

# Effects of Problem-Oriented Willed-Movement Therapy on Motor Abilities for People With Poststroke Cognitive Deficits

**Background and Purpose.** Cognitive deficits after stroke are common and interfere with recovery. One purpose of this study was to determine whether the motor abilities of subjects who have poststroke cognitive deficits and who have received problem-oriented willed-movement (POWM) therapy will improve more than the motor abilities of subjects in the reference group who have received neurodevelopmental treatment (NDT). Another purpose of this study was to identify the relationship between cognitive function and motor abilities for both groups. **Subjects.** The subjects recruited for this study were 36 men and 11 women with various degrees of poststroke cognitive deficits. **Methods.** A randomized block design was used to assign the subjects to 2 groups. Cognitive function and motor ability were evaluated with the Mini-Mental State Examination and the Stroke Rehabilitation Assessment of Movement (STREAM). Both groups received physical therapy 5 or 6 times per week in 50-minute sessions. **Results.** The STREAM scores improved after treatment in both groups. Main group effects were found for the lower-extremity ( $F=4.58$ ,  $P<.05$ ) and basic mobility ( $F=27.49$ ,  $P<.01$ ) subscales of the STREAM. Pretest cognitive function showed a positive relationship with posttest motor ability in the NDT group ( $r=.446$ ,  $P<.05$ ). However, the relationship between pretest cognitive function and posttest motor ability had no statistical significance in the POWM group ( $r=.101$ ,  $P=.630$ ). **Discussion and Conclusion.** These findings suggest that, regardless of a person's cognitive function, POWM intervention is effective in improving lower-extremity and basic mobilities and indicates the need to use relatively intact cognitive function or perceptual function, or both, to improve motor rehabilitation for people with cognitive function deficits. [Tang QP, Yang QD, Wu YH, et al. Effects of problem-oriented willed-movement therapy on motor abilities for people with poststroke cognitive deficits. *Phys Ther.* 2005;85:1020–1033.]

**Key Words:** *Cognitive function, Motor abilities, Perceptual function, Physical therapy, Problem-oriented willed movement, Stroke.*

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Cognitive impairment is one of the most common deficits in people after ischemic or hemorrhagic stroke. The rates of incidence of poststroke cognitive deficits have been reported to be 20% to 37.1%.<sup>1-4</sup> Some researchers<sup>5-7</sup> have suggested that cognitive disturbance is one of the most important factors that might affect functional outcome after stroke. Many people with poststroke cognitive deficits have an urgent need for treatment. However, active participation of these people in physical therapy is decreasing or almost lacking. Therefore, treatment for these people focuses on how best to help them maximize their active movement or participation.

Over the years, many treatment approaches have been developed; among these, neurodevelopmental treatment (NDT) is the most common.<sup>8,9</sup> This treatment is based on the view that, when the brain is damaged, abnormal patterns of posture and movement develop and are incompatible with the performance of normal everyday activities. The neurophysiology- and development-based approaches for the treatment of stroke are the Rood approach, the Bobath neurodevelopmental approach, and the proprioceptive neuromuscular facilitation approach. Neurodevelopmental treatment emphasizes the 3 basic components related to neuromotor control: postural tone, reflexes and reac-

tions, and movement patterns. Therapeutic goals consist of inhibition of primitive reflexes, facilitation of postural reactions, and normalization of muscle tone (rigidity and reflex activity) through a complex process of inhibition and facilitation in a neurodevelopmental sequence. Treatment strategies in this approach include the use of reflex-inhibiting patterns, the elicitation of righting and equilibrium reactions, the use of sensory stimulation, and the use of diagonal patterns. The approach focuses on eliciting and establishing normal patterns of movement through controlled sensorimotor experiences.<sup>10</sup> However, many authors<sup>11-14</sup> have argued whether facilitating normal patterns of movement improves voluntary movement.

In most physical therapy procedures, the emphasis is almost always on the motor system, and perceptual and cognitive aspects are ignored or treated separately.<sup>15,16</sup> Therefore, there is currently an urgent need for integrated therapeutic procedures aimed at the restoration of motor abilities for people with cognitive impairments. In Mulder's human motor behavior model, cognitive, perceptual, and motor mechanisms are viewed not as independent elements but as inseparable parts of this functional system.<sup>17</sup>

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Evidence has been emerging in support of a pragmatic, functional, or task-oriented approach to neurologic rehabilitation.<sup>18–22</sup> A task-oriented approach to stroke and other dysfunctions of the central nervous system is based on models of motor learning principles of spaced practice and intermittent feedback to facilitate real-world activities. This approach emphasizes repetitive practice of tasks by use of available proximal and distal functions. The motor movement related to tasks is behaviorally motivated, and the interaction of the individual with the environment is emphasized. Tasks that are relevant to an individual's daily life are done in random order to optimize learning.<sup>20,23,24</sup> According to a review of the literature, this approach has not been aimed at the restoration of motor abilities for people with cognitive impairments. In addition, the task-oriented approach emphasizes mainly the motor system, and perceptual and cognitive functions are ignored or are not treated as part of a whole functional system. The aim of the problem-oriented willed-movement (POWM) approach is to guide people in accomplishing tasks on the basis of their identified cognitive and movement problems. In distinguishing the main focus of the task-oriented approach from that of the POWM approach, 2 basic principles can be recognized: focusing on the movement task and focusing on movement function, cognitive problems, and perceptual function. It is worthwhile to compare these 2 types of intervention.

One recent study<sup>25</sup> emphasized ability-focused physical therapy for subjects with severely limited physical and cognitive abilities; the results showed that the subjects demonstrated improvement in gross motor abilities that they practiced during therapy. Another study<sup>26</sup> examined whether underlying cognitive deficits influence the ability of subjects who have had strokes to relearn dressing. The authors<sup>26</sup> found that some subjects with cognitive impairments were able to adapt or learn some compensatory strategies to dress. The findings of these 2 studies suggest that people with cognitive deficits do have the ability to learn compensatory strategies for accomplishing some motor acts.

