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A NOVEL APPROACH TO MENTAL PRACTICE COMBINED WITH TASK OBSERVATION (MOTOR IMAGERY): A RANDOMIZED CONTROLLED TRIAL

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ABSTRACT

Background: Task specific training requires some level of function which is not possible in severely paretic upper limb of the post stroke patients. Mental practice and task observation seem to offer beneficial effect to the upper limb of the patients. However, this effect is not so clear probably due to reduced number of repetition of the tasks practiced.
Aim: The aim of this study was to find out whether high repetition of mental practice combined with task observation can provide significant improvement in motor function in patients with severe hemiparesis following stroke.
Methods: Twenty five subjects comprising of 18 males and 7 females were randomized into experimental (n=15) and control (n=10) groups. The experimental and control groups received mental practice and task observation and traditional therapy respectively, 3 sessions per day, 7 days per week for 6 weeks. The outcome was evaluated using WMFT and MAL at baseline, 4 weeks and 6 weeks post intervention. Statistical analysis was carried out using an independent sample t-test and one-way repeated measures ANOVA.
Result: The result showed that there was a significant difference between the experimental and control group at baseline ($p<0.05$). However, at 4 weeks and 6 weeks, there was no significant difference between the experimental and control group ($p>0.05$) on both outcome measures.
Conclusion: Mental practice combined with task observation is effective in the rehabilitation of severe paretic upper limb of stroke patients when performed several 100 times per day.

INTRODUCTION

Task oriented training has been proven to be the mainstay for upper limb rehabilitation after stroke (Van Peppen *et al.*, 2004 and Bosch *et al.*, 2014). However, task oriented training requires some degrees of motor ability such as the ability to extend fingers and wrist to 10° and 20° respectively (Sirtori *et al.*, 2009). Consequently, those with severe upper limb paresis as a result of stroke cannot perform task oriented training. Recently, conflicting evidence has emerged on the potential efficacy of mental practice and motor imagery (task observation) in patients with and without any motor ability (Braun *et al.*, 2006; Zimmermann-Schlatter *et al.*, 2008; Johnson-Frey, 2004; Braun *et al.*, 2010 and Ietswaart *et al.*, 2011). The conflicting evidence could be as a result of the nature of the task performance which is essentially passive.

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When movements are executed passively, the activation of motor cortex is weaker than if they are performed actively (Lotze *et al.*, 2003). Additionally, even with active task performance, high repetition of the tasks is required for motor recovery (Nudo and Milliken, 1996; Abdullahi *et al.*, 2014 and Birkenmeier *et al.*, 2010). However, studies on mental practice and motor imagery traditionally used the hours of task practice to determine the amount of task practiced such as 45 minutes per session; (Ietswaart *et al.*, 2011) and 30 minutes embedded in a regular therapy (Braun *et al.*, 2010). This kind of protocol has been argued not to clearly demonstrate how much tasks were practiced (Abdullahi, 2014) and thus counting the number of task repetitions as a measure of dose could be more straightforward and appropriate (Abdullahi, 2014 and Scrivener *et al.*, 2011). In line with the above argument, researchers have found that, stroke patients irrespective of their stage of stroke can actively perform high repetitions of task practice in the region of 300 times per day, which is required for functional improvement (Abdullahi *et al.*, 2014 and Birkenmeier *et al.*, 2010). We therefore aimed to find out whether mentalizing and observing motor task performance, 300 times each per day can result in significant improvement in upper limb motor function in stroke patients.

METHODS

The study was an experimental study; randomized controlled trial (RCT) with pre-test and post-test design. The study was approved by the research ethics committee of Kano state hospitals management board. The population of this study was stroke patients attending physiotherapy department at Murtala Muhammad specialists' hospital, Kano. For patients to be included in the study, they must fulfill the following criteria: severe upper limb impairment criteria (score of < 2 on Medical Research Council Scale), patients with no severe cognitive impairment (Mini mental scale examination (MMSE) score ≥ 17), patients ≥ 18 years, patients who provided their consents to participate in the study, patient with no any upper limb deformity and patients with first ever stroke.

