Original Article

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Immediate Effect of Physiotherapist-demonstrated Action Observation with Execution for Improving Upper Extremity Motor Function in Stroke: a Pre-post Pilot Study

Shaj Shrestha,[1] Nistha Shrestha,[2] Abhishek Dhalachhe Shrestha,[3] Shambhu Prasad Adhikari[4]

[1]NITTE Institute of Physiotherapy, NITTE University, India, [2]Department of Health Services, Ministry of Health and Population, Government of Nepal, [3]Dhulikhel Hospital, Kathmandu University Hospital, Nepal, [4]School of Health and Exercise Sciences, University of British Columbia, Canada.

ABSTRACT

Background: Video-demonstrated action-observation-execution is an effective intervention for motor re-learning in stroke rehabilitation. But customization of video for each task repeatedly questions its feasibility within limited resources, particularly for daily routine practice and in community settings. Physiotherapist-demonstrated action-observation-execution is a practical intervention based on the principle of observation and consecutive repetitions of observed real, live movements. The main objective of this study was to investigate the immediate effect of Physiotherapist-demonstrated action-observation-execution in upper extremity motor training in stroke.

Methods: Individuals with stroke were screened and 5 eligible participants were recruited. The research was a pre-post. A single session of Physiotherapist-demonstrated action-observation-execution was administered. A functional "Drinking" task was subdivided into simpler acts and trained. Pre and post intervention assessment of movement time using five hand-and-arm items of Nepali Wolf Motor Function Test were carried out. Global recovery was assessed in the form of Visual Analogue Scale.

Results: Paired t-test provided statistically significant difference in total movement time (mean difference=5.04 seconds, standard deviation=1.92, p=0.004) with larger effect size (0.95) indicating impressive improvement in movement time with the training. Substantial difference in global recovery score was noted (mean difference=17.40, standard deviation=3.65, p<0.0001, effect size=1.00) signifying the increased confidence and improved performance of upper extremity post treatment.

Conclusions: The findings indicated that Physiotherapist-demonstrated action-observation-execution could be a feasible intervention to train motor functions in participants with stroke. Large-scale studies are recommended to establish the effectiveness of the intervention.

Keywords: Action-observation; action-execution; hand function; mirror neuron; stroke.

INTRODUCTION

About 80% of stroke survivors develop hemi-paretic upper extremity (UE),[1, 2] leading to difficulty in movement and co-ordination, which impact UE functions.[3] Mirror neuron system (MNS) of rehabilitation is one of the well-studied, best-practiced and evidence-based interventions for motor training.[4-6] Video-demonstrated action observation and execution (AOE) showed good evidence in promoting motor functions through activation of MNS.[7-10] However, it requires longer preparation time for video customization of desired tasks, which raises concern over its feasibility in clinical and community settings. Additionally, studies suggest greater activation of M1 brain region when viewing real-live movements than video-taped movements.[11] Physiotherapist-demonstrated AOE (PD-AOE) can overcome above-mentioned limitations. Moreover, desired movements in PD-AOE are performed live and changes in movements are adjusted as per the need immediately. The current study investigated immediate effect of PD-AOE in UE motor training in stroke.

Correspondence: Dr Shambhu Prasad Adhikari, School of Health and Exercise Sciences, University of British Columbia BC, Okanagan, Canada. Email: shambhu.adhikri@ubc.ca, Phone: +1 778 594 2164.

METHODS

Individuals with stroke were screened and the eligible participants were recruited from clinical services at Department of Physiotherapy, Dhulikhel Hospital (in-patient and out-patient clinic). The study was pre-post pilot study design with non-probability purposive sampling. This piloting aimed to examine the feasibility of administrating the intervention. Therefore, before obtaining a positive outcome, we do not want to recruit a control group which is ethically correct. Down the road, to confirm whether or not the positive outcome is due to the intervention effect, we have to have a control group receiving a usual care or standard treatment. Ethical approval was obtained from the Institutional Review Committee of Kathmandu University School of Medical Sciences / Dhulikhel Hospital (IRC-KUSMS 54/20). Written and informed consent were obtained from each participant prior to inclusion in the study.

