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Number of repetitions versus duration in hours as dose measures of task practice during constraint induced movement therapy: a randomized controlled trial

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Abstract

Background. Constraint induced movement therapy (CIMT) is used in the rehabilitation of an upper limb after stroke. However, its protocol, especially the issue of a dose, seems not clear as duration in hours of task practice is used as a measure of dose.

Aim. The aim of this study is to compare the use of a number of repetitions (sCIMT) and duration in hours (tCIMT) of task practice as measures of dose during CIMT in chronic stroke patients.

Method. The sCIMT performed the same 8 functional tasks each of 20 times, 2 times a day, 5 times a week for 6 weeks with the affected limb (n=5). The unaffected limb was constrained in an arm sling for 90% of the waking hours during the period of the intervention. While tCIMT group performed 2 hours of tasks practice (8 tasks) convenient for them with the affected upper limb and constraint of the unaffected upper limb for 5 hours a day, 5 days a week for 6 weeks (n=5). The study data was collected using Wolf motor function test (WMFT) at baseline, 2, 4 and 6 weeks post-intervention. The data was analyzed using repeated measures ANOVA, independent t-test, and ANCOVA at $p<0.05$.

Findings. The results showed significant difference ($p<0.05$) in WMFT functional ability between baseline, and 2, 4 and 6 weeks post-intervention in the sCIMT group. However, there were no significant differences ($p>0.05$) between sCIMT and tCIMT in WMFT functional ability and performance time at baseline, and 2, 4 and 6 weeks post-intervention.

Conclusion. sCIMT is effective and comparable to tCIMT. However, its protocol seems more clear, simple and practicable.

Key words: stroke, constraint induced movement therapy, dose, motor recovery, upper limb and task repetition

Introduction

Stroke is a neurological condition characterized by rapidly developing clinical symptoms and/or signs of focal and at times global, loss of cerebral function lasting more than 24 hours or leading to death with no apparent causes other than of vascular origin (Hatano, 1976). The consequence of stroke is impairment in brain functions; motor, sensory/ perceptual and cognitive functions (Hendricks et al., 2002; Lang et al., 2013). These impairments can manifest as problems with limb movement, speech problems, neglect and apraxia (Čengić et al., 2011; Sun et al., 2014). An important impairment after a stroke is impairment in motor function of the upper limb which occurs in about 80% of the cases (Nakayama et al., 1994). In the ensuing years such as after 2-3 years post stroke, about 25-45% of the patients may regain some level of functions (Broeks et al., 1999); whereas about 50% will continue to have long term functional impairments (Parker et al., 1986; Olsen, 1990).

One of rehabilitation techniques for upper limb impairment after stroke is constraint induced movement therapy (CIMT). Constraint induced movement therapy involves restraining of the sound limb for a certain period, mostly about 90% of waking hours and encouraging mass practice of functional tasks with the affected limb (Taub and Berman, 1963; Ostendorf and Wolf., 1981; Taub et al., 1993; Wolf et al., 2006). The available evidence showed that the technique is effective at improving moderate and mild impairment (Wolf et al., 2006; Sirtori et al., 2009; Peurala et al., 2012; Thrane et al. 2014). However, like many rehabilitation techniques, CIMT seems to lack clarity of protocols especially as regards to dose (Pollock et al., 2014; Abdullahi, 2014).

The lack of clarity in protocols is evident in the literature which shows different formats concerning the parameters of treatment using CIMT most especially regarding the duration of restraint of the sound limb, duration of treatment and types of tasks performed with the affected limb. Studies such as the EXCITE trial (Wolf et al., 2006) and Uswatte et al. (2006) used 6 hours of tasks practice with the affected limb and constrained the unaffected limb for 90% of the waking hours. Similarly, shorter durations of CIMT such as 3 hours and constraint for 90% of the waking hours (Brogardh et al., 2009) and 2 hours and constraint for 6 hours (Dromerick et al., 2009) for 2 weeks have also been reported.