Because the 2 studies on subjects with cognitive impairments<sup>25,26</sup> did not focus on cognitive function and because the particular compensatory strategies used in motor performance by the subjects were not well addressed, we propose POWM therapy for people with poststroke cognitive impairments. Problem-oriented willed-movement therapy can be viewed as a cognitive problem-oriented treatment approach. Because the cognitive problems are recorded, individualized treatment is planned on the basis of the cognitive and perceptual functions of the patient, and unaffected or partly preserved sensory and cognitive functions are stimulated to facilitate movement. However, POWM therapy also can

be viewed as a task-oriented approach that emphasizes the performance of motor tasks. Some tasks might be similar to those of the task-oriented approach. However, in the task-oriented approach, tasks are not designed on the basis of the competencies and constraints of a person's cognitive and perceptual functions. In addition, intact or relatively preserved sensory and cognitive functions are not adequately stimulated in the task-oriented approach.<sup>27–29</sup>

Tepperman and associates<sup>30</sup> pointed out that the problem-oriented approach would permit the design of the most appropriate management program, aimed at minimizing disability, maximizing function, and returning people who have had strokes to a gratifying existence despite residual impairment and disability. However, little research information is available to verify the effect of this approach. Although evidence supports the task-oriented approach to neurologic rehabilitation, a specific task-oriented approach for people with cognitive deficits is not available. According to Waterland,<sup>31</sup> *willed movement* is defined as movement to which an individual pays attention and makes an effort to accomplish and that satisfies a goal. The 2 aspects of POWM therapy, as defined in the present study, are that an individual makes an effort to accomplish motor tasks and that the therapist directs the individual to accomplish the tasks by using intact or relatively preserved sensory and cognitive functions.

One purpose of this study was to determine whether the motor abilities of subjects who have poststroke cognitive deficits and who have received POWM therapy will improve more than the motor abilities of subjects in a reference group who have received NDT. Another purpose was to identify the relationship between cognitive function and motor abilities for both groups. One hypothesis was that, after 8 weeks of physical therapy, the motor abilities of the subjects in the POWM therapy group would improve more than those of the subjects in the reference group. Another hypothesis was that cognitive function would be positively related to motor abilities for both groups.

## Method

### Subjects

The accessible population of this study included people hospitalized with stroke in Xiangya Hospital, Central South University, Changsha, Hunan, China, from April 2001 to April 2003. In total, 394 people who had strokes and who were recommended by a neurologist to receive physical therapy were screened, and only 48 people met the criteria for inclusion in the study. One subject in the NDT group withdrew during the first 2 weeks of treatment because his wife said that his motor ability had not

**Table 1.**  
Subject Characteristics<sup>a</sup>

Characteristic	No. of Subjects		
	Total (N=47)	NDT Group (n=22)	POWM Group (n=25)
Age (y)			
$\bar{X}$	55.91	54.86	56.84
SD	12.1	13.40	11.03
Range	29–78	31–72	29–78
Sex			
Male	36	18	18
Female	11	4	7
Education (y)			
$\bar{X}$	10.3	10.41	10.2
SD	3.63	3.54	3.78
Range	2–18	5–18	2–15
Days poststroke			
$\bar{X}$	65	55.27	73.56
SD	104.82	66.67	130.41
Range	6–608	8–243	6–608
90	36	17	19
>90	11	5	6

<sup>a</sup>NDT=neurodevelopmental treatment, POWM=problem-oriented willed-movement therapy.

improved after physical therapy. Eligibility criteria for the subjects were as follows: having the first stroke confirmed by computed tomography or magnetic resonance imaging; not being treated at a rehabilitation center; not having global aphasia and severe apraxia, because the severity of these deficits precludes reliable administration of the Mini-Mental State Examination (MMSE)<sup>32</sup>; not being delirious (a state that would affect a subject's ability to participate in MMSE screening); having stable vital signs and neurologic problems, as determined by a physician; being alert; and having cognitive function impairments. The study sample was composed of 36 men and 11 women who were 29 to 78 years of age ( $\bar{X}$ =55.91, SD=12.1). The time from stroke onset was 6 to 608 days (Tab. 1). Almost all of the subjects had 2 or more locations for the stroke, except for 2 subjects with bilateral brain-stem lesions. Nearly half of the subjects had left-sided stroke, and the remaining subjects had bilateral stroke or right-sided stroke. The majority of the subjects had lesions in the temporal lobe, internal capsule, or basal nucleus. Nearly half of the subjects had lesions in other locations, including the frontal lobe and parietal lobe, and a few subjects had lesions in the brain stem, thalamus, and cerebellum (Tab. 2).

#### Instrumentation

Three measures were used for data collection: the MMSE,<sup>33</sup> the Stroke Rehabilitation Assessment of Movement (STREAM),<sup>34</sup> and the Demographic Recording Form. Both the MMSE and the STREAM were translated

**Table 2.**  
Locations of Brain Lesions<sup>a</sup>

Location	No. (%) of Subjects	
	NDT Group	POWM Group
Side of brain lesion		
Left	9 (40.9)	12 (48)
Right	5 (22.7)	7 (28)
Bilateral	8 (36.4)	6 (24)
Specific location of brain lesion		
Temporal lobe	17 (77.3)	19 (76)
Internal capsule	16 (72.7)	19 (76)
Basal nucleus	16 (72.7)	18 (72)
Frontal lobe	12 (54.5)	10 (40)
Parietal lobe	9 (40.9)	11 (44)
Brain stem	3 (13.6)	2 (8)
Thalamus	3 (13.6)	2 (8)
Cerebellum	0 (0)	2 (8)

<sup>a</sup>NDT=neurodevelopmental treatment, POWM=problem-oriented willed-movement therapy.

into Chinese by the primary researcher (QPT). Before the instruments were used to evaluate the subjects, the accuracy and clarity of the translations were assessed with a back-translation technique by 2 Chinese medical experts who were familiar with both Chinese and English.