Eligibility criteria for the study includes: aged 18 to 75 years, post stroke duration less than 6 months after onset, no cognitive impairments (Modified Mini Cog >3), mild-to-moderate motor impairments (motor and coordination scores 31 to 55 out of 66) on Fugl-Meyer assessment of UE (FMA-UE), normal or corrected vision (on the basis of medical reports). Exclusion criteria were; severe pain on Upper extremity (FMA pain domain = 0 on ≥ 3/5 joints), severely restricted shoulder, elbow and hand movements (FMA passive joint motion = 0/2), difficulty in independent sitting for at least 30 minutes, co morbidities if that affected assessment and intervention in this study.

Each participant had individual session for assessment and intervention. PD-AOE was administered by a registered physiotherapist (other than assessor) who was trained and standardized to administer AOE. Pre and post assessments were taken by a physiotherapist who was not involved in the treatment. The post-training assessment was taken immediately after the treatment on the same day.[12, 13] The detail procedure has been outlined in Figure 1.

Task selection: "Drinking" task was selected in mutual collaboration as it was task of choice for multiple participants and had been trained across many studies.[4, 5, 14] Drinking task is an unimanual task that is familiar to the participant, common in practice requiring simple hand-arm movements, goal directed and functional task. The vessel used for drinking task is a common and regular sized glass used in day-to-day activities by most common people in Nepal. [4]

Intervention (Physiotherapist-demonstrated Action-Observation with Execution): Participants received single session of Physiotherapist-demonstrated Action-Observation with Execution (PD-AOE). The task training included two phases; i) Task understanding phase, in which drinking task was divided into three motor acts in sequence of progression in order to ease the complexity of complete task and ii) Task repetition phase, in which complete task was then practiced twice with minimal rest in between. [4, 8] Therapist who administered the intervention was seated beside participants on their paretic side[15] (with adjustments made on height of table and chair). Participants were clearly instructed at the beginning to observe the demonstrated movements carefully with purpose of imitation later on. They were asked to count number of repetitions of each movement silently[16] (count did not need be in exact order). Since maximum corticomotor excitability occurs in first person orientation, the therapist mimicked affected side of participant to demonstrate movements of upper extremity in the same plane that the participant had to later repeat it.[15] Identical movements were performed at a normal speed with enough accuracy. After observation, participants had to execute the observed movements (maximum number of correct movements was emphasized). The physiotherapist assisted in execution phase whenever required (minimal assistance, active movement preferred over assisted movement). Any sort of physical or verbal disturbance was avoided during training. Continuous feedback and emphasis on achievement was provided to motivate the participant.

Total duration of intervention per session for a participant was 25 minutes with rest in between acts included. Justification for dosage and duration of session has been backed by studies providing enough evidences of encoding of motor memory in M1 in healthy older adult immediately following AO and motor practice.[17] Thus, considering the need for sustained attention throughout observation of task as well as prevention of fatigue during execution, we adapted to the condition of participants and administered a dose of 2 minutes of PT-demonstrated AO and 3 minutes of Execution per act i.e., 5 minutes for each motor act (Figure 2).

Outcome Measure: Nepali version of the Wolf Motor Function Test (N-WMFT) was a primary outcome measure. The cross-culturally translated Nepali version of Wolf Motor Function Test (N-WMFT) was used as primary tool to measure immediate effect of PT-demonstrated AO with Execution in UE motor function within a session of training. The movement time (MT) of participant was measured using total of only five items of the N-WMFT; Forearm to table, Extend elbow, Hand to table, Lift pencil and Lift can. The items addressed movement in each joint of upper extremity that was required for drinking task. Each item required primary joint movement i.e., 2 items for shoulder joint, single item for elbow joint and 2 items for fingers. The outcome measure has established psychometric properties with good to excellent criterion validity and reliability.[18] Furthermore, Wolf Motor Function Test (WMFT) has been recognized to detect immediate effect of a single session of task specific training [12, 19] as well as pre-post intervention changes in motor function particularly in stroke.[20] The secondary outcome measure used in the study was global recovery of hand function in the form of Visual Analogue Scale. The measurement of global recovery in stroke is in the form of VAS has been well studied.[21]

Statistics

Sample size was calculated using G*Power software. For a pre-post experimental study, when an effect size was considered 0.45 (medium), μ= 0.05, Power (1-β)= 0.80, the sample size was found to be 51. Since this was a pilot study, the sample size considered was 1/10 of the sample size obtained for a regular study i.e., 1/10 of 51 » 5. Therefore, we recruited 5 participants for this pilot study.

