Revista Brasileira de Fisioterapia
ISSN: 1413-3555
rbfisio@ufscar.br
Associação Brasileira de Pesquisa e Pós-Graduação em Fisioterapia
Brasil

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Revista Brasileira de Fisioterapia, vol. 16, núm. 2, marzo-abril, 2012, pp. 157-165
Associação Brasileira de Pesquisa e Pós-Graduação em Fisioterapia
São Carlos, Brasil

ISSN 1413-3555
Rev Bras Fisioter, São Carlos, v. 16, n. 2, p. 157-65, Mar./Apr. 2012
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ORIGINAL ARTICLE

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Terapia de constrição com indução do movimento e terapia de uso forçado modificadas em pacientes pós-acidente vascular encefálico são eficientes em promover melhora do equilíbrio e da marcha

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Abstract

Background: Previous studies show that chronic hemiparetic patients after stroke, presents inabilities to perform movements in paretic hemibody. This inability is induced by positive reinforcement of unsuccessful attempts, a concept called learned non-use. Forced use therapy (FUT) and constraint induced movement therapy (CIMT) were developed with the goal of reversing the learned non-use. These approaches have been proposed for the rehabilitation of the paretic upper limb (PUL). It is unknown what would be the possible effects of these approaches in the rehabilitation of gait and balance. **Objectives:** To evaluate the effect of Modified FUT (mFUT) and Modified CIMT (mCIMT) on the gait and balance during four weeks of treatment and 3 months follow-up. **Methods:** This study included thirty-seven hemiparetic post-stroke subjects that were randomly allocated into two groups based on the treatment protocol. The non-paretic UL was immobilized for a period of 23 hours per day, five days a week. Participants were evaluated at Baseline, 1st, 2nd, 3rd and 4th weeks, and three months after randomization. For the evaluation we used: The Stroke Impact Scale (SIS), Berg Balance Scale (BBS) and Fugl-Meyer Motor Assessment (FM). Gait was analyzed by the 10-meter walk test (T10) and Timed Up & Go test (TUG). **Results:** Both groups revealed a better health status (SIS), better balance, better use of lower limb (BBS and FM) and greater speed in gait (T10 and TUG), during the weeks of treatment and months of follow-up, compared to the baseline. **Conclusion:** The results show mFUT and mCIMT are effective in the rehabilitation of balance and gait. Trial Registration ACTRN12611000411943.

Keywords: forced use therapy; constrain induced movement therapy; stroke; gait rehabilitation; walking speed; physical therapy.

Resumo

Contextualização: Pacientes hemiparéticos crônicos, após acidente vascular encefálico (AVE), apresentam incapacidade para executar movimentos no hemicorpo parético. Essa incapacidade é reforçada positivamente por tentativas fracassadas de movimento, conceito chamado desuso aprendido. A terapia de uso forçado (FUT) e a terapia de constrição com indução do movimento (CIMT) foram desenvolvidas objetivando a reversão do desuso aprendido do membro superior parético. Não se encontrou na literatura quais seriam os possíveis efeitos dessas técnicas na reabilitação da marcha e do equilíbrio. **Objetivos:** Avaliar o efeito da FUT e da CIMT modificadas (mFUT e mCIMT) na marcha e no equilíbrio durante quatro semanas de tratamento e três meses de seguimento. **Métodos:** Este estudo incluiu 37 sujeitos hemiparéticos pós-AVE, divididos em dois grupos com base no protocolo de tratamento. A imobilização do membro superior não-parético foi feita por 23 horas ao dia, cinco dias por semana. Os sujeitos foram avaliados no início, durante quatro semanas de tratamento e três meses de acompanhamento. Para a avaliação, utilizou-se a Escala de Impacto do AVE (SIS), *Berg Balance Scale* (BBS) e *Fugl-Meyer Motor Assesment* (FM). Para a marcha, utilizou-se o teste de caminhada de 10 metros (T10) e *Timed Up & Go test* (TUG). **Resultados:** Ambos os grupos revelaram um melhor estado de saúde (SIS), melhor equilíbrio, com melhor utilização dos membros inferiores (BBS e FM) e maior velocidade na marcha (T10 e TUG) durante tratamento e seguimento em comparação com o início. **Conclusão:** Os resultados mostram que a mFUT e a mCIMT são eficazes para a reabilitação do equilíbrio e da marcha. Registro de Ensaios Clínicos ACTRN12611000411943.

