Journal of Associated Medical Sciences 2022; 55 (3): 82-90

JAMS
Journal of Associated Medical Sciences

Thai-Journal Citation Index Centre (TCI) & ASEAN Citation Index (ACI)

Journal of Associated Medical Sciences

Journal homepage: https://www.tci-thaijo.org/index.php/bulletinAMS/index

Efficacy of metacognitive strategy training on reducing disability of post-stroke survivor: A pilot study

Kshanaprava Mohakud[1] Samir Sahu[2] Sakti Prasad Das[3] Surjeet Sahoo[4*]

[1]Occupational Therapy, MOT (Rehabilitation), Department of Occupational Therapy, Swami Vivekanand National Institute Rehabilitation Training and Research, Cuttack-754010, Odisha, India.
[2]Department of Medicine, IMS & SUM Hospital, Siksha O Anusandhan (deemed to be) University, Bhubaneswar, Odisha, India.
[3]Swami Vivekanand National Institute Rehabilitation Training and Research, Cuttack, Odisha, India.
[4]Department of Psychiatry, IMS & SUM Hospital, Siksha O Anusandhan (deemed to be) University, Bhubaneswar, Odisha, India.

ARTICLE INFO

Article history:
Received 8 March 2022
Accepted as revised 14 July 2022
Available online 3 August 2022

Keywords:
Stroke, rehabilitation, metacognitive strategy training, independence, disability

ABSTRACT

Background: Post-stroke survivors experience significant challenges with their functional health. Despite advances in neuro-rehabilitation, they cannot participate in meaningful daily life activities, leading to disability. Many intervention approaches are applied in stroke rehabilitation to make them independent and lead a quality life.

Objectives: The objective of this pilot study was to investigate the effect of the Metacognitive Strategy Training (MCST) on Conventional Occupational Rehabilitation Therapy on improving independence and reducing the disability of post-stroke survivors.

Materials and methods: Thirty subjects with post-stroke syndrome participated in an exploratory, double-blind, randomized controlled trial with pre-post and follow-up studies. Subjects were randomized over two intervention groups. Group-1 received MCST with conventional therapy (n=15), and Group-2 conventional therapy only (n=15). The Functional Independence Measure (FIM) measures independence at baseline (Time1), post-intervention (Time2), and after six months (Time3).

Results: Changes in Functional Independence Measure scores for the two groups over six months showed significant effects of group ($F(1,24)=9.422$, $p<0.005$), time ($F(1.160, 27.848)=21.449$, $p<0.0001$) but time and group interaction was not significantly affected ($F(1.160, 27.848)=0.172$, $p=0.719$). Post hoc analysis with a Bonferroni adjustment revealed that FIM was statistically significantly increased from pre-intervention to post-intervention (22.597 (95% CI, 34.511 to 10.683), $p<0.0001$), and from pre-intervention to six month follow up. (24.203 (95% CI,37.554 to 10.853), $p=0.0001$), but not from post-intervention to six months (1.606 (95% CI, -5.988 to 2.776), $p=1.000$).

Conclusion: MCST has better efficiency in reducing disability and improving the independence of post-stroke survivors in the long term.

* **Corresponding author.**
Author's Address: *Department of Psychiatry, IMS & SUM Hospital, Siksha O Anusandhan (deemed to be) University, Bhubaneswar, Odisha, India.*
** **E-mail address:** surjeetsahoo@gmail.com
doi: 10.12982/JAMS.2022.028
E-ISSN: 2539-6056

Introduction

Stroke, the life-changing syndrome, causes sensorimotor, language, and cognitive impairment, which varies on the severity of damage.[1,2] Though there are many advances in neuro-rehabilitation, half of the post-stroke survivor depends on others for their activities of daily living (ADL) as they cannot achieve their functional goals.[3] The limitations in ADL and constraints for meaningful participation in social goals leads to disability of post-stroke individual.[4] It is the fourth leading cause of disability and the fourth-highest burden of disease worldwide (WHO).[5]

Many intervention strategies have been adopted to improve the ADL of post-stroke survivors. Evidence suggests that the conventional approach used for stroke rehabilitation is only confined to improving the particular task trained to the individual after repetitive practices.[6,7] Also, the retention effect of the learned skills is not consistently maintained in the long term.[8,9] The conventional approach lacks the scope for generalization and transferring learned skills to other tasks or contexts to improve the ADL.[10] To overcome this, the novel metacognitive strategy training is applied in stroke rehabilitation.