Descriptive analysis was done to describe participants' demographic and clinical characteristics. Shapiro-Wilk test was conducted to test the normality of data. Paired t-test was used to determine pre-post differences. Effect sizes were calculated using a formula (refer foot note, table 2). Level of significance was considered at $p < 0.05$. Data were analyzed in Statistical Package for Social Sciences (SPSS) version 25.

RESULTS

The current pre-post experimental study intended to determine the immediate effect of PD-AOE in upper extremity motor function of individual with stroke. A total of 48 individuals were screened for eligibility. Among them, five individuals who met the eligibility criteria were enrolled in the study (Figure 1).

As illustrated in Table 1, all participants were from older adult group, whose age ranged from 64 to 71 years (Mean: 68.4 years). There were 80% male and 20% female participants among which three of them had right-sided lesion and remaining two had left sided lesion. There was single case of hemorrhagic stroke and remaining four cases were ischemic stroke. Site of lesion in the brain was relatively heterogeneous as listed in the table 1. Chronicity of stroke ranged from 7 days to 120 days after onset (Mean: 51.2 days).

The mean score of participants in FMA-UE was 45.40 (SD 4.83), which indicated mild-to-moderate level of upper extremity motor impairment. All participants had full score (5/5) in the Modified Mini-Cog test, which inferred no cognitive impairments.

The Shapiro-Wilk test was used to evaluate the distribution of the data of the outcome variables. The p-value of the scores on each variable was >0.05, which indicated normal distribution. Therefore, paired-t test was used to compare pre-post scores.

Table 2 described the outcome of the inferential statistics. Paired t-test demonstrated statistically significant improvement in total movement of five items of N-WMFT (mean difference=5.04, SD=1.92, p=0.004, Effect size, r=0.95). The effect size found in this comparison was substantively large. Significant difference in movement time and large effect size was found for two items, forearm to table (mean difference=0.39 seconds, SD=0.90, p=0.012, Effect size, r=0.90) and extend elbow (mean difference=1.03 seconds, SD=0.51, p=0.011, r=0.91). Significant improvement with moderate effect size was found in the items; hand to table (mean difference=0.64 seconds, SD=0.49, p=0.042, r=0.83) and lifting pencil (mean difference=1.03 seconds, SD=0.78, p=0.043, r=0.82). However, improvement of movement time on lift can was at the borderline level of significance and relatively has a smaller effect size (mean difference=1.95, SD=1.66, p=0.059, r=0.79).

Global recovery of hand function was measured in the form of VAS prior to and after the intervention (Figure 3). There was significant difference in global recovery score (mean difference=17.40, SD 3.65, $p < 0.0001$, r=1.00), which indicated the increased confidence and improvement while performing upper extremity function.

Table 1. Characteristics and clinical features of the participants.								
Participants	Age (years)	Sex	Type of stroke	Side of lesion	Lesion location	Post-stroke duration (days)	FMAUE score	Modified Mini-Cog score
1	71	Male	Haemorrhagic	Right	Subcortical	16	52	5
2	68	Male	Ischemic	Right	Lacuna	92	41	5
3	64	Male	Ischemic	Left	Parieto-occipital lobe	21	42	5
4	69	Male	Ischemic	Right	Temporal lobe and external capsule	120	49	5
5	70	Female	Ischemic	Left	Basal ganglia	7	43	5
Mean (SD)	68.40 (2.70)	-	-	-	-	51.20 (51.24)	45.40 (4.83)	5.00 (.000)
Frequency (%)	-	Male 80% emale 20%	Haemorrhagic 20% Ischemic 80%	Right 60% Left 40%	-	-	-	-

Note: FMA: Fugl Meyer Assessment, Modified Mini-Cog score (out of 5), UE: motor and coordination score of upper extremity (out of 66), SD: Standard deviation