Palavras-chave: terapia de uso forçado; terapia de constrição com indução de movimento; reabilitação de marcha; velocidade de marcha; fisioterapia.

Received: 11/07/2011 – **Revised:** 11/12/2011 – **Accepted:** 11/24/2011

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Introduction

Stroke is one of the major causes of death and disability in adults worldwide[1]. In Brazil is the main cause of death, responsible for the highest mortality rates by age group in Latin America[2,3]. The majority of survivors show some degree of recovery, but more than 50% still present some sensory or motor deficits and, only 30% of these patients can return to work during the first year post-stroke[4,5]. Because stroke affects posture and functional movements, paresis is present in upper and lower limbs (UL and LL) or hemibody[6]. The decline in motor function is also correlated to balance[7]. More than 80% of the survivors have paresis of the UL[8], and 30%-60% of these patients cannot use the paretic UL (PUL) which compromises their independence and quality of life[9].

Maintained posture is an important and complex task for the human body, which involves constant and coherent adjustments in order to maintain the body segments aligned[10]. Trunk stability is a key element for body balance and coordinated use of limbs during functional and gait activities[11]. Hemiparetic patients have asymmetry during static motor activation for either sitting or standing postures as well as for dynamic functional movements such as gait[12,13].

The hemiparetic patient has a lower speed during gait, asymmetry during orthostatic posture and functional movements[14], longer periods of weight bearing on the non-paretic LL, and increase in double support time[15]. This type of gait requires more energy compared to healthy individuals[16] due to the displacement of the body's center of gravity, which raises the metabolic demands and increase fatigue[17]. The center of gravity is shifted towards the non-paretic LL because of the decreased weight distribution in the paretic LL[18,19]. Any task involving simple limb coordination becomes difficult to perform[20]. This asymmetry is observed in static sitting and standing postures as well as during functional movements, being associated to balance impairment and gait disorganization[21]. Reorganizing the gait patterns is one of the main objectives proposed by the rehabilitation programs and highly expected by the patients[22]. About 60% of the post-stroke patients recover from severe gait impairments after a period of 3 months. However, these patients may present a certain degree of deficiency in their balance[23] and only 40% of them recover their normal gait speed[15].

Physical therapy techniques are used for rehabilitation of post-stroke patients[24-26]. An intensive motor rehabilitation facilitates recovery and promotes changes in the neuromuscular system by training repeated tasks[27]. One of the techniques using such a concept is the Constraint-Induced Movement Therapy (CIMT)[28]. The original protocol used restriction of the non-paretic upper limb (NPUL) for 90% of waking hours and a 6-hour daily training for two weeks[4]. The Forced-Use Therapy (FUT) is a technique that preceded the CIMT, consisting of restricting NPUL without training[20]. Use of CIMT or FUT without these classic parameters should be classified as modified CIMT or FUT (mCIMT or mFUT). In both therapies, the main target is the motor rehabilitation of the PUL. There are no published studies providing with clear evidence that these therapies produce positive effects on LL, gait or balance.

By knowing that stroke causes alterations in the center of balance as well as in UL and LL, and that these alterations affect the performance of any task involving simple limb coordination[20], and seeking to find alternatives to rehabilitation, the following questions were asked: Can mFUT and/or mCIMT promote changes in the LL? Can a restriction of NPUL promote changes in the motor strategies of hemiparetic patients and influence their balance and gait? What would be the most important, to simply prevent the non-use of the NPUL (FUT) or to induce the movement through specific stimulations (CIMT)?

Methods

Participants

Thirty-seven participants (19 males and 18 females) took part in this study. The subjects were randomized into the two groups of treatment. For randomization, we use sealed envelopes containing the indication for one of the treatment groups and each participant could freely choose a sealed envelope. The inclusion criteria were: good cognition, absence of joint stiffness, preserved range of motion, ability to walk independently, and able to perform active extension for wrist and metacarpophalangeal joints at 20 and 10 degrees of active extension, respectively. The exclusion criteria were: cardiac arrhythmias, non-controlled blood pressure, and severe respiratory and cardiovascular problems. Medications for stroke treatment and hypertension were allowed (Figure 1).