Metacognitive strategy training (MCST), or strategy training, is a top-down holistic approach that helps to improve ADL and occupational performance and maintains the post-stroke individual's independence. MCST does not focus on the participant's impairment, causing the performance limitation as in the conventional approach.[11] The approach uses meaningful activities as the basis of the end goal of the intervention.[12] It combines theory and evidence of motor, cognitive sciences, and learning principles in a client-centred framework. In this performance-based problem-solving approach, the client learns and acquiesces skills to maintain independence. This process incorporates the strategy of goal-plan-do-check through guided discovery.[13,14] In the MCST intervention process, the client identifies the challenging activities according to their importance. With the help of the therapist, the client sets realistic goals, plans the steps to achieve the goals, then performs the activities, and finally checks the mistakes and rectifies himself. Then the client practices the task in a correct pattern repetitively. During the intervention process, the therapist facilitates learning of the client through prompting, cueing, and questions rather than direct teaching, unlike the conventional approach. By this strategy, the participants go through a personalized assessment of ADL and social goals of real life problems and learn to use these techniques for other untrained new activities and situations through self-monitoring. Hence MCST improves independence in daily activities and promotes participation in meaningful activities leading to continued improvement rather than further deterioration in the long term.[15,16]

The concepts and theories underlying MCST are experience-dependent neuroplasticity which suggests that learning new skills leads to structural and functional changes in the brain.[17] For example, the experience-dependent neuroplasticity causes the enhanced growth of the hippocampal area in music learners. The sensorimotor network changes in dancers occur as they perform the activity repetitively.[18-20] As a result, the experience-dependent neuroplasticity helps the clients re-engage in occupation with the changes in the brain.[21,22] Therefore, the MCST intervention targets the improvement of performance and activity participation which will help for impairment reduction within specific cognitive domains of the participants. MCST approach directly affects the action of the frontoparietal network of our brain. The cognitive control network involves flexible moment-to-moment task control and reflects compositional coding to enable the transfer of knowledge to novel tasks.[23,24]

Previous reports suggest there are escalating pieces of evidence for MCST on the improvement of functional outcomes of post-stroke survivors.[11,15,25–29] Also, shreds of evidence suggest that MCST has more significant improvements in the vocational and community outcomes of the post-stroke individual.[10,11,13,14,24,27,28,30–32] Hence our study has hypothesized that "MCST has a significant effect in improving functional independence and reduction of disability of stroke survivors". The objective of our study is to investigate and compare the efficacy of MCST on conventional therapy on the functional independence and reduction of disability of the post-stroke survivors.

Materials and methods

The study design was an explorative, randomized; double-blind controlled pilot trial. The participants were selected from two centers; a tertiary care hospital and a tertiary care rehabilitation institute. After selection, for allocation of groups, participants were randomized to receive either the conventional occupational therapy or the MCST occupational therapy. The inclusion criteria of the participants for the study were based on the diagnosis of first onset subacute and chronic stroke age 18 to 60 years diagnosed by a neurologist. The client is medically stable (afebrile, with stable vital signs, without essential changes in medical conditions or required changes in treatments within 48 hours before assessment, with functional limitations, being able to take adequate nutrition orally), with sufficient language skills to understand and respond to primary interview and questionnaires.

The exclusion criteria were the followings:

1. Participants of acute post-stroke (less than 15 days), Stroke Patients with comorbidities and other neurological diagnoses like multiple sclerosis, motor neuron disease, and Parkinson's disease.
2. Patients having psychiatric diseases like dementia, current bipolar disorder, major depressive disorder, or psychotic disorder were excluded from this study. The patients having cognitive impairment (screened by MMSE, score <24), aphasia (both receptive and expressive), and vision abnormalities (e.g., diplopia).
3. Patients having alcoholic substances were not included in the study.
4. The participants participate less than 80% of the intervention program or did not follow up were excluded from the study.