The seemingly contestable claim in the literature is that, shorter duration of CIMT has been reported to be superior to the longer duration of CIMT (Nijland et al., 2011; Peurala et al., 2012; Sirtori et al., 2009) in acute and sub-acute and chronic patients. However, a retrospective analysis (Kaplon et al., 2007) of signature CIMT which gives 6 hours of task practice and constraint for 90% of the waking hours, found only 3.5 hours as the actual time spent by patients in carrying out

task practice. Similarly, Stock et al. (2015) reported that only 33% of the total time of a session of rehabilitation during CIMT was spent on pure motor activity. The remaining time was used for feedback, task set up and rest. These suggest, that it does not matter how long patients stay during a rehabilitation session.

Recently, there have been reports (Birkinmeier et al., 2010; Abdullahi et al., 2014; Abdullahi & Shehu, 2014; Abdullahi et al., 2015) of a simple, clear and cost effective method of administering CIMT. This method uses number of repetitions of task practice spread over sessions per day as a measure of dose during CIMT. The reports (Birkinmeier et al., 2010; Abdullahi et al., 2014; Abdullahi & Shehu, 2014; Abdullahi et al., 2015) showed that repetition of task practice per day in the region of 300 and 320 is sufficient for motor recovery, and that it is comparable (Abdullahi & Shehu, 2014) in terms of effectiveness with the CIMT using duration in hours of task practice as a measure of dose. However, the use of number of repetitions, of task practice and duration in hours as measures of dose has not been compared in chronic stroke patients. The aim of this study is to answer the following questions:

1. What will be the effect of the use of number of repetitions, of task practice as a measure of dose during CIMT on motor function in patients who are ≥ 6 months post-stroke?
2. What will be the effect of the use of number of repetitions, of task practice as a measure of dose compared with the use of duration in hours of task practice as a measure of dose during CIMT on motor function in patients who are ≥ 6 months post-stroke?

Methods

The study is a randomized controlled trial (RCT) with pretest-posttest design approved by the Research Ethics Committee of Aminu Kano Teaching Hospital. The population of the study was chronic stroke patients (≥6 months post-stroke) attending physiotherapy department, Aminu Kano Teaching Hospital (AKTH). The study inclusion criteria include clinical diagnosis of haemorrhagic or ischemic stroke, patients who are ≥6 months post-stroke at the start of the study, patients with no significant cognitive impairment as indicated by scores of ≥17 on Mini-Mental State Examination (MMSE), patients with ≥ 20° of wrist and ≥ 10° of all digits extension, patients with no severe aphasia and severe shoulder pain that can affect therapy.

Twenty three stroke patients were assessed for the eligibility to participate in the study. Out of this number, only 13 patients fulfilled the study inclusion criteria. The remaining 10 patients did not fulfill the study inclusion criteria and were excluded from the study. For the patients who fulfilled the study inclusion criteria, only

10 gave their consent to participate in the study and they were randomized into the standardized CIMT (sCIMT) group (n=5) and traditional modified CIMT (tCIMT) group (n = 5) using sealed opaque envelopes. See figure 1 for the study flow chart.

The instruments used in the study are full circle goniometer, Wolf Motor Function Test (WMFT), Mini-Mental State Examination (MMSE), Stop Watch, Visual Observation and Counting of repetitions of tasks practice. The WMFT consists of 15 timed functional tasks and two strength-based tasks (Wolf et al, 1989). It is a reliable and valid test of upper limb motor function (Sawaki et al, 2008). The rating of the functional ability is on a scale ranging from 0 to 5, with higher scores representing better function. Performance time was rated in seconds using a stop watch.

Study participants were assessed at baseline, 2, 4 and 6 weeks post-intervention in both sCIMT and tCIMT groups. The sCIMT performed the same 8 functional tasks each 20 times, 2 times a day, 5 times a week for 6 weeks with the affected limb. The details of the functional tasks performed are described in a previous study (Abdullahi et al., 2014). The unaffected limb was constrained in an arm sling for 90% of the waking hours during the period of the intervention. While tCIMT group performed 2 hours of tasks practice (8 tasks) convenient for them with the affected upper limb and constraint of the unaffected upper limb for 5 hours a day, 5 days a week for 6 weeks. No additional therapy was given to the upper limb during the study period in both groups.

The within group data in both sCIMT and tCIMT groups was analyzed using repeated measures ANOVA, and the between groups data was analyzed using independent t-test. All analyses were carried using SPSS version 12 at $p<0.05$. A one-way analysis of covariance (ANCOVA) was also conducted to determine the effect of the covariate (baseline scores) on the post-interventions scores in the sCIMT and tCIMT groups. This analysis was conducted in order to increase the likelihood of detecting differences between groups.