All patients were recruited from the Neurovascular Outpatient Clinic at the Ribeirão Preto School of Medicine, after being evaluated by the medical staff and later referred to the rehabilitation department. These subjects were submitted to a motor assessment, with the execution of free movement of both UL, and gait test for 20 yards. All subjects had grade 5 in muscle strength in their LL on a force scale of 0-5. The participants were also tested for a cognitive assessment, using the Mini Mental State Examination[29]. The subjects that showed a good free range of motion and scored ≤15 points for the illiterate, or ≤22 for 1 to 11 years of education or even education

≤27 with more than 11 years were eligible to participate in the study and were analyzed in relation to their inclusion and exclusion criteria[29]. The patients who met the inclusion criteria signed the informed consent form were enrolled in this study. The study protocol was approved by the Human Research Ethics Committee of Clinics Hospital at the Ribeirão Preto School of Medicine, Universidade de São Paulo, Ribeirão Preto, SP, Brazil (protocol number 5995/2006). It was registered in the Brazilian National Information System on Ethics on Human Research (CAAE-0119.0.004.000-06) and prospectively registered in the Australian New Zealand Clinical Trials Registry (ACTRN12611000411943).

Interventions

During the study, subjects declared that they were not participating in any other rehabilitation protocol.

Immobilization, mobilization, and stretching of the NPUL

Immobilization was performed by means of a tubular mesh involving the NPUL in abduction, rotating the shoulder internally, allowing elbow flexion above 90º (Figure 2).

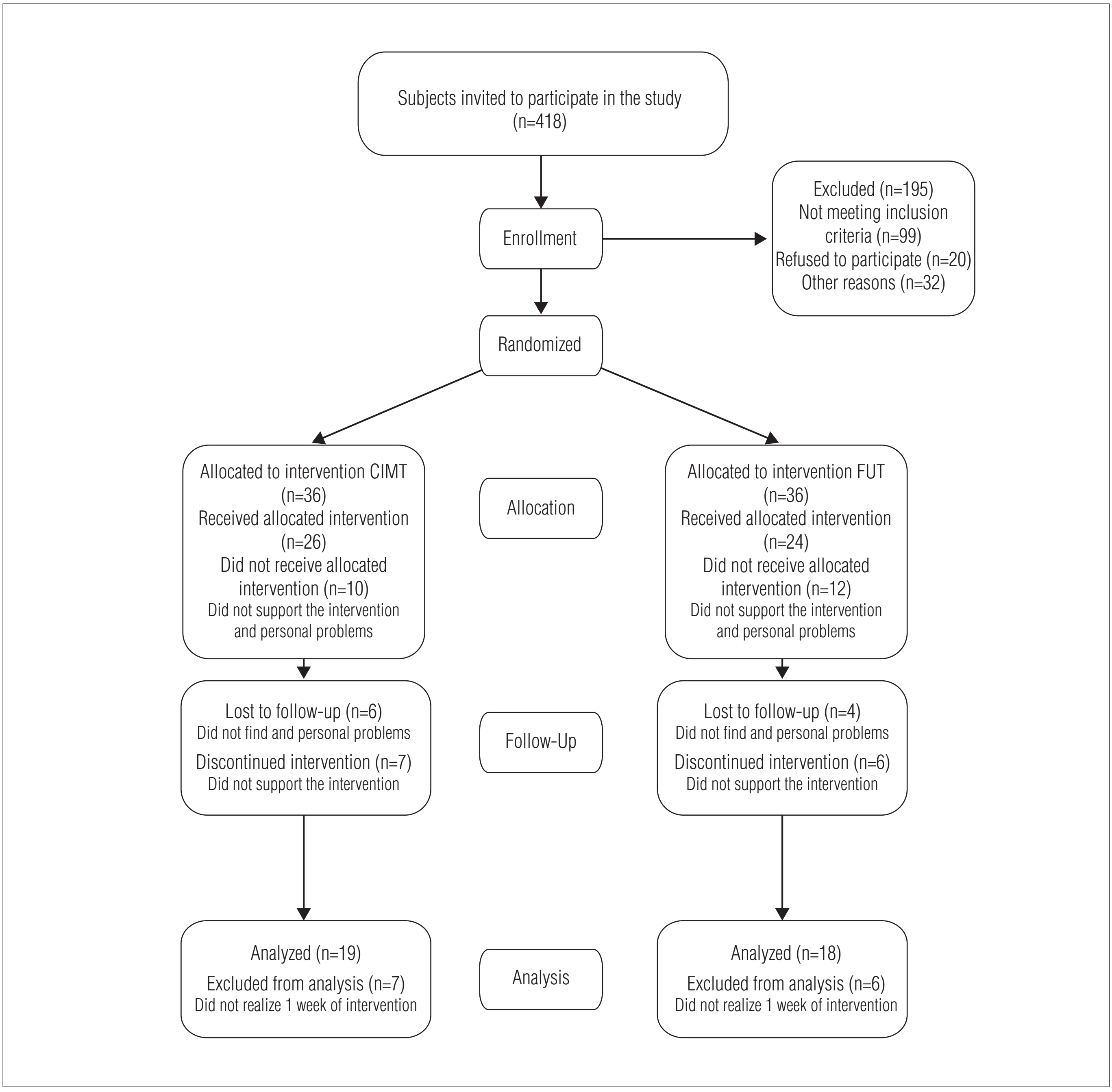

Figure 1. Flowchart of participants along the trial.