Twenty five consecutive patients with stroke who gave their written consents were randomly assigned into experimental group (n=15) and control group (n=10). See figure 1 for the study flow chart. Participants were assessed at baseline and 4; and 6 weeks post-intervention for motor function using Wolf Motor Function Test (WMFT) and Motor Activity Log (MAL). WMFT is a measure of upper limb function with an established reliability and validity (Wolf *et al*., 1989). It comprises of 15 time-based tasks and 2 strength based tasks. MAL is originally a structured self-report of amount and quality of use of the affected arm comprising of 30 ADL based activities. The scale has been reported to have a high internal consistency, high inter-rater reliability and high test–retest reliability (Miltner *et al*., 1999). In both WMFT and MAL, each item is scored from 0-5, with a higher score indicating a better functional ability. In this study, the scores were assumed to have equal intervals; and participants were rated after performing the tasks.

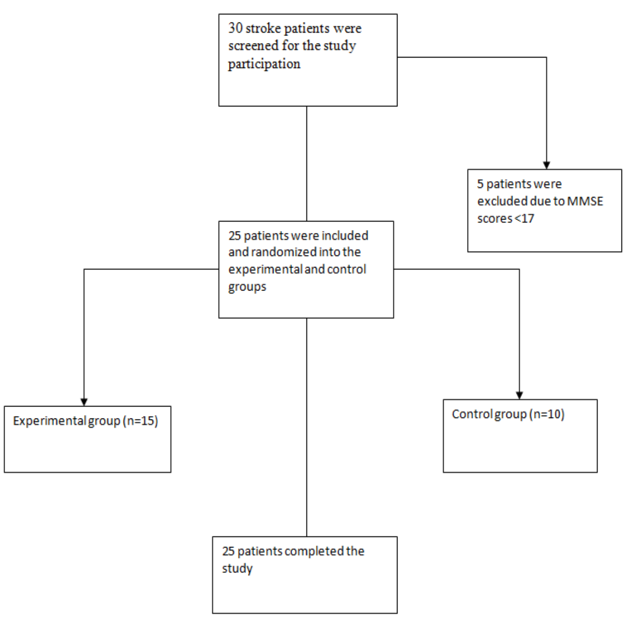

Figure 1. The Study Flow Chart

In the experimental (mental practice plus task observation group), mental practice and observation of performance of 8 tasks used in a study by Abdullahi and colleagues were carried out (Abdullahi *et al*., 2014). The tasks were carried each 20 times per session, 3 times a day for 6 weeks. No constraint was used for the unaffected limbs. In the control group, the participants went through usual treatment strategies done for severe paretic stroke patients such as: passive movement (where all major joints of the upper limb were mobilized 20 times per session, 3 times a day for 6 weeks), weight bearing exercises of the upper limb (20 minutes per session, 3 times a day for 6 weeks) and active passive bilateral therapy (30 times per session, 3 times a day for 6 weeks).

Data Analysis

The characteristics of the study participants were summarized using descriptive statistics of table, numbers and percentages. The data generated by WMFT and MAL were analyzed using an independent sample t-test to compare between group differences at baseline, and 4; and 6 weeks post-intervention. Similarly, a one-way repeated measures ANOVA was used to compare difference between baseline and 4; and 6 weeks post-intervention scores within group. Attempts were made to determine the effect of a covariate (baseline scores) on the post-intervention scores at 4 and 6 weeks using analysis of covariance (ANCOVA), but the data violated the assumption of equality of error variances. Thus, this analysis was not included in this report.

RESULTS

Twenty five stroke patients comprising of males (N=18) and females (N=7) with mean age 56.8 years and mean time since stroke 13.7 weeks were included in the study. The left side and right affectation were (N=15) and (N=10) respectively. Table 1 details the characteristics of the study participants.

Comparison of Differences between Groups

An independent sample t-test was conducted to compare the effect of experimental and control groups post interventions on motor function assessed using WMFT and real world arm use assessed using MAL. Table 2 details the result for this analysis. For the WMFT, at baseline there was a significant difference between experimental group (M=0.46, SD=0.30) and control group (M=0.86, SD=0.43), t (25) =-2.78, p=0.01).The magnitude of the difference in the means (Mean difference = -0.40, 95% CI: -0.70 to -0.10) was very large, eta squared = 0.25.