**MMSE.** The cognitive functions of subjects in the NDT and POWM groups were evaluated initially by a physician and after 8 weeks of physical therapy with the MMSE. The instrument includes 19 items to rapidly screen 6 cognitive components: orientation, registration, attention, memory, language, and praxis. The total score ranges from 0 to 30. The cognitive function impairment criterion differed according to the different educational backgrounds of the subjects. Subjects were considered to have cognitive deficits when their MMSE scores were less than 17 for subjects with illiteracy, less than 20 for subjects with a junior school education, and less than 24 for subjects with a high school education or above. The intrarater and interrater reliability (type not reported) were .99 for total scores and .96 to .99 for subscale scores. The validity and reliability of MMSE scores were assessed by Folstein and associates.<sup>33</sup> The instrument yielded valid and reliable data, with correlation coefficients for test-retest reliability (type not reported) ranging from .89 to .98. The reported ranges of reliability values are similar across various studies for subjects with Alzheimer-type and vascular dementias.<sup>35,36</sup> Before the instrument was used in the present study, the reliability of the data was tested among 15 subjects who had had strokes, who had met the inclusion criteria, and who had been hospitalized in Xiangya Hospital, Central South University. All 15 subjects were tested by the same physician from the Department of Neurology, Xiangya

Hospital, Central South University, in the morning over several days, because we believed that different times of day would affect MMSE scores. The Cronbach alpha value was calculated to be .90.

**STREAM.** The motor functions of the subjects in both groups were assessed initially by a physician and after 8 weeks of intervention with the STREAM. The STREAM consists of 30 items that are equally distributed among 3 subscales for test movements: upper-limb movement, lower-limb movement, and basic mobility items. The instrument measures movement activities in supine, sitting, and standing positions and walking activities. The score for the limb movement items ranges from 0 to 3 points. The score for the basic mobility items ranges from 0 to 4 points, similar to the score for the limb movement items, except for the addition of a category to allow for independence with the help of mobility aids. Each subscale then is transformed to a score of 100 to correct items not scored (because of pain, limited range of motion, and so forth); therefore, equal weight is given to each of the subscales. The STREAM total score is obtained by summing the transformed subscale scores and then dividing the sum by 3. The possible total score ranges from 0 to 100 points, with each transformed subscale score ranging from 0 to 100 points. The content validity of data for the STREAM has been established.<sup>37</sup> Criterion-related validity has been assessed. The results indicated that scores on the STREAM were associated with scores on the Box and Block Test, the Berg Balance Scale, the Barthel Index, gait speed, and the Timed "Up & Go" Test (with Pearson correlation coefficients ranging from .57 to .80) and that categories of the STREAM were associated with categories of the Berg Balance Scale and the Barthel Index.<sup>38</sup>

Another study<sup>39</sup> also has assessed criterion-related validity. The Spearman rho values for the STREAM and a modified Rivermead Mobility Index and for the STREAM and the Rivermead Mobility Index were .92 and .78, respectively, indicating high concurrent validity of the STREAM scores. The psychometric characteristics of the STREAM were found to be slightly superior to those of the modified Rivermead Mobility Index and the Rivermead Mobility Index for subjects with strokes.<sup>39</sup> The STREAM has been shown to have excellent internal consistency, with a Cronbach alpha value of greater than .98 for subscales and overall. The intrarater and interrater reliability were demonstrated by generalizability correlation coefficients of .99 for total scores and .96 to .99 for subscale scores.<sup>34</sup> In the present study, the internal consistency was tested among 15 subjects who had had strokes and who had met the criteria. Cronbach alpha values were calculated to be .95, .93, .86, and .83 for the total and upper-extremity, lower-extremity, and basic mobility scores, respectively.

### *Data Collection*

Before the study was conducted, we determined that each subject was able to follow instructions, and each subject provided informed consent by signing an approved consent form. If the subjects met the study criteria, then the cognitive function of the subjects was evaluated, and subjects with cognitive deficits were recruited for this study. Next, motor ability was assessed, and the Demographic Recording Form was completed. Because we believed that motor ability and cognitive function might be the important variables that would affect the recovery of motor performance, we applied a prestratified randomization procedure to ensure an equal distribution of the subjects. The subjects were separated into 9 blocks based on motor function (0–33, 34–66, and >66) and cognitive function (0–8, 9–16, and 17–23) scores. Because almost all of the subjects ( $n=45$ ) in this study had received an education of high school or above, the stratified block on cognitive function was based on the criteria for subjects with a high school education or above only. Next, the subjects were randomly assigned to either a POWM group or an NDT group within each of the 9 blocks. To ensure a standard approach in each intervention, half of the therapists were trained by the primary investigator (QPT) to apply NDT, and the others were trained by the primary investigator to apply POWM therapy. Therefore, each therapist performed the same methods of physical therapy during the entire study. After 8 weeks of treatment, the second assessment, including the MMSE and the STREAM, was conducted. In order to minimize bias, pretreatment and posttreatment data for all evaluation forms, including those of the MMSE and the STREAM, as well as data for reliability testing of the instruments were assessed by a physician from the Department of Neurology, Xiangya Hospital, Central South University, who had 6 years of clinical experience (specializing in cerebrovascular disease), who was trained to use the instruments, and who was unaware of the subjects' group assignments.

### *Interventions*

**NDT.** The physical therapists for subjects in the NDT group administered the NDT program.<sup>16,40</sup> A total of 22 of the 47 subjects were treated with the NDT regimen (Tab. 3). The subjects in this group would begin to receive the treatment after the activity schedule was established and after we determined that the focus of the intervention for the subjects was based on the principles of normalization of motor performance and quality of movement.