This immobilization was maintained for 23 hours during five days a week over a period of four weeks. The tubular mesh was removed every day by the researchers for cleaning, mobilization, and stretching the UL. On Saturdays, the caregiver or family members were instructed to remove the tubular mesh of the participants, at the same hour the physical therapy sessions. Throughout the weekend, the patient was then free to move both UL normally. The NPUL mobilization was performed by using traction techniques and joint circular movements, with 30 repetitions for each joint. All muscle groups of the UL were stretched. A total of three repetition consisted of keeping the extension pressure for 45 seconds were performed. This procedure enabled the patient to have unrestricted movements for at least 60 minutes. Then, another immobilization was prepared using a new tubular mesh.

Motor stimulation of PUL

Subjects in the mCIMT attended an exercise-training program for 5 days a week. The program was applied only to the PUL. Each session lasted 50 minutes on average of and during this period the NPUL was maintained free next to the body. Bimanual activity was only permitted in special tasks, i.e. manipulation tasks with paper clip, but the PUL should be the main conductor of activity. Each session included a 5-10 minutes warm-up periods, scapula mobilization, flexion exercises that were combined with shoulder abduction, elbow extension and wrist extension flexion movements. In addition trunk extension and rotation associated with UL movements, and functional activities such as unlocking a door, among other tasks were performed[30-33]. All exercises were performed using three series of 10 repetitions and the rest interval was determined for each subject in order to avoid fatigue and excessive tiredness. LL was not stimulated in both groups. Exercises were performed with subjects sitting on a chair with standard dimensions at a maximum range and with some resistance by the physical therapist, whenever possible. For the functional activities we used a support table.

Figure 2. Patient during restriction procedure using tubular mesh.

Motor evaluation

Motor evaluation was performed on a weekly basis (except for the admission scale) during the 4-week treatment period and every 30 days after treatment for three months. There were eight assessment time-points of evaluations: initial (baseline), three weekly (1st, 2nd, and 3rd weeks), post-treatment (4th week), and monthly follow-ups over three months period (1st, 2nd, and 3rd follow up). The physical therapist responsible for evaluating all the subjects was blinded to the treatment groups.

Scales

The Stroke Impact Scale (SIS) version 3.0[34] was used on baseline, 4th week and all subsequent follow-ups. SIS integrates significant dimensions of function and quality of life by self-report. The version used has 59 questions and evaluates 8 domains (strength, hand function, performance and independence in activities of daily living, mobility, communication, emotion, memory and thoughts) with a maximum score of 295 points[35]. In our study, we used only the items that assessed the performance of activities of daily living, LL strength and locomotion (walking and transfers), resulting in a maximum score of 80 points.

Balance was evaluated by Berg Balance Scale (BBS)[31] and LL function by Fugl-Meyer Assessment of Motor Recovery (FM)[36-38]. The BBS assesses balance performance by using 14 items. Each item has an ordinal scale of five alternatives ranging from 0 to 4 points, with a maximum score is 56 points[39,40]. The FM evaluates the sensorimotor recovery of UL and LL post-stroke. The maximum scores are 66 and 34 points for upper and LL, respectively, which defines a normal motor function[36,38]. We used only the LL section of this instrument.

Gait analysis was performed by the 10-meter walking test (T10)[41,42] and Time Up & Go test (TUG)[43,44]. The T10 evaluates the time to walk a distance of 10 meters[45]. The participants were instructed to conduct the test quickly and safely. In our study, the execution time of each evaluation test was performed twice and we averaged the results. The TUG measures the time need to rise from a chair and walk a distance of 3 meters, return and sit down, without any assistance[46,47]. For both tests, the data of the start were normalized in percentage, corresponding to 100% of the time to perform the test. Assessments of all weeks and all follow up time points were also normalized into percentages, regarding the percentage of the beginning of the test. All evaluations were recorded on video through a Sony digital camera for further and more detailed analysis.