To maintain and confirm the balanced group sizes blocked randomization of ratio 1:1 procedure was used

from each site. The random number function in Excel (Microsoft Corporation, Microsoft Excel 2010, Version 14.0.) was used to create a random sort order within each block. To ensure allocation concealment, we created sequentially numbered sealed opaque envelopes with the support of an external therapist who was not associated with the study. After reviewing all inclusion/exclusion criteria and getting consent from the patients, the treatment group allocation was completed. The treating therapist was blinded to the randomization procedure and block size. The ethical committee approved the study at the university.

Assessment and intervention procedures

After the recruitment of participants, the baseline assessment was conducted by one of the authors, who was blinded to group allocation. Before starting therapy, the occupational therapist conducted a goal-setting interview using the Canadian Occupational Performance Measure (COPM) for both groups. The participants spell out 4 to 6 meaningful functional activity goals prioritizing their importance. The experimental MCST intervention was based on CO-OP treatment guidelines.[33] The duration of the intervention MCST group was 45 minutes in each session for a minimum of 3 sessions and a maximum of 5 sessions in a week. Each participant was given a maximum of 10 sessions of MCST therapy. Among the selected goals, only three goals were trained, and the rest untrained activities were kept for the transfer of skills for the experimental group. The therapist trained participants on the global cognitive strategy goal-plan-do-check.

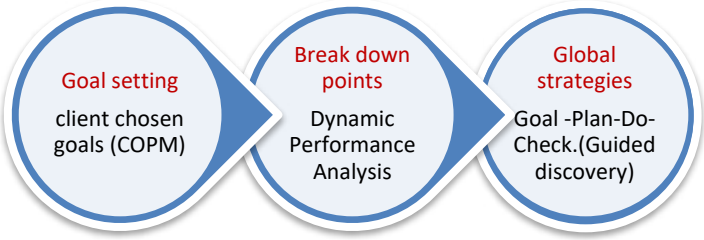

Figure 1. *Intervention process of MCST group.*

The MCST intervention procedure consists of the key principles such as goal setting, Dynamic Performance analysis and global strategies (Figure.1). The participants used this strategy during the treatment procedure as the fundamental concept of the problem-solving framework, which enabled identifying domain-specific strategies, acquiring skills, and achieving goals. The therapist guided the participants in discovering a plan to achieve the goals for their individualized prioritized tasks. The participants performed the activities as per the plan and then checked whether the plan had worked as expected. If the goal was not achieved, the therapist facilitated the participants to modify the plan or the alternative methods to reach the goal. In every new plan, the participant repeats the strategy Do-Check cycle till the achievement of the goal. The therapist regularly gives opportunities to participants and facilitates the generalization of skills and strategies in different contexts and environments. During this whole procedure, the participants were provided with a workbook and materials to note the critical points for achieving individualized goals. At the end of each session, the therapists prompted the participants to identify critical principles they learned and discuss methods for applying these principles in subsequent sessions. Then the participants checked whether the plan worked or required reviewing. The these steps were repeated iteratively until the goals were achieved.

The control group was given conventional therapy, a combination of component-based therapy, and task-specific training. The therapy is based on impairment-level or component-level treatment (e.g., ROM, muscle strength, muscle tone, synergy, etc.) and techniques with short-term goals evaluated by the therapist and managed by direct training and whole-activity treatments. In the control group, participants engaged in a facilitated discussion with the therapists, who used already transcribed, open-ended questions to encourage the participants' rehabilitation experiences.

Both the MCST and the control groups also received stroke rehabilitation with specific services as per the individual needs like physical therapy, speech-language therapy, or nursing.

Outcome measures

The measurement of the study was done through the functional independence measure (FIM) and the demographic characteristics of all the participants. Demographic (age, gender, education, occupation) were collected through personal interviews and medical information (stroke onset, sub-type, stroke-affected side, area of lesion) from the patients' medical records that were included in the study. One of our authors, who was blinded to group allocation, conducted a standardized assessment before the intervention at starting Time 1), after 2 weeks of discharge from occupational therapy at two months (Time 2), and six months after Time 1 (Time 3). As the number of intervention sessions varied among participants based on the severity of their stroke and their individual

rehabilitation needs, the therapists or the administrative staffs were asked to inform the authors when the participant was discharged from occupational therapy after the completion of 12 sessions or 6 weeks of therapy, whichever came first. Time 2 assessments were performed for 15 days or two weeks after intervention for both groups to give community exposure to the participants.