**POWM therapy.** The physical therapists for subjects in the POWM group administered the POWM program (Tabs. 3 and 4). As defined in the present study, the

**Table 3.**

Problem-Oriented Willed-Movement (POWM) Therapy and Neurodevelopmental Treatment (NDT) Session Formats

Group	Impairment of Subjects	Description
POWM therapy	Memory	Recite the outline of the movement before physical therapy (not during the session time). Allow 5 min for preparatory techniques. Establish a priority among the activities, including mat activity, sitting, standing, walking, gait training, and up-down stair training, every 7–10 d on the basis of the movement deficit and the complexity of the motor activity, as judged by the subjects. The highest-priority activities are those that can solve the major problem of the movement deficit and that are the most easily performed by subjects. Allow 30–35 min for the highest-priority activities and 10–15 min for the second-highest-priority activities. Practice each movement 20–25 times per session. The goal is to improve motor functions by helping subjects to remember each motor activity.
	Attention	Allow 5 min for preparatory techniques. Establish a priority among the activities, including mat activity, sitting, standing, walking, gait training, and up-down stair training, every 3–4 d on the basis of the movement deficit and the subjects' interests. Allow 25–30 minutes for the highest-priority activities, 10–15 min for the second-highest-priority activities, and 5–10 min for the third-highest-priority activities. Practice each movement 10–15 times per session and give sufficient time for subjects to complete each activity. The goal is to improve motor functions by helping subjects to concentrate on each motor activity.
	Language comprehension	Allow 5 min for preparatory techniques. Establish a priority among the activities, including mat activity, sitting, standing, walking, gait training, and up-down stair training, every 5–7 d on the basis of the movement deficit and the complexity of the motor activity, as judged by subjects. The highest-priority activities are those that can solve the major problem of the movement deficit and that are the most easily understood with subjects. Select simple methods of communication with subjects. Allow 30–35 min for the highest-priority activities and 10–15 min for the second-highest-priority activities. Practice each movement 10–15 times per session and give sufficient time for subjects to understand each activity. The goal is to improve motor function by helping subjects to understand the motor performance instructions of the therapist.
	Apraxia	Allow 5 min for preparatory techniques. Establish a priority among the activities, including mat activity, sitting, standing, walking, gait training, and up-down stair training, every 7–10 d on the basis of the movement deficit, the subjects' interests, and the frequency of the movements used in daily living activities. The highest-priority activities are those that can solve the major problem of the movement deficit, that can satisfy subjects' interests, and that are used most often by subjects in daily living activities. Allow 30–35 min for the highest-priority activities and 10–15 min for the second-highest-priority activities. Practice each movement 20–25 times per session. The goals are to improve voluntary motor function by facilitating involuntary movements used in daily living activities and helping subjects to better understand motor performance.
NDT		Allow 5 min for preparatory techniques. Establish a priority among the activities, including mat activity, sitting, standing, walking, gait training, and up-down stair training, every 7 d on the basis of the developmental sequence. Choose therapeutic activities to match subjects' level of development and to stimulate the next higher level of development. Allow 30–35 min for therapeutic activities matching subjects' level of development and 10–15 min for activities of the next higher level of development. Practice each movement 10–15 times per session. The goal is to normalize motor performance and inhibit abnormal movement patterns.

POWM program emphasizes the use of intact or relatively preserved sensory and cognitive functions of the participants to facilitate their attention to achieve a specific motor task. The therapy program was composed of a number of stages. First, cognitive, perceptual, and movement functions were assessed. Second, intact or relatively preserved cognitive and perceptual functions were assessed. Third, cognitive and motor problems were assessed. Fourth, individualized treatments for subjects with different cognitive impairments were selected (the cognitive and perceptual functions that had been selected to facilitate the movement were changed throughout the intervention on the basis of the condi-

tions of the subjects). Finally, an intervention particular to each subject was performed.

Problem-oriented willed-movement therapy does not adhere to the motor development sequence. Rather, this approach is individualized according to the degrees of cognitive and motor deficits of subjects. The individualized therapeutic methods used by the therapist to facilitate motor learning included the following: (1) using many repetitions of practice of tasks for subjects with memory impairments; (2) selecting colorful and interesting objects as the targets to direct movement, selecting interesting motor activities, and allowing sufficient

**Table 4.**  
50-Minute Problem-Oriented Willed-Movement Therapy Treatment Session Format

Activities	Description
Preparatory techniques	Provide care and lay objects at the hemiplegic side of the subjects. Position the subjects.
Mat activity training	Provide range of motion and stimulate active movement for the subjects. Practice the sitting, sitting to kneeling, and kneeling to standing activities. Change the position. Upper-extremity, lower-extremity, and trunk weight bearing.
Sitting training	Shift the center of gravity of the body to both hemiplegic and unaffected sides. Regain balance in the sitting position. Practice upper-extremity and trunk weight bearing and stimulate active movement of the upper extremities, lower extremities, and trunk (eg, if training the subjects to flex both hip joint and knee joint, the therapist verbally instructs the subjects to kick the red ball posteriorly or facilitates the learning through demonstration).
Standing training	Push the subjects to the sides, forward, and backward, slowly at first and later with more speed. Place the subjects on a movable surface when they are able to do equilibrium reactions on a stable surface to regain balance. Meanwhile, protect the subjects from falling. Weight bearing on both lower extremities on the same surface. Later, weight bearing on hemiplegic lower extremity while standing on a higher footboard with unaffected lower extremity moving to the side, forward, and backward and then on hemiplegic lower extremity while standing with unaffected lower extremity suspended. At the same time, shift to the hemiplegic side when practicing the weight bearing. Use the techniques described in the Appendix to trigger the active movement.
Walking training	Walk to the side and backward of the subjects to regain balance. Gait training and up-down stair training.

time for subjects with attention problems; (3) emphasizing by demonstration rather than by verbal instruction for subjects with language comprehension problems; and (4) providing visual and auditory guidance, demonstrating repeatedly, and using practice of motor activities in front of a mirror for subjects with apraxia.<sup>41</sup> The POWM techniques used for subjects with different kinds of cognitive problems are described in the Appendix. The subjects were given instructions to perform individual and concrete activities rather than instructions to try to change abnormal movement patterns. For example, a subject with motor impairments in the upper extremity was asked to touch colorful objects over the head instead of performing shoulder flexion with elbow extension. All efforts were made to help the subjects best accomplish a specific goal attentively.

