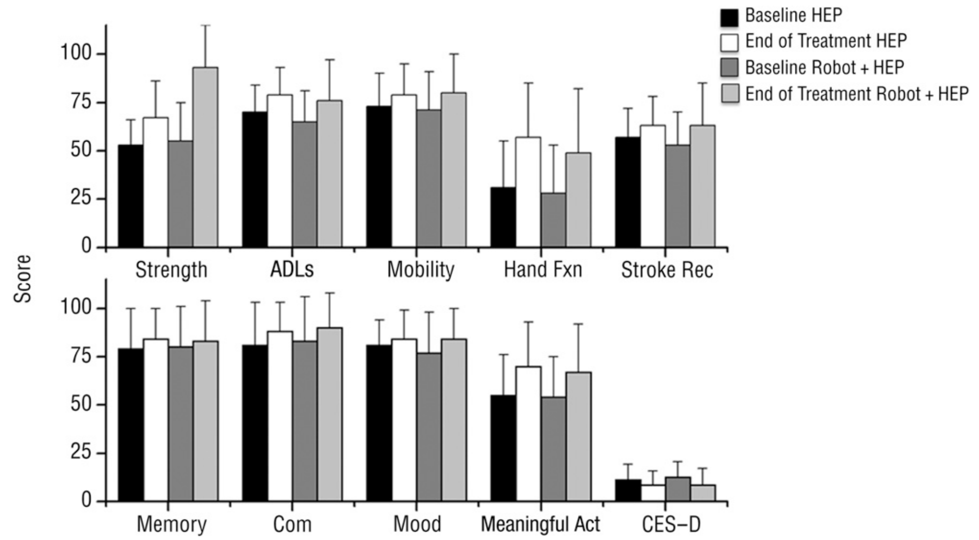

Figure 1. Mean scores on the nine domains of the SIS and the CES–D from baseline to end of treatment for both intervention groups.
Note. Error bars indicate standard deviations. Act = Activities; ADLs = Activities of Daily Living; CES–D = Center for Epidemiologic Studies Depression Scale; Com = Communication; Fxn = Function; HEP = home exercise program; Rec = Recovery; SIS = Stroke Impact Scale.

Table 2. Change in Scores on the Stroke Impact Scale and Center for Epidemiologic Studies Depression Scale

	HEP Group (n = 48)			Robot + HEP Group (n = 51)			
Assessment	Estimate	95% CI	p	Estimate	95% CI	p	p for Interaction
SIS							
Strength	12.4	[7.0, 17.8]	<.001	9.5	[4.2, 14.7]	.001	.442
Memory	6.3	[0.8, 11.7]	.024	2.6	[−2.7, 8.0]	.324	.346
Communication	7.8	[3.5, 12.0]	<.001	5.7	[1.6, 9.9]	.007	.498
ADLs/IADLs	10.0	[5.1, 14.9]	<.001	10.0	[5.2, 14.8]	<.001	.992
Mobility	6.4	[1.8, 11.0]	.007	8.4	[3.9, 12.9]	<.001	.541
Hand Function	26.5	[18.7, 34.4]	<.001	22.7	[14.9, 30.5]	<.001	.495
Meaningful Activities	15.2	[9.0, 21.5]	<.001	14.9	[8.7, 21.0]	<.001	.930
Mood	3.3	[−1.4, 8.1]	.168	7.3	[2.7, 11.9]	.002	.235
Stroke Recovery	6.0	[1.2, 10.8]	.014	10.5	[5.7, 15.2]	<.001	.197
CES–D	−3.0	[−5.4, −0.5]	.017	−4.0	[−6.3, −1.7]	.001	.553

Note. Analyses adjusted for the effects of age at enrollment, time between stroke and enrollment, baseline CES–D score and baseline Fugl-Meyer score. ADLs = Activities of Daily Living; CES–D = Center for Epidemiologic Studies Depression Scale; CI = confidence interval; HEP = home exercise program; IADLs = Instrumental Activities of Daily Living.