Table 2. Pre-post comparison using paired-t test. (N=5)						
Variables	Paired differences in pre-post test					
	Mean (SD)	t-statistics	df	p-value	95% CI	Effect size (r)
NWMFT (movement time in seconds)						
Total of 5 items	5.04 (1.92)	5.89	4	0.004**	2.66 - 7.42	0.95
Forearm to table	0.39 (0.20)	4.32	4	0.012*	0.14 - 0.64	0.90
Extend elbow	1.03 (0.51)	4.49	4	0.011*	0.39 - 1.67	0.91
Hand to table	0.64 (0.49)	2.95	4	0.042*	0.03 - 1.25	0.83
Lift pencil	1.03 (0.78)	2.92	4	0.043*	0.05 - 2.00	0.82
Lift can	1.95 (1.66)	2.62	4	0.059	-0.12 - 4.02	0.79
Global recovery scale score	-17.40 (3.65)	-10.67	4	0.000**	-21.93 - - 12.87	1.00

Note: p-value: from paired sample t-test, n: number of participants, * significance at p-value < 0.05, ** significance at p-value < 0.01, mean and standard deviation obtained from statistical difference of pre and post training data. Effect sizes were calculated using the following formula; Effect size= $\sqrt{[t^2/(t^2+df)]}$

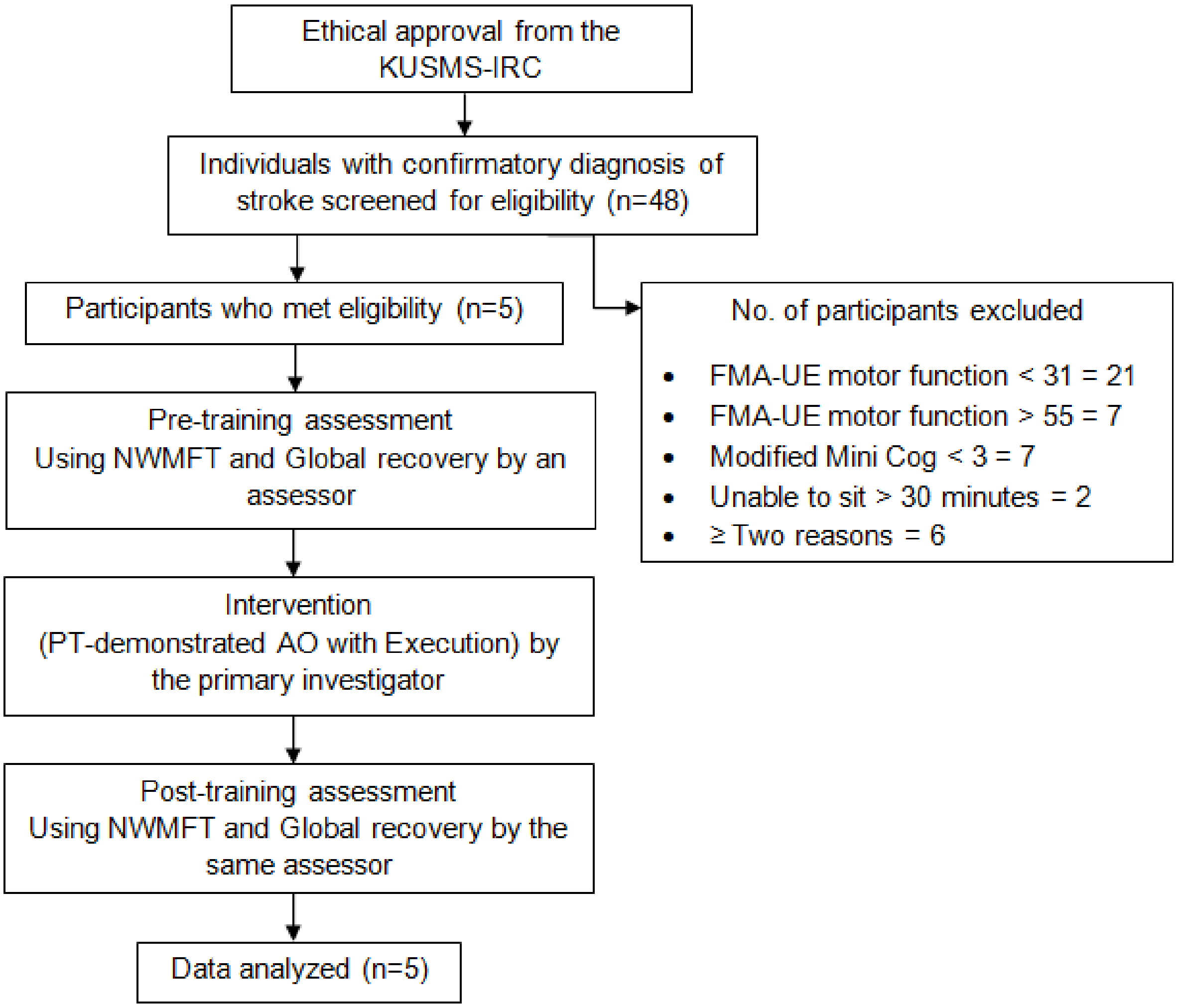

Figure 1. Flow diagram of procedure, n: number of participants, FMA-UE: Fugl-Meyer assessment-upper extremity, NWMFT: Nepali-Wolf Motor Function Test, VAS: Visual Analogue Scale.

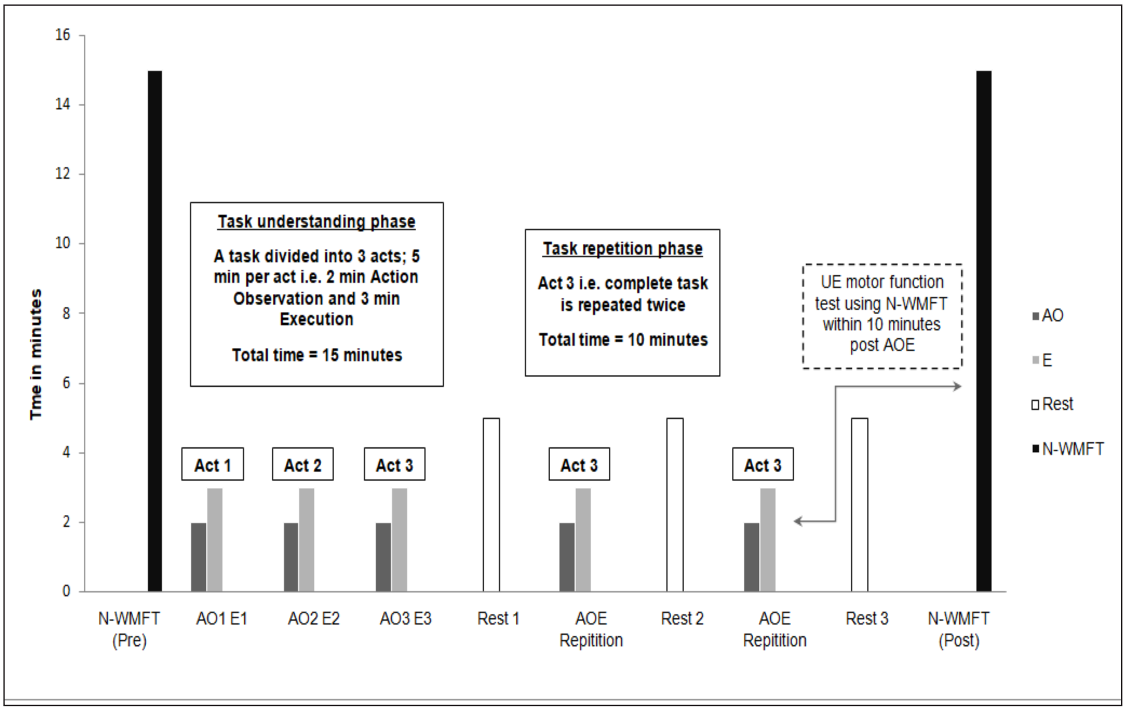

Figure 2. Physiotherapist-demonstrated action observation with execution protocol.

