

ARTICLES

Mental Imagery for Promoting Relearning for People After Stroke: A Randomized Controlled Trial

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ABSTRACT. Liu K, Chan C, Lee TM, Hui-Chan CW. Mental imagery for promoting relearning for people after stroke: a randomized controlled trial. *Arch Phys Med Rehabil* 2004;85:1403-8.

Objective: To study the efficacy of mental imagery at promoting relearning for people after a stroke.

Design: Prospective, randomized controlled trial.

Setting: An inpatient rehabilitation stroke unit in Hong Kong.

Participants: Forty-six inpatients, 60 years of age or older, after a cerebral infarction.

Interventions: Patients were randomized to receive 15 sessions (1h/d for 3wk) of either the mental imagery program or the conventional functional training intervention on the relearning of daily living tasks.

Main Outcome Measures: Performance of 15 trained and 5 untrained tasks, including household, cooking, and shopping tasks; and the Fugl-Meyer Assessment and Color Trails Test (CTT).

Results: Patients engaged in mental imagery-based intervention showed better relearning of both trained and untrained tasks compared with the control group (trained tasks: $P < .005$; untrained tasks: $P < .001$). They also demonstrated a greater ability to retain the trained tasks after 1 month and transfer the skills relearned to other untrained tasks ($P < .001$). However, among the various ability measures, the mental imagery group showed a significant increase in the CTT scores only after the intervention ($P < .005$).

Conclusions: Mental imagery can be used as a training strategy to promote the relearning of daily tasks for people after an acute stroke. The imagery process is likely to improve the planning and execution of both the trained and the untrained (novel) tasks. The effect of its relearning appears to help patients to retain and generalize the skills and tasks learned in the rehabilitation program.

Key Words: Imagery (psychotherapy); Mental disorders; Randomized controlled trials; Rehabilitation; Stroke.

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AN INTENSIVE STROKE rehabilitation program is beneficial in improving activities of daily living in patients with stroke.¹ Different approaches are used in this field of rehabilitation. One of them takes the form of neurologic facilitation interventions, which are designed to bring about changes in the underlying neural structures affected by stroke, such as neurodevelopmental treatment,² motor relearning approach,³ and, more recently, constraint-induced movement therapy.⁴ Another category is the compensatory approach, which aims at substituting the deficits with preserved functions and involves the use of compensatory strategies, such as the 1-handed technique and adaptive aids.^{5,6} These approaches are common in that they involve different extents of relearning of the lost functions. The relearning of functions can be enhanced in different ways, such as by increasing the number of repetitions, by providing a nondistractive environment, and by the gradation of task difficulty and empowerment. Recent studies^{5,7} have revealed that mental imagery also has positive effects on patients' relearning of lost functions and performance.

Mental imagery is a process in which a function, a behavior, or a performance is rehearsed mentally, as if the person is actually performing it.⁷ It is believed to enhance relearning by involving the patient in actively gathering perceptual information from memory and undergoing the experience of "seeing the performance of the behavior with the mind's eye."⁸ This process demands perception and executive function, which, in the case of motor imagery, is mediated by the activation of the parietal, frontal, and prefrontal regions.⁸⁻¹⁰ Functional imaging studies reveal a partial overlapping of brain activations between imagining and actually performing a task; for example, the contralateral superior parietal lobe is activated when imagining body parts,¹¹ and the premotor cortex and the putamen are activated when imagining finger movements.¹⁰

The mental imagery technique is practiced by athletes to enhance their performance through mentally practicing the body movements required for particular bodily actions when field practice is not feasible.^{12,13} Mental imagery has also been applied to stroke rehabilitation, to promote upper-extremity motor function and to improve the condition of neglect.¹⁴⁻¹⁸ However, the use of the mental imagery technique in the relearning of daily task performance has not been widely explored. This article reports a randomized controlled trial that compares the effect of a 3-week, standardized, mental imagery program with that of a conventional, functional rehabilitation training program on promoting relearning after stroke. We hypothesized that mental imagery is better able to improve task performance for people with stroke than is functional retraining.

METHODS

Patients meeting the following criteria were recruited to participate in the study: (1) diagnosed as having had a first unilateral cerebral infarction as confirmed by a computed tomography scan, (2) age 60 years or older, (3) independent in performing daily activities before admission, (4) able to communicate effectively, as screened by the Cognistat,¹⁹ and (5) having given their voluntary consent. Ethics approval was

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Supported by The Hong Kong Polytechnic University.