At 4 weeks, there was no significant difference between experimental group (M=0.79, SD=0.41) and control group (M=0.87, SD=0.43), t (25) =-0.47, p=0.64.The magnitude of difference in the means (Mean difference = -0.81, 95% CI: -0.44 to 0.27) was very small, eta squared =0.01.

At 6 weeks, there was also no significant difference between experimental group (M=0.89, SD=0.42) and control group (M=0.89, SD=0.43), t (25) =-0.06, p=1.00. The magnitude of difference in the means (Mean difference = -0.01, 95% CI: -0.36 to 0.36) was very small, eta squared <0.01.

Table 1. Characteristics of the study participant

SN	Age	Sex	Time since stroke	Side affected	MRCS	NIHSS	MMSES	Group participants allocated to
1.	45	Male	12 weeks	Left	1	3	25	Experimental
2.	50	Male	8 weeks	Right	0	4	29	Experimental
3.	45	Female	12 weeks	Right	1	3	28	Experimental
4.	55	Female	16 weeks	Left	1	3	25	Experimental
5.	48	Male	10 weeks	Left	1	3	23	Experimental
6.	60	Male	13 weeks	Left	1	3	24	Experimental
7.	55	Male	12 weeks	Right	0	4	27	Experimental
8.	48	Male	9 week	Left	0	4	26	Experimental
9.	59	Female	16 weeks	Left	1	3	25	Experimental
10.	60	Male	15 weeks	Right	1	3	26	Experimental
11.	58	Male	12 weeks	Left	1	3	26	Experimental
12.	47	Male	15 weeks	Right	1	3	30	Experimental
13.	50	Male	10 weeks	Left	1	3	25	Experimental
14.	57	Male	12 weeks	Left	1	3	27	Experimental
15.	49	Male	14 weeks	Right	1	3	27	Experimental
16.	52	Female	15 weeks	Right	1	3	29	Control
17.	58	Female	16 weeks	Left	1	3	22	Control
18.	45	Female	13 weeks	Left	1	3	29	Control
19.	52	Male	15 weeks	Right	1	3	27	Control
20.	59	Female	18 weeks	Right	2	3	30	Control
21.	57	Male	20 weeks	Left	1	3	24	Control
22.	90	Male	12 weeks	Left	0	4	22	Control
23.	75	Male	17 weeks	Left	1	3	24	Control
24.	85	Male	16 weeks	Right	1	3	20	Control
25.	60	Male	15 weeks	Left	1	3	25	Control

Table 2. T-test result showing difference in WMFT and MAL scores between groups at baseline and 4; and 6 weeks post-intervention

Scale (Mean +SD)	Time period (Mean +SD)	Experimental	Control	t-value	p-value
		(n=15)	(n=10)		
WMFT	Baseline	0.46 ± 0.3	0.86 ± 0.43	-2.7	0.01
	Fourth week	0.79 ± 0.41	0.87 ± 0.43	-0.47	0.64
	Sixth week	0.89 ±0.42	0.89 ± 0.43	-0.06	1.00
MAL (AOU)	Baseline	0.32 ±0.18	0.57 ±0.33	-2.48	0.02
	Fourth weeks	0.46 ± 0.24	0.58 ±0.34	-1.00	0.33
	Six weeks	0.55 ±0.28	0.60 ±0.37	-0.40	0.69
MAL (QOU)	Baseline	0.32 ± 0.18	0.57 ± 0.33	-2.4	0.02
	Fourth week	0.46 ± 0.24	0.58 ± 0.34	-1.00	0.33
	Six weeks	0.55 ± 0.28	0.60 ± 0.37	0.40	0.6

Table 3. ANOVA Result showing the difference within group at baseline and 2; and 4 weeks post-intervention