Each subject in each group received one-on-one direct physical therapy 5 or 6 times per week in 50-minute

sessions. If a subject missed a treatment session, then he or she would be instructed to add an additional session the following week. During the study, the frequency of therapy was reduced for 4 subjects in the POWM group and for 2 subjects in the NDT group because these subjects no longer had problems that required regular therapy; these subjects received physical therapy 2 or 3 times per week. The criteria for the subjects without regular physical therapy included having total STREAM scores of more than 70, having no limited range of motion, having no joint pain, and having the ability to independently perform activities of daily living. Because we believed that time is one of the main factors influencing motor ability, we evaluated the subjects after 8 weeks of physical therapy. Four therapists provided treatment. All of the therapists had 2 or more years of physical therapy experience with people who have had strokes. These therapists were equally assigned to the NDT group and to the POWM group.

The physical therapy session of 50 minutes for the 2 groups consisted of: (1) preparatory techniques, including environmental modification and body positioning; (2) mat activity training, including passive range of motion, weight bearing, changing position, sitting, kneeling, and standing; (3) sitting training, including balance activities, weight bearing, and shifting; (4) standing training, including balance training, weight bearing, and shifting; and (5) walking training, including balance training, gait training, and up-down stair training (Tabs. 3 and 4).

#### Data Analysis

All data were analyzed with the SPSS version 11.0\* statistical package. Because the Levene test<sup>42</sup> showed that the variables of the STREAM are equal across groups, a factorial design (group × time) for repeated measures (FDRM) only on time was used. Because age range and the duration since onset of stroke were both very large, we defined age and duration as covariates in order to eliminate the effects of these 2 variables on group effects. Because the MMSE is an ordinal scale, the Mann-Whitney rank test was used to compare pretest

\* SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606.

**Table 5.**

Means and Standard Deviations for Subjects in the Neurodevelopmental Treatment (NDT) Group (n=22) and Subjects in the Problem-Oriented Willed-Movement (POWM) Therapy Group (n=25) and Results of the Mann-Whitney Rank Test for Pretreatment Mini-Mental State Examination Scores

Group	$\bar{X}$	SD	Range	Mean Rank	P
NDT	11.18	5.60	0–20	23.73	.898
POWM	11.48	4.93	0–21	24.24	

**Table 6.**

Means and Standard Deviations for Subjects in the Neurodevelopmental Treatment (NDT) Group (n=22) and Subjects in the Problem-Oriented Willed-Movement (POWM) Therapy Group (n=25) and Results of the Mann-Whitney Rank Test for Posttreatment Mini-Mental State Examination Scores

Group	$\bar{X}$	SD	Range	Mean Rank	P
NDT	14.86	6.59	2–23	20.82	.135
POWM	17.44	6.25	1–27	26.80	

results between groups. The Spearman rho test was used for analysis of correlation between the MMSE and the STREAM. The level of significance for this study was established at  $P < .05$ .

## Results

The potential scores for cognitive function measured by MMSE are 0 to 30. The pretreatment MMSE scores of the subjects in the NDT group ranged from 0 to 20 ( $\bar{X}=11.18$ ,  $SD=5.60$ ). The pretreatment MMSE scores for the subjects in the POWM group ranged from 0 to 21 ( $\bar{X}=11.48$ ,  $SD=4.93$ ) (Tab. 5). With respect to pretreatment MMSE scores between groups, the Mann-Whitney rank test showed that there was no difference between the NDT group (mean rank of 23.73) and the POWM group (mean rank of 24.24) ( $P=.898$ ). The means, standard deviations, and ranges of the posttreatment MMSE scores are shown in Table 6. A higher score indicates a higher level of cognitive function. The Mann-Whitney rank test also showed that there was no difference between the NDT group and the POWM group with regard to posttreatment MMSE scores.

For the STREAM measure of pretreatment, an independent  $t$  test showed no significant difference between the 2 groups. The means and standard deviations of the STREAM scores for the subjects in both groups on 3 dimensions (upper-extremity, lower-extremity, and basic mobilities) and the total STREAM score are shown in Table 7. A higher score indicates a higher level of motor ability. The degrees of freedom and the  $F$  values for the main effect of time, the main effect of group, and the effect of the group  $\times$  time interaction determined with FDRM also are shown in Table 7.

For overall STREAM and for all domains of STREAM, an effect of time was found. This result indicated that both groups of subjects demonstrated improvement in motor abilities after physical therapy interventions. Main effects of group were found for the STREAM domains of lower-extremity modalities ( $P < .05$ ) and basic mobilities ( $P < .01$ ) and overall STREAM ( $P < .05$ ). The mean scores for subjects in the POWM group were statistically significantly higher than those for subjects in the NDT group. These results indicated that the lower-extremity, basic, and overall motor abilities of subjects in the POWM group improved more than those of subjects in the NDT group after interventions (Tab. 7).