Result

Ten patients with age range 30-78 years, mean age 58.80±14.33 years, time since stroke range, 8-49 months and mean time since stroke, 28.70±12.40. There were 7 females and 3 males, and 6 patients and 4 patients with right sided hemiplegia respectively in the study. Nine of the patients had ischaemic stroke and only 1 had haemorhagic stroke. Analysis of the difference between groups (using independent t-test for age and time since stroke, and Mann-Whitney U test for type of stroke, side affected and sex), showed that there was significant difference between groups ($p>0.05$). See table 1 for this analysis and the characteristics of the included study participants.

Determination of within group differences using one-way repeated ANOVA

Result for WMFT (Functional ability)

For the sCIMT group, there was a significant difference in motor function between baseline, 2 weeks, 4 weeks and 6 weeks Wilk's lambda=0.02, F=(3,5)=29.20, p=0.03, multi-variate partial eta squared=0.98. Sub-group analysis revealed significant differences between baseline and 4 weeks (means difference=- 0.82, 95% CI; -1.13 to -0.52, p=0.001), baseline and 6 weeks (means difference=- 1.30, 95% CI; -1.90 to -0.70, p=0.003), 2 and 6 weeks (means difference=-0.98, 95% CI; -1.49 to -0.46, p=0.005 and 4 and 6 weeks (means difference=-0.47, 95% CI; -0.93 to -0.02), p=0.04.

For the tCIMT group, there was no significant difference in motor function between baseline, 2 weeks, 4 weeks and 6 weeks Wilk's lambda=0.l7, F=(3,5)=3.21, p=0.25, multivariate partial eta squared=0.83. The result of this analysis is presented in table 2.

Result for WMFT (Performance time)

For the sCIMT group, there was no significant difference in the speed of motor activity between baseline, 2 weeks, 4 weeks and 6 weeks. Wilk's lambda=0.l83, F(3,5)=2.97, p=0.26, multivariate partial eta squared 0.82. For the tCIMT, there was no significant difference in the speed of motor activity between baseline, 2 weeks, 4 weeks and 6 weeks, Wilk's lambda=0.13, F(3,5)=4.54, p=0.19, multivariate partial eta squared 0.87. The result of this analysis is presented in table 2.

Effectiveness of standardized constraint induced movement therapy (sCIMT) and traditional constraint induced movement therapy (tCIMT) compared using independent t-test

Result for WMFT (functional ability)

At baseline, there was no significant difference between the sCIMT (mean=2.34, SD=0.52) and tCIMT (mean=3.01, SD=0.48) t (10) =-2.15, p=0.06 two-tailed. The magnitude of the difference in the mean (mean difference=-0.68, 95% CI; -1.4 to 0.05) was very large, eta squared=0.37. At 2 weeks,

there was no significant difference between the sCIMT (mean=2.66, SD=0.77) and tCIMT (mean=3.20, SD=0.32) t (10) = -1.45, p=0.19 two-tailed. The magnitude of the difference in the mean (mean difference= -0.54, 95% CI; -1.4 to 0.32) was very large, eta squared=0.21. At 4 weeks, there was no significant difference between the sCIMT (Mean=3.16, SD=0.52) and tCIMT (mean=3.60, SD=0.38) t (10) =- 1.52, p=0.17 two-tailed. The magnitude of the difference in the mean (Mean difference 0.44, 95% CI; -1.10 to 0.22) was very large, eta squared 0.22. At 6 weeks also, there was no significant difference between the sCIMT (mean=3.64, SD=0.66) and tCIMT (mean 3.65, SD=O.40) t (10) =-0.38, p=0.97 two-tailed. The magnitude of the difference in the mean (mean difference=-0.01, 95% CI; -0.81 to 0.79) was very small, eta squared=0.02. See table 3 and figure 2 for more details.