Scale	Study group	Time period	N	Mean + SD	F-value	P-value
WMFT	Experimental	Baseline	15	0.46±0.30	22.93	<0.05
		4th week	15	0.79±0.41		
		6th week	15	0.89±0.42		
	Control	Baseline	10	0.86±0.43	3.80	0.007
		4th week	10	0.87±0.43		
		6th week	10	0.90±0.44		
MAL (AOU)	Experimental	Baseline	15	0.32±0.18	17.99	<0.05
		4th week	15	0.46±0.24		
		6th week	15	0.55±0.28		
	Control	Baseline	10	0.57±0.33	5.18	0.143
		4th week	10	0.58±0.34		
		6th week	10	0.60±0.37		
MAL (QOU)	Experimental	Baseline	15	0.32±0.18	17.99	<0.05
		4th week	15	0.46±0.24		
		6th week	15	0.55±0.28		
	Control	Baseline	10	0.57±0.33	5.18	0.14
		4th week	10	0.58±0.34		
		6th week	10	0.60±0.37		

For the MAL (AOU), at baseline there was a significant difference between experimental group (M=0.32, SD=0.19) and control group (M=0.57, SD=0.33), t (25) =-2.48, p=0.002. The magnitude of the difference in the means (Mean difference = -0.25, 95% CI: -0.47 to -0.04) was very large, eta squared = 0.21.

At 4 weeks, there was no significant difference between experimental group (M=0.46, SD=0.24) and control group (M=0.58, SD=0.34), t (25) =-1.00, p=0.33. The magnitude of difference in the means (Mean difference = -0.12, 95% CI: -0.36 to 0.12) was very small, eta squared =0.04.

At 6 weeks, there was also no significant difference between experimental group (M=0.55, SD=0.28) and control group (M=0.60, SD=0.37), t (25) =-0.40, p=0.69). The magnitude of difference in the means (Mean difference = -0.05, 95% CI: -0.33 to 0.22) was very small, eta squared =0.007.

For the MAL (QOU), at baseline there was a significant difference between experimental group (M=0.32, SD=0.19) and control group (M=0.57, SD=0.33), t (25) =-2.38, p=0.003). The magnitude of the difference in the means (Mean difference = -0.25, 95% CI: -0.46 to -0.03) was very large, eta squared = 0.20.

At 4 weeks, there was no significant difference between experimental group (M=0.46, SD=0.24) and control group (M=0.57, SD=0.34), t (25) =-1.01, p=0.33.The magnitude of difference in the means (Mean difference = -0.12, 95% CI: -0.36 to 0.12) was very small, eta squared =0.04.

At 6 weeks, there was also no significant difference between experimental group (M=0.55, SD=0.28) and control group (M=0.60, SD=0.37), t (25) =-0.40, p=0.69. The magnitude of difference in the means (Mean difference = -0.05, 95% CI: -0.32 to 0.22) was very small, eta squared =0.01.

Comparison of within Group Differences

A one -way repeated measures ANOVA was conducted to compare mean scores on WMFT and MAL for the experimental and control groups respectively at baseline, four weeks and six weeks post-intervention. The result for this analysis is detailed in table 3. For the WMFT, in the experimental group, there was a significant difference between baseline, 4 weeks and 6 weeks post-intervention, Wilks lambda =0.22, F(2,15) =22.92, p < 0.05, multivariate partial eta squared = 0.78. From baseline to 4 weeks post-intervention, there was a significant improvement in motor function (mean difference = -0.33), 95% CI: -0.47 to -0.20, p<0.05. From baseline to 6 weeks post-intervention, there was also a significant improvement in motor function (mean = -0.43), 95% CI: -0.60 to -0.26, p<0.05. Similarly, from 4 weeks to 6 weeks post-intervention, there was a significant improvement in motor function (mean difference = -0.10), 95% CI: 0.17 to -0.21, p< 0.005.

For the control group, there was no significant difference between baseline, 4 weeks and 6 weeks post-intervention, Wilks lambda =0.51, F(2,10) =3.80, p=0.007, multivariate partial eta squared =0.49.

For MAL (AOU), there was a significant difference between baseline, four weeks and six weeks post stroke intervention, Wilks lambda =0.28, F(2,15) =17.99, p< 0.05, multivariate partial eta square = 0.72. From baseline to 4 weeks post-intervention, there was a significant improvement in motor function (mean difference = -0.14), 95% CI: -0.21 to -0.78, p<0.05. From baseline to 6 weeks post-intervention, there was a significant improvement in motor function (mean difference= -0.24), 95% CI: -0.38 to -0.10, p<0.05. From 4 weeks to 6 weeks post-intervention, there was no significant improvement in motor function (mean difference = -0.91), 95% CI: -0.19 to 0.12, p< 0.05.