Note: AO: action-observation, E: execution, N-WMFT: Nepali-Wolf Motor Function Test

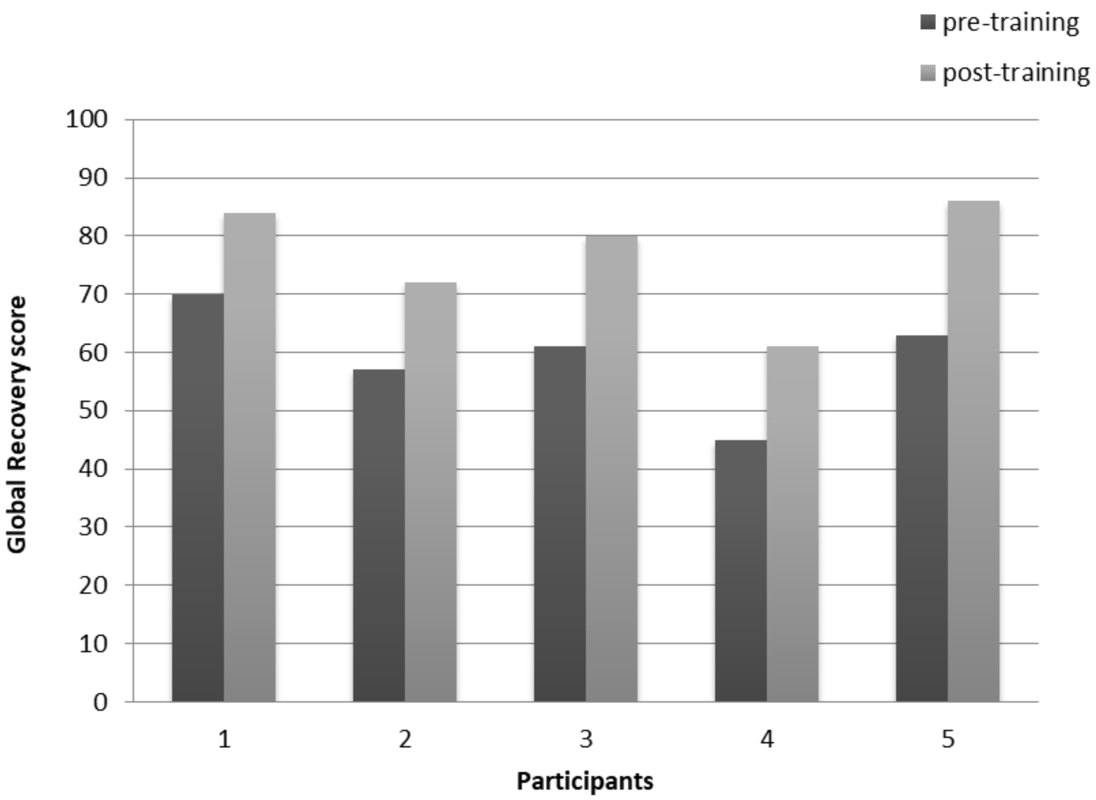

Figure 3. Bar diagram showing pre-post differences in global recovery scale.

DISCUSSION

We investigated an immediate effect of PD-AOE in individual with stroke. Beneficial effect in upper extremity motor function was found immediately following intervention.

Participants had heterogeneous characteristics in age, type and site of lesion. The spontaneous motor improvement in upper extremity after PD-AOE was independent to chronicity of stroke which is justified by established effectiveness of Action-Observation (AO) in improvement of upper extremity motor function in patient with acute,[22] sub-acute,[4] and chronic stroke.[23]

The remarkable reduction in movement time of all of 5 items of N-WMFT as well as total movement time indicated immediate improvement in upper extremity motor performance by the contribution of PD-AOE. However, due to the lack of an equivalent comparison study, we can't ensure that the positive effect was purely due to the intervention. But this study demonstrated that the intervention was feasibly implemented in individuals with stroke. However, based on the literatures, we can interpret that the PD-AOE induced improvement in participants' performance. The reason for such instant improvement might be the changes at substrate level [6, 24] since AO activates parieto-frontal mirror neuron system as well as the cortical motor loop.[24, 25] Thus, activation of mirror neuron system and motor cortex by AO therapy enhanced motor re-learning in individuals with stroke. Systematic review by Zhang et al. [10] concluded that association of AO that results in the activation of mirror neuron system promoted motor relearning in individuals with stroke. However study by Cowles et al. [15] and Fu et al. [26] concluded that observation followed by practice had no significant effect in motor recovery early after stroke, which is likely due to difference in integration of AO therapy in those studies.