Main effects of age were found for the STREAM domains of upper-extremity and basic mobilities and overall STREAM ( $P < .05$ ). Further analysis of the data indicated that younger subjects improved more than older subjects. No duration effects were found for overall STREAM and domains of STREAM. Power analysis also was carried out with effect size, which is another useful measure for the interpretation of differences between groups.<sup>39</sup> With respect to the effect of time, the effect sizes were .38, .33, .47, and .51 for the STREAM domains of upper-extremity, lower-extremity, and basic mobilities and overall STREAM, respectively. With respect to the effect of group, the effect sizes for lower-extremity and basic mobilities and overall STREAM were .10, .39, and .14, respectively. According to Cohen,<sup>43</sup> effect sizes of .33, .38, .39, and .47 should be interpreted as small, and an effect size of .51 should be interpreted as medium (Tab. 7).

The Spearman rho test was used to analyze the degrees of association between pretest cognitive function and posttest motor ability and between posttest cognitive function and posttest motor ability. The results showed that pretest cognitive function was positively related to posttest motor ability in the NDT group ( $r=.446$ ,  $P < .05$ ). However, no statistically significant relationships were identified between pretest cognitive function and posttest motor ability measures ( $r=.101$ ,  $P=.630$ ) or between posttest cognitive function and posttest motor ability measures ( $r=.030$ ,  $P=.886$ ) in the POWM group. Because the subjects were selected on the basis of cognitive function, the pretest relationship between cognitive function and motor ability was not tested.

## Discussion

Cognitive deficits after stroke are common and interfere with recovery.<sup>44</sup> The 4 typical dilemmas of rehabilitation for people with cognitive deficits are as follows. First, these individuals may not be able to accomplish the demands of motor performance, because they cannot easily understand the instructions of the therapist.<sup>45,46</sup> Second, they may not concentrate on motor learning,

**Table 7.**

Mean Scores and Standard Deviations for Subjects in the Neurodevelopmental Treatment (NDT) Group (n=22) and Subjects in the Problem-Oriented Willed-Movement (POWM) Therapy Group (n=25) and Results of Repeated-Measures Analysis of Variance for the Stroke Rehabilitation Assessment of Movement (STREAM) Subscales (Upper-Extremity, Lower-Extremity, and Basic Mobilities) and Total Scores

Parameter	STREAM				Effect								
	Pretest		Posttest		Time			Group			Time × Group		
	$\bar{X}$	SD	$\bar{X}$	SD	df <sup>a</sup>	F	ES <sup>b</sup>	df	F	ES	df	F	ES
Upper extremity													
NDT group	22.50	24.34	39.32	26.65	1	26.14 <sup>c</sup>	.38	1	0.90	.02	1	19.85 <sup>c</sup>	.32
POWM group	19.00	20.57	52.80	22.18									
Lower extremity													
NDT group	22.05	22.40	35.91	24.67	1	21.14 <sup>c</sup>	.33	1	4.58 <sup>d</sup>	.10	1	45.61 <sup>c</sup>	.52
POWM group	19.20	18.91	62.80	23.81									
Basic mobility													
NDT group	5.76	7.78	28.18	23.16	1	37.67 <sup>c</sup>	.47	1	27.49 <sup>c</sup>	.39	1	40.69 <sup>c</sup>	.49
POWM group	8.80	10.71	64.80	25.00									
Overall score													
NDT group	16.77	16.62	34.47	23.31	1	44.32 <sup>c</sup>	.51	1	7.09 <sup>d</sup>	.14	1	54.87 <sup>c</sup>	.56
POWM group	15.67	15.45	60.13	20.80									

<sup>a</sup> Degrees of freedom adjusted with Greenhouse-Geisser epsilon statistics.

<sup>b</sup> ES=eta squared (value of effect size).

<sup>c</sup>  $P < .01$ .

<sup>d</sup>  $P < .05$ .

because of attention problems (distraction).<sup>47-49</sup> Third, they may not use cognitive function to direct motor learning, because cognitive function is separated from the motor process.<sup>17</sup> Finally, repetition of motor performance tasks may be impaired because these individuals may not remember what has been done. Therefore, people with cognitive impairments cannot actively participate in a physical training procedure.<sup>50</sup> However, in most common physical approaches, such as NDT and Vojta methods,<sup>51</sup> the focus is on normalizing movements, active participation is not focused, and perceptual and cognitive aspects are ignored.<sup>11</sup> According to a literature review, integrated rehabilitation that considers the effects of perceptual and cognitive functions on motor abilities for subjects with cognitive deficits is almost lacking. Therefore, we propose the POWM approach. The main purpose of this study was to examine whether subjects receiving POWM therapy will show greater improvement in motor abilities than subjects receiving NDT.

In this study, almost all of the subjects had 2 or more locations for the stroke; this finding is similar to those of other studies of subjects with dementia.<sup>52,53</sup> The combination of stroke features in our study sample might explain why all of the subjects had motor and cognitive impairments. Approximately half of the subjects had left-sided stroke, and the remaining subjects had bilateral stroke or right-sided stroke. Location in the dominant hemisphere, a bilateral stroke feature, might be associated with cognitive problems. These findings

partially confirmed the findings of Erkinjuntti and associates.<sup>53</sup>

Middle cerebral artery hemorrhage and occlusion are the most common stroke events. These events can result in extensive damage to the brain, including partial parietal, temporal, and frontal lobes, especially in the areas of the internal capsule or basal nucleus.<sup>54</sup> Most of our subjects had lesions of the internal capsule, temporal lobe, or basal nucleus. Lesions involving the internal capsule have the poorest outcome for motor abilities because of the condensed organization of corticofugal projections and the density of pyramidal fibers from the primary motor cortex in this subsector.<sup>55</sup> Because the numbers of subjects who had lesions involving the internal capsule were approximately the same in both groups, we inferred that the location did not have much effect on the study results.