No party having a direct interest in the results of the research supporting this article has or will confer a benefit on the author(s) or on any organization with which the author(s) is/are associated.

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0003-9993/04/8509-8691\$30.00/0

doi:10.1016/j.apmr.2003.12.035

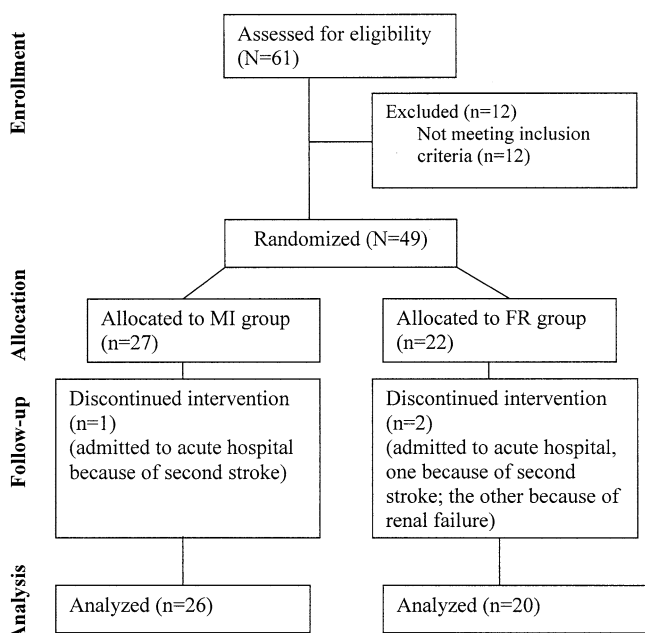


Fig 1. Flow of patient participation through each stage of the study. Abbreviations: FR, functional retraining; MI, mental imagery.

obtained from the hospital and the Hong Kong Polytechnic University before commencing the study.

Written informed consent was obtained from each patient before being screened for study participation. Each patient was then randomly assigned by means of drawing lots to either the mental imagery group or the functional retraining group (fig 1). The randomization process was carried out by a therapist who was not involved in any part of the study. All clinical assessments were conducted by 2 occupational therapists who were blind to the study. Both of them received training in the administration of all the clinical instruments used in the study.

In both groups, patients received training for a total of 3 weeks with five 1-hour sessions each week. Two occupational therapists provided the training in the mental imagery program, and 2 other occupational therapists provided training in the functional retraining program. The therapists attended a 2-hour briefing session on the clinical program for which they were responsible. The session covered the theoretical background and a demonstration of the standardized techniques used in either the mental imagery or the functional retraining program. Both programs were held in the activity room and the modeled daily living room, located in the occupational therapy department of the hospital. During these 3 weeks, patients in both groups were trained to perform 3 sets of daily tasks. There were 5 tasks in each set, the demands of which overlapped, including, for example, mobility functioning, balance, or upper-limb coordination. The difficulty level of each set of tasks was organized in ascending order (appendix 1). The validity of the task demand and the difficulty has been reported elsewhere.^{20,21} The training for the easiest task set (eg, folding laundry) was covered in the first week; the training for the most difficult set (eg, shopping, taking transportation) was covered in the third week. Patients in both groups also received 1-hour physiotherapy (PT) sessions for training in walking and general muscle strengthening 5 days a week during the study. Patients received PT at a different time of the day than the 2 programs to

minimize the fatigue of the patients for attending 2 consecutive treatment sessions without a break.

In the mental imagery program, patients were trained in the technique of mental imagery to practice specific tasks. Different but related mental imagery skills and the actual performance of tasks were practiced each week to help patients develop competence in using imagery as a learning tool. In the first week, the focus was on analyzing task sequences to facilitate the motor planning and problem identification process using computer-generated pictures and movies. In the second week, patients identified their own problems for rectification through the use of mental imagery. Picture cards depicting the task sequences were used if the patients needed help recalling the steps. In the third week, the focus was on practicing the rectified task performance using mental imagery and actual practice. The detailed steps are listed in table 1. To further standardize the protocol, a computer program was developed to guide patients to relearn the steps involved in performing each of the 15 tasks. Each step was presented as a picture, with verbal explanations of the physical and mental demands of that particular step (to enhance task analysis). Visual aids were also used to help patients reflect on the problems that they encountered when they actually performed the tasks. They watched the video playback to confirm the problems that they identified (to enhance problem identification). Patients were guided to develop strategies to overcome the problems. The tasks, with or without modifications, were mentally rehearsed before patients practiced them. Mental rehearsal and actual practice were intertwined throughout the relearning process.