The functional Independence Measure (FIM) assesses and grades functional independence. It is an eighteen-items questionnaire, and it measures physical and cognitive function and the level of independence and disability of an individual. It is a Likert type of 7-point scale and graded in descending order as -7. Complete Independence (Safety and Timely), 6-Modified independence (with the help of device), 5-Helper-Modified Dependence with Supervision, 4- Minimal Assistance (subjects performs75% of task), 3-Moderate Assistance (subjects performs 75% of task), 2-Maximal Assistance (subjects performs50% of task), 1-Total Assistance or entirely dependent. The internal consistency in 96.9% of tests and item discriminant validity in 100% of tests. The validity and reliability of FIM are maintained for assessing independence in people with stroke, and the reliability coefficients for each impairment category for both subscales ranged from 0.86 to 0.97.[34,35]

Data Analysis

Data were analyzed by SPSS Version 17.0 (SPSS Inc., Chicago), and the significance level for all tests was set at $p<0.05$. The normality of data was confirmed using Shapiro-Wilk's test. To examine baseline between-group differences, independent sample t-tests were used for continuous data and x^2 (chi-square) for categorical data. Between-group baseline comparisons were made on age, gender, education, and FIM scores. Means and standard deviations were calculated for both groups for the primary outcome measure, FIM. We used repeated measure ANOVA to examine the participant's independence in daily activities (FIM scores) improved over time at three-time points (from baseline to three months and six months and three months to six months) with different intervention assignments (MCST & conventional). Wilk's lambda was calculated followed by appropriate Mauchly's test of sphericity, and pairwise comparison between time, group, and time group interaction was compared with a significance level less than 0.05. Post hoc analysis with a Bonferroni adjustment was done for multiple comparisons.

Results

From the flow of the study procedure, fifty-six participants enrolled in the study (Figure 2). Of these, 17 participants were excluded because they did not meet eligibility criteria, and 3 participants withdrew during the screening process before randomization. Thus, we randomized 36 participants to the intervention, 18 in each group. Six participants could not continue at least 80% of the intervention program. Hence only thirty participants are considered for the study (Figure 2).

Our study found 73.3% male and 26.7% female in the experimental group and 91% male and 9% female in the control group. The mean age is 46.42±9.88 and 44.81±11.25 for the experimental group & control group, respectively. The mean year of education is 13.46±3.99 and 13.23±3.93for the experimental group & control group, respectively. Mostly ischemic left side affection hemiplegia participated in both groups in our study. The mean stroke duration was 13.30±15.33& 12.74±14.81 for the experimental group & control group, respectively. All the participants were right-handed in the experimental group, and 91% were right-handed in the control group. Both groups did not differ in baseline criteria (Table 1). Table 2 represents FIM's mean and standard deviation between the groups at different time points.