The means of the pretreatment MMSE scores for subjects in the NDT group and in the POWM group were 11.18 and 11.48, respectively. In the study by Visintin and colleagues,<sup>29</sup> among 100 subjects with stroke, the pre-training cognitive status score was 8.5 for both the body-weight-support group and the no-body-weight-support group, as measured by the 10-item Short Portable Mental Status Questionnaire, with a total score of 10. This approach was established for people after strokes to retrain gait through body-weight-support and treadmill stimulation. The authors argued that this strategy provides a dynamic and task-specific approach that inte-

grates 3 essential components of gait while the patient is walking on the treadmill: weight bearing, stepping, and balance. This approach was not used for individuals with cognitive deficits because the practice procedures did not have any differences between subjects with cognitive deficits and subjects without cognitive deficits.<sup>29</sup> Another task-oriented therapeutic study also assessed cognitive status measured by MMSE. The mean scores were 26, 27, and 27 for the control group, the upper-limb training group, and the lower-limb training group, with a range of scores from 24 to 29. These results indicated that all of the subjects in this study had no cognitive deficits.<sup>56</sup> No other studies with NDT or a task-oriented approach for subjects with cognitive deficits were available for comparison of data related to MMSE scores.

A significant difference in overall motor abilities was found between the POWM group and the NDT group after different physical therapy interventions. This finding indicated that the overall motor abilities of subjects in the POWM group improved more than those of subjects in the NDT group. These data confirmed that many factors contribute to the recovery of motor performance; cognitive function is a very important factor.<sup>48,57,58</sup> To perform a skilled motor act, a person must understand what the act entails,<sup>45</sup> remember long enough to accomplish the act,<sup>59,60</sup> formulate an organized plan to accomplish the task, create a mental image of the action, and actually execute the detailed plan.<sup>54,59</sup> Cognitive abilities, such as judgment, comprehension, and repetition, have a positive relationship with functional performance.<sup>44,48</sup> As previously mentioned, because active participation in therapy for people with cognitive impairments is decreasing or lacking, the key points of physical therapy for these individuals are as follows: how to motivate them to consciously pay attention to the movement and how to facilitate understanding of motor learning instruction and active execution of a new motor task. Willed-movement therapy presents a way to achieve conscious attention to movement. In the POWM group, intact or relatively preserved cognitive and sensory functions were stimulated in order to trigger a movement reaction.

According to the 2 physical intervention procedures described, it was evident that the 2 groups differed mainly in the focus of the therapy. Problem-oriented willed-movement therapy focuses on attention and motivation. On the basis of the goal of motor learning and in the interest of the subjects, the therapist directed the subjects' attention to their movements, consequently making them actively participate in motor learning. Furthermore, the therapist used intact or relatively preserved perceptual and cognitive functions to facilitate the movements, giving subjects some control over the train-

ing regimen. Neurodevelopmental treatment focuses mainly on the normalization of movement. The reasons why subjects who received POWM therapy showed greater improvement in motor abilities than subjects who received NDT might be related to the facts that attention directs an abstract motor act<sup>50</sup> and the execution of a novel motor act cannot be seen as a learning process directed only at the reacquisition and reorganization of the movement<sup>17</sup> but can be seen as a process in which cognitive function directs motor performance.<sup>54,59</sup>

Modern concepts have drastically modified the framework of rehabilitation from conventional NDT to a more dynamic, task-oriented approach.<sup>61,62</sup> A pilot trial that compared conventional therapy for the arm with functional task practice and strengthening for an additional 20 hours during 4 to 6 weeks of inpatient rehabilitation showed both short-term and long-term gains in motor control for those who received more focused interventions.<sup>27</sup> When well-defined interventions to improve walking were tested in selected groups of subjects in randomized clinical trials, gains were common for subjects who received task-oriented interventions.<sup>28,29</sup> The experimental group, which received a standardized training program based on a task-oriented approach, were able to reach faster and farther, increase load through the affected foot, and increase activation of affected leg muscles compared with the control group, which received sham training involving completion of cognitive-manipulative tasks within arm's length.<sup>18</sup> All tasks in these studies were instrumental tasks or were related to activities of daily living. As previously stated, POWM therapy is a task-oriented approach in which the motor movements related to tasks are behaviorally motivated.

There is evidence that the POWM treatment and task-oriented approach differed with regard to the assessment of the subjects, the orientation to therapy, the facilitating techniques for performing the task, and the subjects being treated. First, in the POWM group, the cognitive, perceptual, and movement functions of all subjects were assessed before the intervention. Because the task-oriented approach is not well established for subjects with cognitive deficits, the cognitive and perceptual functions of these subjects could not be assessed. Second, the POWM approach is a cognitive, movement problem-oriented approach as well as a task-oriented approach. Third, the facilitating techniques for accomplishing the task are different. The POWM approach uses intact or relatively preserved sensory and cognitive functions that are not well addressed in the task-oriented approach. For example, in a task-oriented approach, the subjects are verbally instructed to reach an objective. In the POWM approach, therapists select colorful and interesting objects or sound objects as the targets to

direct any movement in any direction. Finally, POWM therapy is designed to treat subjects with motor and cognitive impairments. Studies that use a task-oriented approach for subjects with cognitive problems have not yet been carried out.

Several researchers<sup>63–65</sup> have already investigated the effects of attention on motor learning. The results have shown that directing subjects' attention to the effects of their movements can be more beneficial for learning than directing their attention to the details of their own actions.<sup>63–65</sup> Our study also focused on attention to motor learning. The disparities between our study and other studies involve the following aspects. In the present study, the existing perceptual and cognitive functions of the subjects were emphasized and used. The therapists directed the subjects' attention to either the effects of their movements ("external focus") or the details of their own actions ("internal focus"). If the subjects could understand and follow the directions of the therapists who instructed them to pay attention to the effects of their movements, then an external focus of attention was directed. Otherwise, an internal focus of attention was directed. The findings of this study were partially consistent with those of the study of Ketelaar et al<sup>8</sup> for subjects with cerebral palsy; in that study, the therapists also emphasized active participation to meet the goal. However, there are many differences in rehabilitation methods between the 2 studies. In the study by Ketelaar et al,<sup>8</sup> the goal was more abstract, functional activities were focused, and no specific cognitive functions or sensory stimulations were used.