Result for WMFT (performance time)

At baseline, there was no significant difference between the sCIMT (mean=3.94, SD=2.10) and tCIMT (mean=4.10, SD=1.60) t (10) =-0.l4, p=0.89 two-tailed. The magnitude of the difference in the mean (Mean difference=-0.16, 95% CI; -2.88 to 2.56) was very small, eta squared<0.01. At 2 weeks, there was no significant difference between the sCIMT (mean=3.63, SD=1.84) and tCIMT (mean=3.52, SD=0.67) t (10) =0.12, p=0.91, two-tailed. The magnitude of the difference in the mean (mean difference=0.10, 95% CI; -1.91 to 2.12) was very small, eta squared<0.01. At 4 weeks, there was no significant difference between the sCIMT (mean=2.96, SD=1.99) and tCIMT (Mean=3.05, SD=1.10) t (10) = - 0.09, p=0.93, two-tailed. The magnitude of the difference in the mean (mean difference=-0.09, 95% CI; -2.44 to 2.25) was very small, eta squared=0.01. At 6 weeks, there was also no significant difference between the sCIMT (mean=2.22, SD=0.72) and tCIMT (mean=2.19, SD=0.74) , t(10) =0.06, p=0.95, two-tailed. The magnitude of the difference in the mean (Mean difference=0.03, 95% CI; - 1.03 to 1.09) was very small, eta squared <0.01. See table 3 and figure 3 for more details.

Determination of the effect of a covariate (baseline scores) on the post-intervention scores

Result for WMFT (functional ability)

At 2 weeks, the Levene's test of equality of error variances has p=0.84. This means the variances are equal and thus the assumption has not been violated.

After adjusting for baseline scores, the test of between subjects effects showed that, there was no significant difference p=0.53, on 2 weeks post intervention, F(1,10)=0.44, partial eta squared 0.06. There was also a strong relationship between the baseline and post-intervention scores at 2 weeks as indicated by partial eta squared value of 0.76. This means that, the covariate explained 76% of the variance in the dependent variable.

At 4 weeks, the Levene's test of equality of variances has p=0.13. This means that the variances are equal and thus the assumption has not been violated. After adjusting for baseline scores, the test of between subjects effects showed that, there was no significant, difference p=0.99, on 2 weeks post-intervention, F(l, 10)<0.01 partial eta squared <0.01. There was also a strong relationship between the baseline and post-intervention scores at 2 weeks as indicated by partial eta squared value of 0.51. This means that, the covariate explained 51 % of the variance in the dependent variable. At 6 weeks, the Levene's test of equality of error variances has p-value=0.39. This means that the variances are equal and thus the assumption has not been violated. After adjusting for baseline scores, the test of between subjects effects showed that there was no significant difference, p=0.13 on 2 weeks post-intervention, F(1,10)=2.99, partial eta squared=0.3. There was also a strong relationship between the baseline and post-intervention scores at 2 weeks as indicated by partial eta squared value of 0.55. This means that, covariate explained 55% of the variance in the dependent variable. See table 3 for this analysis.

Result for WMFT (performance time)

At 2 weeks, the Levene's test of equality of error variances has p=0.54. This means that the variances are equal and thus the assumption has not been violated. After adjusting for the baseline scores, the test of between subjects effects showed that there was no significance difference, p=0.54 on 2 weeks post-intervention F(1,10)=0.42, partial eta squared=0.06. There was also a strong relationship between the baseline and post-intervention scores at 2 weeks as indicated by partial eta squared value of 0.92. This means that the covariate explained 92% of the variance in the dependent variable. At 4 weeks, the Levene's test of equality of error variances has p=0.63. This means that the variances are equal and thus the assumption has not been violated. After adjusting for the baseline scores, the test of between subjects effects showed that there was no significance difference, p=0.92, on 2 weeks post-intervention, F(1,10)=0.01 partial eta squared =0.001. There was also a strong relationship between the baseline and post-intervention scores at 2 weeks as indicated by partial eta squared value of 0.77. This means that the covariate explained 77% of the variance in the dependent variable.

At 6 weeks, Levene's test of equality of error variances has p=0.65. This means that the variances are equal and thus the assumption has not been violated. After adjusting for the baseline scores, the test of between subjects effects showed that, there was no significant difference p=0.19 on 2 weeks post-intervention F(1,10=2.99 partial eta squared 0.23). There was also a strong relationship between the baseline and post-intervention scores at 2 weeks as indicated by partial eta squared value of 0.62. This means that the covariate explained 62% of the variance in the dependent variable. See table 4 for more details.