devices in the clinic, in which SIS scores were found to improve in both the robot-assisted group and the control group that was not using the device (Kutner et al., 2010; Page et al., 2013). Although we are unable to determine precisely why the two groups in our study had such similar outcomes, the flexibility of the HEP to adapt to participants' individual goals may have played a role. For example, if a participant had a goal to return to playing tennis, the HEP could be individualized and graded to achieve this goal, whereas the robot-assisted intervention was more difficult to adapt and was therefore less individually goal oriented. Another possible explanation for the similarity in results is that dosage (each group was required to complete 3 hr/day) may have a greater impact on QOL and depression than the type of intervention. In addition, some of the improvements in QOL and depression could have been the result of the regular phone contact between the therapist and the participant, which occurred in both groups. Many of the participants in this study looked forward to the weekly phone calls, not only as a way to advance their exercise programs but also as a social outlet.

A recent study by Hou et al. (2013) stated that early stroke rehabilitation reduces the risk for depression in first-time stroke patients by approximately 43%, citing possible reasons such as increased concentration of endorphins, improved fitness levels, improvements in somatic symptoms, and social interaction. Participants in our study qualified for enrollment if they lacked access to traditional rehabilitation; therefore, one may presume that the limited access to early stroke rehabilitation may have increased the incidence of depression in this cohort. Not in our study, however, in which 33% of participants scored >16 on the CES–D, a result that mirrors Hackett et al.'s (2005) systematic review finding that one-third of people after stroke suffer from depression. Nevertheless, an important result from the current study was that telerehabilitation, whether administered using robot-assisted therapy or an individualized HEP, was associated with a significant improvement in CES–D scores. We thought that feedback from the device as well as the ability to more accurately monitor the participant would have improved outcomes; however, we found that both groups improved similarly, and the change over time with scores of <16 on the CES–D was significant in the HEP group but not in the robot + HEP group.

Despite the equivalence of these two interventions, there are several reasons why a therapist may select one telerehabilitation mode over the other. The HEP may be better suited for clients who are less familiar with technology because there may be instances in which troubleshooting and machine adjustments need to be made. In addition, the client's living space must have room for the device. Depending on level of mobility and assistance at home, not everyone may be able to don the device. Last, people who enjoy ADL-based activities as part of their exercise regimen or who have substantial spatial inattention may benefit from a HEP intervention over a robot-assisted device. Alternatively, a robot-assisted device may be more beneficial for someone who embraces technology.

Another benefit of a robotic device is that repetitive activities can be performed without allowing compensatory motions, which is aligned with goals of traditional rehabilitation, in which the aim is to restore motor function while minimizing compensation. Also, a trained rehabilitation specialist can objectively monitor a client's progress when using telerehabilitation in conjunction with a robotic device, as with the Hand Mentor Pro. During this study, the

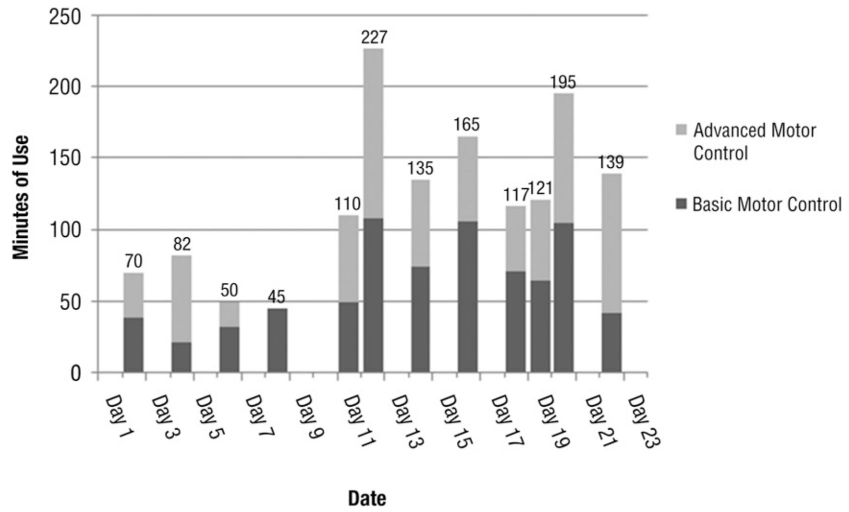

Figure 2. Representative chart depicting monitoring capabilities during the robot-assisted therapy intervention.