In the functional retraining program, the demonstration-then-practice method was adopted. Patients were required to practice the same tasks following a sequence and training schedule similar to that of the mental imagery program. Unlike the mental imagery program, however, the problems encountered by patients were rectified with the help of therapists. Common problems were mainly associated with sensorimotor and cognitive functions, such as decreased motor control over

Table 1: Experimental Protocol for Use of Mental Imagery

| | |
|---------------------------|--|
| Task analysis enhancement | 1. Show patient the beginning and ending steps |
| | 2. Get patient to identify the steps in the task through mentally imagining the task |
| | 3. Present patient with randomly sequenced picture cards |
| | 4. Get patient to rearrange the picture cards into the correct sequence |
| Problem identification | 5. Get patient to visualize his/her own performance with the help of the picture cards, which are in the correct sequence |
| | 6. Get patient to identify the problems encountered and solutions in each step by going through the mental process |
| Task performance | 7. Get patient to imagine his/her own task performance with the rectified steps |
| | 8. Get patient to actually perform the task and videotape the performance |
| | 9. Get patient to evaluate the performance on the videotape to adjust the problems and solutions Repeat steps 6–9 until patient learns the tasks with the proper method |

the limbs and difficulty planning before performing a task. The therapists considered the limitations of patients and designed an adapted task performance. Each step involved in the adapted performance was demonstrated to the patients. The demonstration was repeated until patients gained confidence to practice them. Patients then practiced the tasks under the supervision of therapists. Further task modification and demonstration was provided throughout the program to maximize the functional patients' regain.²²

Different outcome measures were administered to the patients to capture the changes across the 3-week program. Patients' level of competence in performing the trained tasks (15 in total) before and after the training would reflect the extent to which the tasks were relearned. The 5 most difficult tasks trained in the third week were readministered to patients at the 1-month follow-up. The performance on these tasks would evaluate the carrying-over effect of the relearned skills. Five new tasks that were not trained in the 3-week program and had a similar difficulty level to those in the last task set were administered to patients at the end of the third week (appendix 1). The performance on these new tasks would indicate patients' ability to transfer the skills learned in the training program. Patients' performance on the tasks was assessed using a 7-point Likert scale (1, complete dependence; 7, complete independence) (appendix 1). The interrater reliability of the task performance testing ranged from .89 to .98. In addition, the Color Trails Test^{23,24} (CTT) and 3 subtests of the Fugl-Meyer Assessment²⁵ (FMA)—upper-extremity motor function, lower-extremity motor function, and sensation—were completed before the commencement and after the completion of the intervention. The CTT is an orthographic neuropsychologic test used to measure sustained visual attention and visual scanning of people aged 18 years or above.

Data analysis was conducted using SPSS, version 11.0,^a for Windows. Repeated-measure analysis of variance (ANOVA) tests were used to evaluate the task relearning of both groups. Analysis of covariance (ANCOVA) tests with after-training task competence as the covariate were used to detect the carrying-over effect of learned task competence and the transferring to untrained tasks for the 2 groups. The changes in the 6 ability measures of the 2 groups were tested using the repeated-measure multivariate analysis of variance (MANOVA).

RESULTS

A total of 49 patients participated in the clinical trial. Three patients dropped out during the first week of the program: 1 from the mental imagery group and the other 2 from the functional retraining group. They were all readmitted to an acute hospital: 2 because of a second stroke and 1 because of renal failure. All 3 patients had shown good compliance at the time they dropped out. Of the 46 patients who completed the clinical trial, 24 were women and 22 were men. Their FIM instrument mean motor and cognitive subscale scores ± standard deviation (SD) were 42.07±14.77 and 30.41±2.53, respectively. All 46 were diagnosed with cerebral infarction in the middle cerebral artery region, with 1-sided hemiplegia. Age, gender, duration of stroke onset, and FIM motor and cognitive subscales were comparable between the mental imagery (n=26) and the functional retraining groups (n=20) (table 2).