Table 1. Characteristics of the study participants

Characteristics	**sCIMT (n=5)**	**tCIMT (n=5)**	**p-value**
Mean age (years)	57.20±9.50	56.40±12.27	0.94
Mean time since stoke (months)	25.60±12.34	31.80±13.03	0.46
Sex (M/F)	2/3	1/4	0.51
Side affected (L/R)	1/4	3/2	0.22
Type of stroke (I/H)	5/0	4/1	0.32

Key: R/L=Right/Left, M/F=Male/Female, I/H=Ischaemic/Haemorrhagic

Table 2. Within group difference between baseline, and 2, 4 and 6 weeks post-intervention

Scale	**Time period**		**sCIMT**					**tCIMT**	
		n	**Mean±SD**	**F**	**p-value**	n	**Mean±SD**	**F**	**p-value**
WMFT FA	Baseline	5	2.34±0.52	29.20	0.03*	5	3.01±0.48	3.21	0.25
	2 weeks	5	2.66±0.77			5	3.20±0.32		
	4 weeks	5	3.16±0.52			5	3.60±0.38		
	6 weeks	5	3.64±0.66			5	3.65±0.40		
WMFT time	Baseline	5	3.94±2.10	2.97	0.26	5	4.10±1.60	4.54	0.19
	2 weeks	5	3.63±1.84			5	3.52±0.67		
	4 weeks	5	2.96±1.99			5	3.05±1.10		
	6 weeks	5	2.22±0.72			5	2.19±0.74		

Table 3. Between groups differences at 2, 4 and 6 weeks post-intervention with baseline scores as the covariates

Scale	Time period		sCIMT					tCIMT	
		n	Mean±SD	F	p-value	n	Mean±SD	F	p-value
WMFT FA	Baseline	5	2.34±0.52	29.20	0.03*	5	3.01±0.48		
	2 weeks	5	2.66±0.77			5	3.20±0.32	0.44	0.53
	4 weeks	5	3.16±0.52			5	3.60±0.38	0.000	0.99
	6 weeks	5	3.64±0.66			5	3.65±0.40	2.99	0.13
WMFT time	Baseline	5	3.94±2.10	2.97	0.26	5	4.10±1.60		
	2 weeks	5	3.63±1.84			5	3.52±0.67	0.42	0.54
	4 weeks	5	2.96±1.99			5	3.05±1.10	0.01	0.92
	6 weeks	5	2.22±0.72			5	2.19±0.74	2.13	0.19

Table 4. Between groups differences at baseline, 2, 4 and 6 weeks post-intervention

Scale	Time period		sCIMT			tCIMT	
		n	Mean±SD	n	Mean±SD	t-value	p-value
WMFT FA	Baseline	5	2.34±0.52	5	3.01±0.48	-2.15	0.06
	2 weeks	5	2.66±0.77	5	3.20±0.32	-1.45	0.19
	4 weeks	5	3.16±0.52	5	3.60±0.38	-1.52	0.17
	6 weeks	5	3.64±0.66	5	3.65±0.40	-0.38	0.97
WMFT time	Baseline	5	3.94±2.10	5	4.10±1.60	-0.14	0.89
	2 weeks	5	3.63±1.84	5	3.52±0.67	0.12	0.91
	4 weeks	5	2.96±1.99	5	3.05±1.10	-0.09	0.93
	6 weeks	5	2.22±0.72	5	2.19±0.74	0.66	0.95