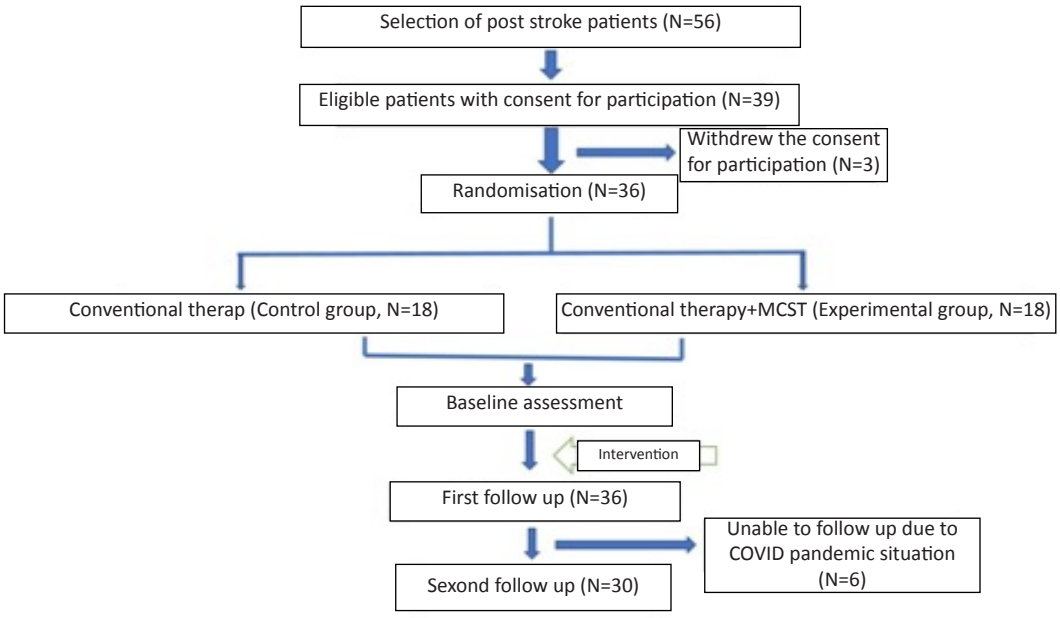

Figure 2. *Flow diagram of study procedure.*

Table 1 Socio demography data.

Variables	Experimental Group (n=15)	Control Group (n=15)	
Age			
Mean±SD	46.42±9.88	44.81±11.25	T=0.065, *p*=0.437
Gender			
Male	73.3%	91%	X^2=1.262, *p*=0.261
Female	26.7%	9%	
Year of education			
Mean±SD	13.33±4.065	12.55±3.04	T=0.508, *p*=0.616
Affection side			
Left. side	80%	55%	X^2=1.930, *p*=0.165
Right. Side	20%	45%	
Subtype stroke			
Hemorrhagic	27%	36%	X^2=0.280, *p*=0.597
Ischemic	73%	64%	
Stroke duration (month)			
Mean±SD	13.30±15.33	12.74±14.81	T=0.863, *p*=0.397
Type of stroke			
Acute	73%	73%	X^2=0.140, *p*=0.647
Chronic	27%	27%	
Dominance hand			
Rt. handed	100%	91%	X^2=.053, *p*=0.819
Lt. handed	0%	9%	

Table 2 Descriptive statistics with mean and SD for experimental and control group at three time points for FIM.

	Variable	Mean	SD
FIM 1	Experimental group	100.27	24.417
	Control group	75.91	31.316
FIM 2	Experimental group	120.73	7.43
	Control group	100.64	20.68
FIM 3	Experimental group	124.40	2.613
	Control group	100.18	30.717

From the repeated measures ANOVA for the FIM at 3-point time Sphericity assumption is violated (p<0.001). Since the sphericity assumption was violated “Greenhouse -Geisser" correction method was referred to as interpretation (Table 3).

As our data violated the assumption of sphericity, we look at the values in the "Greenhouse-Geisser" row. We can report that When only considering time as an independent variable, there is a significant difference between the scores of FIM of groups over three-time points with (F 1.160, 27.848)=21.449, p<0.0001).

Table 3 Mauchly's test of sphericity. Measure: FIM at different time points.

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
FIM	0.276	29.581	2	0.000*	0.580	0.617	0.500

**Significant (p<0.001).*

Similarly, considering only one group, there is (F (1,24)=9.422, p<0.005) of two groups over six months of the period. When considered time and group interaction then there is no significant difference (F (1.160, 27.848)=0.172, p=0.719). From the result, we conclude that the changes in score from one-time point to another time point (baseline to post-intervention to follow up) between the groups. Similarly, the change or difference between groups averaged over each time point. But the difference between the group is not improved at different time points (Table 4 and 5).

Table 4 Tests of within-subjects effects. Measure: FIM at different time points.

		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
FIM	Sphericity Assumed	9299.139	2	4649.569	21.449	0.000*	0.472
	Greenhouse-Geisser	9299.139	1.160	8014.263	21.449	0.000*	0.472
	Huynh-Feldt	9299.139	1.233	7539.981	21.449	0.000*	0.472
	Lower-bound	9299.139	1.000	9299.139	21.449	0.000*	0.472
FIM * group	Sphericity Assumed	74.370	2	37.185	0.172	0.843	0.007
	Greenhouse-Geisser	74.370	1.160	64.094	0.172	0.719	0.007
	Huynh-Feldt	74.370	1.233	60.301	0.172	0.734	0.007
	Lower-bound	74.370	1.000	74.370	0.172	0.682	0.007
Error (FIM)	Sphericity Assumed	10405.297	48	216.777			
	Greenhouse-Geisser	10405.297	27.848	373.649			
	Huynh-Feldt	10405.297	29.599	351.537			
	Lower-bound	10405.297	24.000	433.554			

** Significant (p<0.0001).*

Table 5 Tests of between-subject effects.