No significant differences were revealed in the baseline measures of performance in the first task set (mental imagery, 5.1±1.1; functional retraining, 5.4±0.8), the CTT (mental imagery, 307.1±146.7; functional retraining, 384.8±156.1), and the FMA (upper-extremity motor function: mental imag-

Table 2: Demographic and Clinical Characteristics of Patients

| | MI Group | FR Group | Between-Group Difference P Values |
|------------------------------|-----------|-----------|-----------------------------------|
| Patients (n) | 26 | 20 | |
| Gender (male/female) | 11/15 | 11/9 | .39 |
| Age (y) | 71.0±6.0 | 72.7±9.4 | .50 |
| Duration of stroke onset (d) | 12.3±5.3 | 15.4±12.2 | .25 |
| FIM motor subscale score | 42.6±16.4 | 41.4±12.7 | .79 |
| FIM cognitive subscale score | 30.5±3.0 | 30.3±1.9 | .71 |

NOTE. Values are mean ± SD unless otherwise indicated. Abbreviations: FR, functional retraining; MI, mental imagery.

ery, 22.5±18.2; functional retraining, 25.2±13.0; lower-extremity motor function: mental imagery, 17.7±8.6; functional retraining, 18.9±7.6; sensation: mental imagery, 23.5±1.7; functional retraining, 23.6±1.0).

The results of the repeated-measure ANOVAs showed that the mental imagery group reached a significantly higher level of performance on the trained tasks than the functional retraining group after completing both weeks 2 and 3 of the training (table 3, fig 2). Patients in the mental imagery group also reached a significantly higher level of performance on the untrained tasks tested at the end of the training program (mental imagery, 5.1±1.3; functional retraining, 3.8±0.9; *P*<.001) (table 4, fig 2). The results of the ANCOVAs also suggested that the mental imagery group reached a significantly higher level of performance on the trained tasks at the 1-month follow-up (mental imagery, 5.8±1.2; functional retraining, 3.9±0.9; *P*<.001). For the cognitive and sensorimotor abilities, the repeated-measure MANOVAs showed no significant differences in CTT and FMA subscale scores between the 2 groups (*F*_{4,22}=1.36, *P*=.28). However, univariate test results indicated that the mental imagery group showed significantly greater improvement in CTT subscale scores across time than the functional retraining group (table 5).

DISCUSSION

The results of this study revealed that patients who were trained in the mental imagery technique appeared to reach a higher level of performance than the control group on both the trained and untrained tasks. The higher level of performance on the trained tasks would suggest that mental imagery, when compared with the demonstration-then-practice method, is a more effective strategy for enhancing and retaining relearning among patients who participated in the study. However, the higher level of performance on the untrained tasks would indicate that mental imagery probably promotes the generalization of the skills learned by these patients. Despite the fact that 3 patients dropped out of the trial, analysis of their profiles suggests that potential bias would be minimal because their baseline characteristics and performance levels were similar to those who remained in the study.

Studies have shown that mental imagery is beneficial for the relearning of motor function^{14,16} and unilateral spatial neglect¹⁵ for patients after stroke. The results of our study provide further evidence of the usefulness of mental imagery in promoting the relearning of daily functioning that demands the integration of sensory and motor functioning and cognitive abilities. Further analysis of other ability measures administered to patients in this study reveals that the relearning may be attributed to the improved attention and sequencing-processing

Table 3: Results of Patients' Relearning of the Trained Tasks and Between-Group Differences