Remote monitoring of this participant's performance and compliance was addressed during a weekly phone call on March 13, 2013, resulting in improved compliance during the subsequent 2-wk time frame. Additional data (not shown) included drill-down options for each game to view specific performance parameters, including range of movement, amount of resistance, and repetitions attempted versus successfully completed.

therapist was able to compare the self-reported progress of robot + HEP group participants with the objective report on the website, thus providing the therapist with a more complete picture of intervention compliance and motor progression.

Refer to Figure 2 for a representative depiction of daily time of use of the robot-assisted device that the therapist was able to remotely monitor. On Day 10, when the therapist noticed that daily time of use was lower than requested of the participant, she called the participant to encourage greater compliance. Thereafter, there was a noticeable increase in daily use. The HEP-only model relies on participants to accurately self-report the HEP time without a method to objectively measure repetitions or time. Finally, the robot-assisted device provides sensory and proprioceptive feedback to participants with very little distal movement in their more affected UE, something that is often lacking in a traditional HEP program.

There is no universally accepted protocol for dosage of UE rehabilitation after stroke with respect to time, intensity, and number of repetitions to induce improvements in motor function or to have an impact on QOL. One of the strengths of this study is that the robot + HEP and HEP groups were prescribed time-matched interventions (3 hr/day, 5 days/wk, for 8 wk). A large clinical trial involving 127 participants with chronic stroke found no difference between groups in SIS scores when in-clinic robotic therapy was compared with time-matched comparison therapy after 12 wk (Lo et al., 2010). However, when robot-assisted therapy was compared with usual care (medical care and in some cases limited rehabilitation) in the same study, the difference in SIS scores was significant, favoring the robot-assisted group.

In our study, the exact number of repetitions of UE activities was not known; however, we can presume on the basis of the exercise prescription and reported compliance (both self-reported and based on data from the device) that participants in both groups were completing hundreds, perhaps thousands, of repetitions per day. We did not have a usual-care group to serve as a control. The results of our study and those of Lo et al. (2010) possibly imply that goal-directed, highly repetitive tasks after stroke may improve QOL metrics.

We acknowledge several limitations of our study. First, we relied on participant self-report for HEP compliance. Despite tools such as exercise diaries, there was no way to know whether the participant was providing an accurate account. Future studies should consider incorporating a wrist accelerometer or similar technology to more accurately quantify compliance, and repetitions would provide a more objective understanding of the dose–effect relationship. Second, the first 6 mo after stroke are of particular importance in recovery (Rodin et al., 2006); thus, we cannot rule out the impact of spontaneous recovery or the development of compensatory strategies on our motor results and on self-reported QOL. Third, we were not able to determine precisely why the QOL and depression outcomes improved. Improvements may be attributed to the intervention, the motor improvements from the intervention, or the weekly interaction between the participant and the therapist.

The results of this study indicate that an 8-wk home-based robot-assisted intervention resulted in QOL improvements comparable to those of a dosed-matched HEP intervention. Further research needs to be performed to determine whether there is a cohort of people who, based on function, access to traditional rehabilitation, or other factors, would benefit most from robot-assisted intervention or telerehabilitation. In addition, further studies are needed to determine ideal dosages that result in motor and nonmotor improvement. This study provides evidence to support that robot-assisted therapy and HEP administered using a telerehabilitation model may be a valuable approach to improving QOL and depression in people after stroke, especially in an underserved population.

Implications for Occupational Therapy Practice

The results of this study provide several relevant contributions to the field of occupational therapy:

- Robot-assisted therapy, coupled with a well-designed HEP, and HEP alone improve QOL and depression measures in people <6 mo after stroke.
- An 8-wk program was sufficient time to observe changes in the QOL and depression measures for this client population.
- Use of a robot-assisted device in the home provided an objective way for therapists to remotely monitor people after stroke through an electronic database system and a weekly phone conversation.
- For people after stroke with limited access to traditional therapy, home-based interventions may be a valuable intervention for continued nonmotor recovery.

Disclosure

Steven L. Wolf is Chairman of the Scientific Advisory Board and was previously a paid consultant for Kinetic Muscles, Inc. R. Curtis Bay was a paid consultant for Kinetic Muscles, Inc., for this study. ▲

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