For the control group, there was no significant difference between baseline, 4 weeks and 6 weeks post-intervention, Wilks lambda =0.62, F (2, 10) = 2.51, p=0.14, multivariate partial eta squared = 0.39.

For the MAL (QOU), in the experimental group, there was a significant difference between baseline and 4 weeks and 6 weeks post-intervention, Wilks lambda =0.28, f(2,15) =17.99, p< 0.05, multivariate partial eta squared = 0.72. From baseline to 4 weeks post-intervention, there was a significant improvement in motor function (mean difference = -0.14, 95% CI: -0.21 to -0.78, p<0.005). From baseline to 6 weeks post-intervention, there was a significant improvement in motor function (mean difference= -0.24), 95% CI: -0.38 to -0.10, p<0.005. From 4 weeks to 6 weeks post-intervention, there was no significant improvement in motor function (mean difference = -0.91), 95% CI: -0.19 to 0.12, p> 0.005

For the control group, there was no significant difference between baseline, 4 weeks and 6 weeks post-intervention, Wilks lambda =0.62, F (2, 10) = 2.51, p=0.14, multivariate partial eta squared = 0.39.

DISCUSSION

This study investigated the effect of combined mental practice and task observation (motor imagery) in the rehabilitation of severely paretic upper limbs in stroke patients. The outcome of the study revealed significant improvements in motor function and quality of the upper limb assessed using WMFT and MAL in patients that received mental practice and task observation. At baseline, there was significant difference on both outcome measures in favour of the control group. At four and six weeks, there were however no significant differences between the experimental and control groups. The idea of mental practice and motor imagery emanated from previous study in monkey's brain (Nelissen *et al.*, 2011). This research discovered the existence of specialized neurons known as "mirror neurons" that discharge on both action performance and action observation of a second individual, with performance of a motor action and with observation of another individual performing similar motor tasks. Motor imagery is thought to generate an internal representation of motor action that can be activated for motor relearning (Jeannerod and Decety, 1995).

The study carried out by page and colleagues is also in line with this study; it shows that subjects participating in a regimen combining mental practice and physical practice showed large reductions in affected arm impairment as measured by the Fugl-Meyer (FM), and large increases in movement as measured by the Action Research Arm Test (ARAT) (Page *et al*., 2007). In both cases mental practice and physical practice subjects showed significant changes. On a contrary, the findings of the present study was opposed by the findings of Ieswaart and colleagues which suggested that mental practice with motor imagery does not enhance motor recovery in patients early post-stroke (Ietswaart *et al*., 2011). The absence of effect that was observed from the study could be as a result of the focus on the duration of the mental practice and motor imagery rather than the number of repetition of the motor imagery, as duration spent may not show how much tasks were observed and /or mentalized. However, the present study focused more on high repetition of both mental practice and task observation on various tasks performed using the upper limbs. Furthermore, the whole days of the week were engaged in the practice, while only 3 days of the week was used for intervention in the study by Ieswaart *et al*. and colleagues and Braun and colleagues (Braun *et al*., 2010 and Ietswaart *et al*., 2011).

Additionally, as opposed to previous protocols; (Braun *et al*., 2006; Braun *et al*., 2010 and Ietswaart *et al*., 2011) our protocol required patients to mentalize the tasks immediately after observing the therapist or a relative did it. For example, if a patient was to mentalize picking up a cup and drinking from it 20 times, the therapist or the relative performed the task first, and then followed by mental practice by the patients until the task was observed and mentalized 20 times sequentially. This was to foster better compliance with the protocol. Furthermore, the mean age of the participants (56.8 years) in the present study is much lower than that in the study by Braun and colleagues, which was 77.7 years (Braun *et al*., 2006). Advancing age can be an impediment to functional performance (Kimberley *et al*., 2010). Consequently, difference in the effectiveness of mental practice in favour of the present study protocol, could be a factor of age. Nonetheless, similar to the previous study this study is limited in that it has a small sample size and the sizes of the lesion of the individual participants were not known.

Conclusion

Rehabilitation of the severely paretic upper limb is effective through the combination of high repetitions of task observation and mental practice.

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