When subscales of motor ability were used, subjects in the POWM group improved more on lower-extremity and basic abilities, but no difference in upper-extremity mobilities was found after 2 different physical therapy interventions. Because most of the subjects in the study had had strokes within 3 months, these results were consistent with the findings of Desrosiers and associates,<sup>66</sup> who reported that motor recovery occurred at different rates in the upper and lower extremities; that of the upper extremity occurred later and extended into the period after discharge from active rehabilitation.

The interesting and noteworthy findings of this study were the positive relationship between pretest cognitive function and posttest motor ability in the NDT group but no statistically significant relationship between pretest cognitive function and posttest motor ability in the POWM group. These results suggested that subjects with a higher level of cognitive function improved more on motor ability in the NDT group because subjects with a higher level of cognitive function might actively use the cognitive process to perform the motor act. However, for subjects with a lower level of cognitive function, the

cognitive process for motor learning is damaged; that is, cognitive function and motor performance are separated. Therefore, motor recovery for these subjects is not satisfying.

The finding of a positive relationship between cognitive function and motor ability in the NDT group was consistent with the findings of McDowd et al<sup>48</sup> and Fong et al.<sup>57</sup> In the POWM group, for both subjects with a higher level of cognitive function and subjects with a lower level of cognitive function, cognitive function is not separated from the motor process because intact or relatively preserved cognitive function is used to stimulate a motor act. Furthermore, perceptual function also is used in the POWM rehabilitation procedure. These results suggested that POWM treatment maximized the potential of perceptual and cognitive functions for motor recovery, especially for subjects with a lower level of cognitive function. Therefore, for subjects with a lower level of cognitive function, treatment strategies tailored to a subject's specific cognitive and perceptual strengths and deficits might enhance active participation to the same degree as for subjects with a higher level of cognitive function. The compensatory role of intact or relatively preserved cognitive and perceptual functions might improve the ability to execute a motor act. Therefore, improvement in motor function in subjects with a higher level of cognitive function should not be different from that in subjects with a lower level of cognitive function.

## Conclusion

Our results indicated that significant improvements in lower-extremity mobility, basic mobility, and total mobility were obtained when POWM therapy was used versus when NDT was used. However, there was no benefit with respect to upper-extremity mobility. These results suggested that the POWM intervention is effective in improving lower-extremity and basic mobilities, including rolling, bridging, sitting, standing, and walking, in subjects who have had strokes and who have cognitive impairments. The findings of this study suggest that therapists should emphasize the role of perceptual and cognitive functions and intentions in managing the mobility of people with cognitive impairments after strokes. The lack of a statistically significant relationship between pretest cognitive function and posttest motor function in the POWM group emphasized the facilitating role of intact cognitive function or perceptual function, or both, in motor rehabilitation for people with cognitive deficits.

There are several limitations of this study. The results of this study cannot be generalized to all people with hemiplegia after a stroke, because the subjects who participated in this study had mild to severe cognitive

function deficits. Further research is needed to identify whether POWM therapy will benefit people with other head impairments, such as head injury or brain tumor, and people with slight alterations in consciousness. The sample size was relative small, thus leading to a relatively small effect size with regard to the group effect. Replication of this study with a large sample size over a relatively longer period is needed. Even though age and duration since the onset of stroke were defined as covariates to eliminate their effects on group results, the potential for sampling bias should be considered.

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## **Appendix.**

### Outline of the Problem-Oriented Willed-Movement Therapy Used in This Study

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#### **Memory impairment**

- Simplifying each movement with simple verbal guidance and demonstrating the motor act
- Reciting the outline of the movement
- Practicing each movement 20–25 times per session
- Giving continual reinforcement for maximizing the movement until it is initially learned and giving reinforcement intermittently to maintain the movement<sup>23</sup>
- Giving positive feedback promptly for any progress
- Discontinuing the movement if the subjects feel fatigue
- Changing the type of movement if the subjects feel bored
- Using different styles of presentation

#### **Attention problems**

- Selecting colorful and interesting objects as targets to direct the movement
- Selecting motor activities based on the major motor problems and interests of the subjects
- Changing the tone of speech
- Giving sufficient time for each activity
- Using tactile, auditory, and visual stimuli to augment the attention of the subjects
- Eliminating other stimuli that are not related to the practice
- Giving positive feedback promptly for any progress

#### **Language comprehension problems**

- Emphasizing by demonstration rather than by verbal instruction
- Selecting colorful objects as targets to direct the movement
- Giving positive feedback when subjects respond to instructions correctly
- Selecting visual, tactile, thermal, and deep sensation cues other than auditory sensation cues to stimulate the subjects
- Selecting a position in which the motor movement is within the vision of the subjects; for example, the therapist may choose a sitting or a standing position rather than a prone position for a subject to perform knee flexion

#### **Apraxia**

- Providing visual and auditory guidance
- Demonstrating repeatedly
- Practicing the motor activities in front of a mirror<sup>a</sup>
- Simplifying each movement
- Selecting activities that are usually part of daily living activities to facilitate the involuntary action and reinforcing the involuntary action to facilitate the voluntary action

#### **Willed movement**

- Establishing a target for each movement
- Helping the subjects to understand the instructions of the therapist by using intact or relatively preserved perceptual or cognitive functions
- Giving sufficient time for the subjects to understand and accomplish the movement instruction
- Selecting training activities that are within the capabilities of the subjects
- Selecting training activities that relate to subjects' interests and needs in order to maximize active participation
- Emphasize active movement after passive range of motion
- Varying training materials and methods to augment the attention of the subjects
- Giving positive feedback for each desired response

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<sup>a</sup>Sathian K, Greenspan AI, Wolf SL. Doing it with mirrors: a case study of a novel approach to neurorehabilitation. *Neurorehabil Neural Repair*. 2000;14:73–76.