Source	df	F	Sig.
Intercept	1	773.273	0.000
Group	1	9.422	0.005*
Error	24		

** Significant (p<0.0001).*

Post hoc analysis with a Bonferroni adjustment revealed that FIM was statistically significantly increased from FIM 1 to FIM 2 (MD -22.597 (95% CI, -34.511 to -10.683), p<0.001) and FIM 1 to FIM 3 (MD -24.203 (95% CI, -37.554 to -10.853), p<0.001) but not from FIM 2 to FIM 3 (MD -1.606 (95% CI, -5.988 to 2.776), p>0.001 (Table 6).

Table 6 Pairwise comparisons. Measure: theme.

(I) FIM	(J) FIM	Mean Difference (I-J)	SE	Sig.b	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
1	2	-22.597*	4.629	0.000*	-34.511	-10.683
	3	-24.203*	5.187	0.000*	-37.554	-10.853
2	1	22.597*	4.629	0.000*	10.683	34.511
	3	-1.606	1.703	1.000	-5.988	2.776
3	1	24.203*	5.187	0.000	10.853	37.554
	2	1.606	1.703	1.000	-2.776	5.988

** Significant (p<0.0001).*

Discussion

From the pilot study, we investigated the effect of MCST intervention on improving the functional independence of post-stroke survivors. We found there is a better improvement of functional independence in activities of daily living in the participants of MCST as compared to the participants of the conventional group after the completion of therapy. Also, after six months from baseline, that is, after the 3 moths follow-up period, this improvement is better in the MCST group than in a conventional therapy group. These findings are consonant with the previous study's findings.[10,11,15,33] These improvements may be because, in MCST, we used the global cognitive strategy with dynamic performance analysis, and the therapist acts as a moderator, not a direct trainer like in conventional therapy.[14,24,28] MCST improves goal-directed behaviour, planning, self-monitoring, and problem-solving skill of the participants. The goal-directed behaviour also creates interest, motivation, and control over participants' emotions. It improves the active participation and determination of the participants.[10,11,15] Hence, they do repeated practice in different environments in a different context, which improves experience dependant neuronal plasticity in the brain network, shaping the subsequent recovery trajectories.[36,37] It establishes patterns of behaviour or habits of the individual.[38] As a result, there is a more remarkable improvement in functional independence leading to a reduction in disability in the MCST treatment approach compared to conventional therapy. There is no significant improvement from post-intervention (3 month) to the follow-up (6 month) between the groups. However, the mean score of the MCST group is improved

where as in the conventional therapy group there is no such change in improvement in scores. This fact might pronounce there is steady improvement in the MCST intervention. This improvement may be because, the MCST intervention helps in generalization of learning and makes the participants confident [15,33] In our study the MCST group has more female participants than the conventional therapy which slowed down the rate of recovery of the MCST group.[39,40] Hence caused the statistical insignificance between 3 months & 6 months.

Limitation

The study is a pilot study with a Small sample size. Therefore, a large sample size is recommended to generalize the inference. The conventional therapy given to the control group was not standardized for the intervention based on impairment and components decided by the therapist. A standardize conventional intervention protocol may be used in future studies for better comparison of Experimental MCST intervention. This study had a relatively short follow-up period, three months after the post-intervention assessment and an average of 7 months following the baseline assessment. Hence a larger follow-up period, at least minimum of 1 year is recommended to infer a better retention effect of the MCST intervention.

Conclusion

MCST has greater efficacy in improving independence and reducing disability of post-stroke survivors than standard conventional therapy. So it can be applied as an intervention technique in the field of neurorehabilitation of post-stroke survivors for its long-term effect & better outcome. Many valuable lessons are learned while conducting this early phase of the clinical trial, which may be useful in designing the future confirmatory trials.

Funding Source

Nil.

Conflict of Interest

The authors declare no conflict of interest among them.

Acknowledgements

The authors are highly grateful to the Dean IMS & SUM Hospital and Director of Swami Vivekanand National Institute Rehabilitation Training and Research for their constant support throughout the study. The authors are also thankful to the staff and the patients of Occupational Therapy department for their help during the study.

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