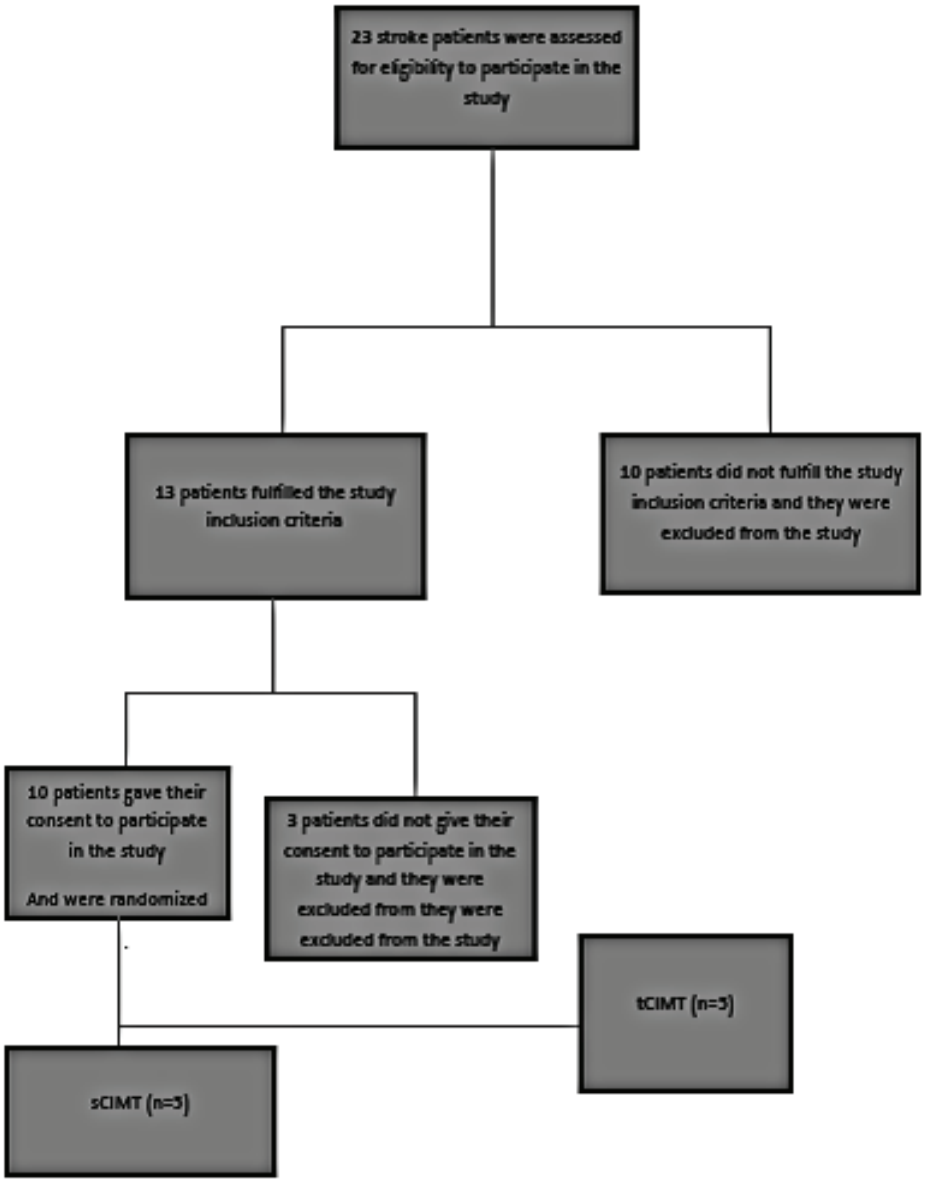

Fig.1. The study flowchart

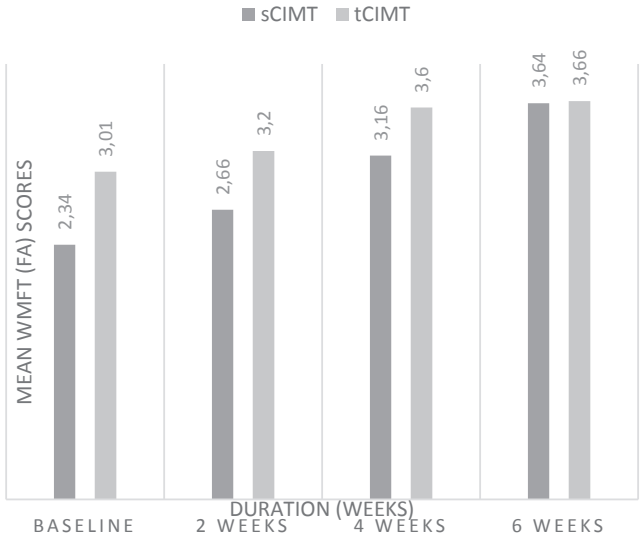

Fig. 2. Comparison of WMFT functional ability scores between groups at baseline, 2, 4 and 6 weeks post-intervention