| | MI Group | | FR Group | | Between-Group Difference P Values |
|------------------------------|-----------------|----------------|-----------------|----------------|--------------------------------------|
| | Before Training | After Training | Before Training | After Training | |
| Task performance (week 1) | 5.1±1.1 | 6.5±0.8 | 5.4±0.8 | 5.8±0.5 | NS |
| Carry out money transactions | 5.3±1.3 | 6.4±1.0 | 5.3±1.1 | 5.6±0.9 | |
| Wash the dishes | 5.2±1.3 | 6.5±1.0 | 5.3±0.9 | 5.7±0.9 | |
| Prepare tea | 5.5±0.9 | 6.9±0.5 | 5.5±1.1 | 6.1±0.6 | |
| Fold the laundry | 4.8±1.5 | 6.2±0.4 | 5.6±1.0 | 5.7±1.3 | |
| Hang out the laundry | 4.7±1.6 | 6.3±1.3 | 5.5±1.0 | 5.8±0.9 | |
| Task performance (week 2) | 4.4±0.7 | 6.2±0.7 | 4.7±0.7 | 5.0±0.6 | .011* |
| See the doctor | 3.6±0.9 | 5.6±0.9 | 3.4±0.8 | 3.7±0.7 | |
| Use the telephone | 4.9±1.4 | 6.3±1.3 | 5.5±1.1 | 5.9±1.0 | |
| Take medication | 5.2±1.1 | 6.9±0.5 | 5.9±1.0 | 6.4±0.9 | |
| Make the bed | 4.0±0.9 | 6.1±0.9 | 4.1±0.9 | 4.4±0.9 | |
| Prepare fruit | 4.2±1.0 | 6.4±0.9 | 4.6±1.2 | 4.7±1.2 | |
| Task performance (week 3) | 3.8±1.2 | 5.3±1.0 | 3.9±1.1 | 4.0±0.9 | .046* |
| Go to a cafeteria | 3.8±1.3 | 5.4±1.1 | 3.7±1.2 | 3.8±0.7 | |
| Go to a park/outdoors | 3.4±1.4 | 5.2±1.1 | 3.5±1.2 | 3.6±0.9 | |
| Fry vegetables with meat | 3.8±1.3 | 5.3±1.0 | 4.1±1.4 | 4.2±1.1 | |
| Tidy the table after a meal | 4.8±1.5 | 5.5±1.0 | 4.7±0.9 | 4.5±1.0 | |
| Sweep the floor | 3.3±1.6 | 5.3±1.1 | 3.7±1.5 | 4.0±1.3 | |

NOTE. Values are mean ± SD. Task performance scores obtained for each week are the average of the scores on the 5 task items trained during that week.

Abbreviations: NS, not significant.

*P≤.05.

abilities of patients who underwent mental imagery training, which is indicated by their improved CTT subscale scores. Improved attention is associated with improved planning and execution of task performance. Improved sequential processing is associated with the generation of images depicting each step of the daily tasks.⁵ Such behavioral observation is also confirmed by the results of other studies that used radiologic imaging techniques. Parson et al²⁶ used positron emission tomography scans to demonstrate the activation of the prefrontal, parietal, and cerebellar regions of the brain during mental imagery tasks. Functionally, these activations refer to enhanced attention and working memory and a higher level of processing ability. All are essential for the execution of task performance

during the recall of task performance over time and for the relearning of untrained tasks.

In our study, the patients in the mental imagery group did not show a significant improvement in their motor abilities. Our findings do not seem to concur with those of previous studies, which demonstrated that mental imagery, particularly involving the motor function, produced actual brain activations over the supplementary motor area, the anterior cingulate cortex, the bilateral premotor cortex, the bilateral superior and inferior parietal cortexes, the posterior cerebellar cortex, and the primary motor cortex (the motor components of the brain).²⁷ This phenomenon is likely related to the design of the mental imagery protocol used in the study. In our training, patients relearned the steps of task performance by actively engaging in self-regulation and imagery processes. This demanded substantial attention and sequential processing abilities. Because of these processes, we postulate that mental imagery can improve the planning and execution of task performance but not necessarily sensorimotor abilities.⁵ These observations are supported

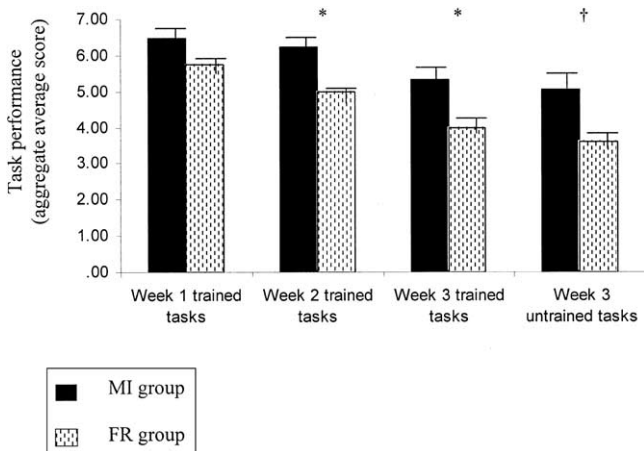


Fig 2. Bar graph showing the task performance of patients after training. NOTE. Task performance score is the average of the performance scores on the 5 task items. *P≤.05; †P≤.001.