Similar drinking behavior training which included video-AO was previously conducted.[27] However, in contradiction, our study included water filled in regular sized plastic glass and in addition; participants actually drank the water during execution. This allowed greater resemblance to the actual function while providing sense of accomplishment of the task. Thus, task-based AO might have assisted in manifestation of beneficial effects with single session of PD-AOE in the present study. [28, 29]

Constant verbal motivation throughout the session made participants attentive and encouraged practice as it is evident in the literature.[4] Motivation facilitated in distraction-free observation of the task and correct movement pattern all through execution, thus promoting positive effect immediately after single session of PD-AOE.

Our study protocol incorporated live demonstration of task by the physiotherapist unlike the orthodox practice of using pre-taped video featuring a model doing a particular task. [9, 10] This particular replacement of standard practice of observing movements in a video by live action observation plausibly intensified the effect of PD-AOE which led to betterment in upper extremity motor performance. The findings of our study were concordant with previous literature, [11] that recorded stronger activation of primary motor cortex (M1) when an individual observed live hand movements rather than videotaped or pre-recorded actions.

To best of our knowledge this is the first study to conduct AO with execution by means of live demonstration. However, given the similarity in concept of activation of mirror neuron system we can equate our results to pre-existing literatures of video-AO therapy. Similar to video-AO therapy, participants demonstrated noteworthy improvement in their upper extremity motor function following a single session of PD-AOE.

Substantial improvement in movement time of two items of N-WMFT, forearm to table and extend elbow demonstrated task specificity in accordance with the principles of neuroplasticity outlined by Kleim et al., 2008.[30] In our study the task during both assessment as well as intervention required reaching towards the table. Furthermore, the first motor act in drinking task also had reaching component. Greater repetition of reaching for the glass during drinking task in execution phase and pre-assessment might have improved their elbow extension and forearm to table. This indicated task specificity findings, consistent to studies, which have reported that task-specific training, induced motor improvements.[19, 27]

There was improvement in the movement time for lifting can but not significantly enough, which is consistent with findings of the study by Adhikari et al., 2018.[4] Since lifting against weight of the can required adequate strength, it resulted in longer time to complete the task. Immediate increase in strength after PD-AOE is not expected within a single session of treatment. Nevertheless, slight improvement in movement time for lifting can is suggestive of significant improvement in strength as well. Thus, this warrants for longer course of PD-AOE to achieve significant improvement in strength.

Substantial improvement in global recovery after the intervention (Figure 3) further solidified the progress in upper extremity motor function. The findings by Adhikari et al., 2018 are consistent with the findings of our study where the global recovery was assessed in the form of VAS after participants received 30 minutes of AOE.[4] Participants reported increase in confidence during upper extremity movements with PD-AOE.

Even if the sample size is small, the inferential statistics have given a clear and significant outcome and we believe that this approach of analysis is meaningful. Furthermore, we calculated an effect size using an established formula, and we found medium to high effect size. This indicated that the immediate effect of the intervention is substantial and measurable. This can be further proved in future studies by recruiting a comparable control group receiving a usual care or standard treatment.

This study also had some limitations. The small sample size prohibits clinical significance of the intervention and requires larger-scale study to establish PD-AOE for clinical practice. No control group for comparison might have compromised the level of evidence. Neuroimaging measures would have better justified measurement in the intervention-induced improvement in upper extremity motor function, which could be an area for future research.

CONCLUSIONS

This study concludes that PD-AOE enhanced the upper extremity motor function immediately after a single session of treatment in individuals with stroke. Significant improvement in movement time and global recovery score after intervention with overall larger effect size indicated enhanced motor function which would suggest implementation of PD-AOE for motor training in stroke rehabilitation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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