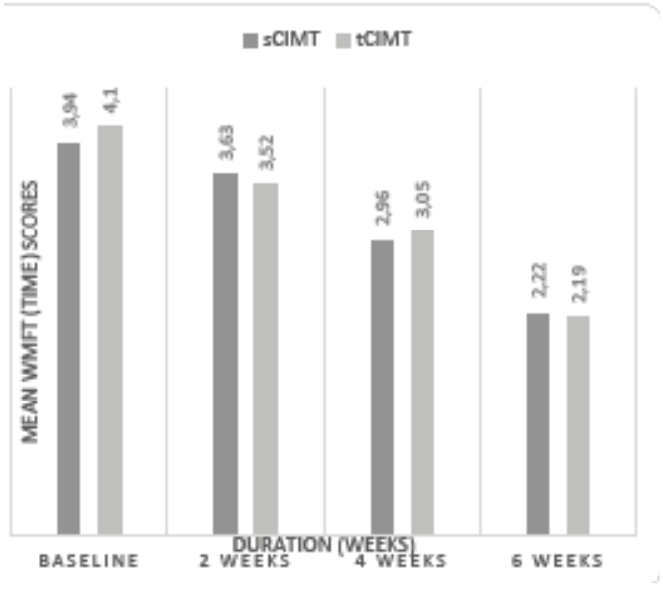

Fig. 3. Comparison of WMFT functional ability scores between groups at baseline, 2, 4 and 6 weeks post-intervention

Discussion

The study showed the feasibility and effectiveness of the use of repetition of task practice as a measure of dose during CIMT. Most importantly, it has demonstrated no significant difference between the use of number of repetitions of task practice and the use of the traditional protocol of CIMT which uses duration in hours of task practice as measures of dose. The result of the study showed steady improvement in WMFT scores at 2 weeks, 4 weeks and 6 weeks from the baseline in both the sCIMT and tCIMT groups. At 6 weeks, only the functional ability score for the sCIMT group attained minimal clinically significant difference (MCID) value (+ l.3). MCID is defined as 'the smallest difference in score in the domain of interest which patients perceive as beneficial and which would mandate, in the absence of troublesome side effects and excessive cost, a change in the patient's management' (Jaeschke et al., 1989).

Although the tCIMT has been shown to be very effective at improving motor function and activities of daily living (Wolf et al., 2006; Sirtori et al., 2009), its protocol seems not to be clear as to how much task is being practiced per session (Kaplon et al., 2007; Stock et al., 2015; Abdullahi et al., 2014). Contrastingly, the sCIMT seems to have a clear protocol since the number of repetitions per session and/ or per day required for motor recovery is known. The number of repetitions per day required for motor recovery is reported to be in the region of 300 and 320 per day (Birkinmeier et al., 2010; Abdullahi et al., 2014; Abdullahi & Shehu, 2014). This finding is consistent with the findings of previous studies on animals where repetitions of functional task of between 400 and ≥ 600 were reported to result in motor learning (Kleim et al., 1998; Nudo et al., 1996). Fortunately, 300 repetitions of task practice have been shown to be possible within just 1 hour. This casts doubts the appropriateness of the use of duration in hours as a measure of dose of task practice during CIMT as high or low repetition of task practice may be possible within short or long duration.

Findings like this are significant to the healthcare system. Stakeholders, such as the patients, their informal caregivers, the health professionals and health management organizations (HMOs) will be keen to know the amount of task practice required for improvement. In Japan for instance, the HMOs only pay for CIMT which does not exceed 5 hours (Kagawa et al., 2013; Amano et al., 2015). If the HMOs know that the required amount of task practice for motor recovery can be performed within fewer hours than they pay, this may help them reduce spendings. Thus, patients and their caregivers will also claim for fewer premiums they pay to the HMOs. In developing countries where the patients and/ or their relatives pay for health services, this finding will be a welcome development for them to claim for less charge. This study, however, has some limitations such small sample size.

Conclusion

The use of number of repetitions of task practice is an effective measure of dose of task practice during CIMT. Its effectiveness is comparable to the traditional CIMT which uses duration in hours as a measure of dose which has been previously shown to be effective at improving upper limb motor function and activities of daily living (ADL). However, using number of repetitions, of task practice as a measure of dose during CIMT seems to be clear, simple and cost effective.

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