Table 4: Results of Performance on the Untrained Tasks Assessed at the End of Week 3

| Level 3b Tasks | MI Group | FR Group | Between-Group Difference P Value |
|-----------------------------|----------|----------|-------------------------------------|
| Untrained task performance | 5.1±1.3 | 3.8±0.9 | <.001* |
| Take transportation | 5.0±1.3 | 3.5±1.0 | |
| Go shopping | 5.2±1.3 | 3.7±1.0 | |
| Cook rice with steamed fish | 5.4±1.1 | 4.5±0.9 | |
| Clean the bathroom | 4.6±1.4 | 3.6±1.3 | |
| Change the bed | 5.0±1.4 | 4.0±1.2 | |

NOTE. Values are mean ± SD. Task performance score is the average of the performance scores on the 5 task items.

*P≤.001.

in studies on motor performance and mental imagery by Parsons et al²⁶ and Yaguez et al.²⁸

Mental imagery appears to be a useful training technique for people with brain injury. Its value is not just that it increases a patient's ability to relearn. Our experience suggests that, for patients who find the actual practice of tasks too demanding, such as those with poor mobility functioning and a low energy level, mentally rehearsing the performance can serve as a supplement to performing the task during the training. This would further increase the effectiveness of the training program and, more important, the generalization of the learned skills, which is essential for adapting to community living after a stroke.

Our study is limited by its comparatively small sample size, short follow-up period, and lack of control of patients' brain lesion sites. The content and difficulty level of the tasks used in the training and assessment, although carefully validated in earlier studies, might confound the results because of differences in personal experience and preference across individual patients. The extent to which patients actively engaged in the imagery processes was not controlled in this study. If patients exerted different degrees of effort, this would increase the between-subject variability of the treatment outcomes, which might lower the significance of the treatment effect. Future studies should explore how impaired cognitive abilities, such as attention and memory, impede patients' ability to engage in mental imagery. The neural mechanisms underlying mental imagery and relearning of patients with particular brain lesions such as parietal or frontal should also be investigated.

CONCLUSIONS

Studies on the application of the mental imagery technique to the rehabilitation of patients who have had a stroke have focused on improving isolated abilities or functions, such as upper-limb motor abilities. Our study has demonstrated the positive effects of using the technique to improve patients' relearning of and performance on more complicated daily tasks. This offers further evidence on the role of active cortical control, which can be mediated by mental imagery to enhance the relearning potential of patients with stroke.⁸

Table 5: Univariate Tests of the Between-Group and Within-Group Effects on the Abilities of Patients in the 2 Groups

| Subscale Items | F ₁ | P Value |
|---|----------------|---------|
| Between-group effects | | |
| CTT 2 | 5.39 | .03* |
| FMA upper-extremity motor function | 0.35 | .56 |
| FMA lower-extremity motor function | 0.13 | .73 |
| FMA sensation | 0.02 | .89 |
| Within-group effects | | |
| CTT 2 | 8.27 | .00* |
| FMA upper-extremity motor function | 0.05 | .83 |
| FMA lower-extremity motor function | 14.94 | .00* |
| FMA sensation | 2.13 | .16 |
| Interaction effects | | |
| CTT 2 × groups | 0.50 | .48 |
| FMA upper-extremity motor function × groups | 1.84 | .19 |
| FMA lower-extremity motor function × groups | 0.22 | .64 |
| FMA sensation × groups | 0.54 | .68 |

*P ≤ .05.

APPENDIX 1: DAILY TASKS USED FOR TRAINING AND ASSESSMENT AND THE EVALUATION CRITERIA

| | Daily Tasks for Training and Assessment | Daily Tasks for Assessment of Generalization |
|--------|--|---|
| Week 1 | Put clothes on hanger Fold the laundry Prepare a cup of tea Wash the dishes Carry out money transaction | |
| Week 2 | Prepare fruit Make the bed Take medication Use the telephone See the doctor | |
| Week 3 | Sweep the floor Tidy the table after a meal Fry vegetables with meat Go to a park/outdoors Go to the canteen | Change the bed Clean the bathroom Cook rice with steamed fish Go shopping Take transportation |
| Score | Descriptors | |
| 7 | Complete independence (The patient is able to perform the task in a timely and safe manner.) | |
| 6 | Modified independence (The patient is able to perform the task independently with the use of a device.) | |
| 5 | Supervision (The patient is able to perform the task under a person's supervision.) | |
| 4 | Minimal assistance (The patient is able to perform 75% or more of the task.) | |
| 3 | Moderate assistance (The patient is able to perform 50% to 74% of the task.) | |
| 2 | Maximal assistance (The patient is able to perform 25% to 49% of the task.) | |
| 1 | Total assistance (The patient is unable to perform 25% or more of the task.) | |

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