Statistical analysis

We used Kruskal-Wallis One Way Analysis of Variance on Ranks for within-group comparisons between weeks and follow ups, with Dunn´s post-hoc test. Possible between-groups differences we tested by Mann-Whitney rank sum tests. The significance level chosen was α=0.05.

Results

The 37 participants were randomly allocated into the mFUT or mCIMT groups, to check if only forced use or intense stimulation of the PUL would be able to provide changes in the balance and gait. Sides of hemi-paresis, mean stroke duration and mean age are described in Table 1.

The subjects have a typical helicopod hemiparetic gait and a good balance on the BBS, up 41 points at baseline evaluation[39].

From a total of 418 potential participants listed, 195 did not meet the criteria for inclusion and/or exclusion was dismissed after medical assessment, 20 refused immediately, another 32 reported problems, i.e. difficulties with public transportation to attend the treatment sessions. After this initial assessment we selected 72 potential subjects.

In mCIMT the 36 subjects that started, 10 reported not support the tubular mesh or indicated personal and/or family problems and abandoned in the first week. During the second week there were more 7 dropouts, these subjects were not accounted in the analysis. After completion and along the follow up, 6 subjects did not return for reevaluation. For the mFUT, 36 were assessed at baseline, 12 did not stand the tubular mesh and were excluded in the first week. Along the protocol, 6 more were discharged and were not accounted for the analysis. Along the follow up periods, 4 participants did not return, but were included in the analysis until the time they were assessed.

The analysis of the SIS values at baseline showed a significant increase in the 4th week and in all follow up periods, compared to the start for the mCIMT (H=34.41). For the mFUT this increased was observed in the 1st follow up (H=10.134). No differences were found between 4th week of treatment all remaining follow up periods compared to baseline. The between-group comparison showed that mCIMT at baseline had a significantly lower score than the mFUT (T=420.50). However, in assessing the 4th week follow up the mCIMT showed a significantly higher score than mFUT (T=271.00). Thus, increase in the SIS values reveal a neuro-behaviour improvement in the 4th week, which was maintained during all follow up periods for the mCIMT. For the mFUT, the baseline score of the SIS is only significantly higher on first follow up without maintenance in the next assessments.

By analyzing the BBS scale in relation to baseline, the mFUT showed a significant increase in the score after the 4th week and all follow up periods (H=19.60). For the mCIMT, this increase occurred in the 2nd week follow up, which was maintained during the 3rd and 4th weeks and all follow up periods and were higher when compared to the 1st week (H=89.74). The comparison showed that mCIMT group at baseline had a lower score than the mFUT, however this difference disappeared after the 1st week (T=473.50).

FM scale had higher scores in the mFUT (H=20.84) and mCIMT (H=79.99) after the 3rd week and all follow up periods. The mCIMT showed a higher score after the 3rd and 4th weeks and all follow up periods compared to the 1st week (H=79.99). The comparison showed that group mCIMT had a lower score than the mFUT at baseline (T=140.50) and after the 1st week

Table 1. Demographic and clinical characteristics of subjects.

Groups	Gender	Age (years)	Paretic side	Time of stroke (months)	Etiology
mCIMT	M – 63.15% F – 36.85%	54.15±12.94	R – 73.68% L – 26.32%	19.57±20.88	I – 100%
mFUT	M – 50% F – 50%	50.78±15.65	R – 50% L – 50%	30.83±31.81	I – 94.5%
p value	p=0.50	p=0.46	p=0.35	p=0.26	p=0.78

R: right; L: left; M: male; F: female.

(T=169.50). However mCIMT in 3rd and 4th weeks (T=305.00; T=318.50) and in the 1st and 2nd follow-ups (T=344.50; T=331.50) showed higher scores than the mFUT. These three scales reveal improved level of independence, decreased disability, and improved static and dynamic balance in both groups.

Similarly T10 test showed an increase in gait speed for the mFUT. Data show a decrease in time needed to complete the task during all weeks as well as maintenance of the effects over all follow up periods compared to baseline (H=29.78). The mCIMT showed a decrease in time needed to complete the task in the 2nd, 3rd and 4th week and during all follow up periods. In this group, also the 5th week and 3rd follow-up shows a decrease in time when compared to 1st week (H=57.56). The comparison revealed a decrease in task completion time for the group mCIMT in the 3rd and 4th week (T=423.00; T=450.00) and all follow up periods (T=221.00; T=209.50; T=209.00). Compared to start, the TUG test showed that the mFUT had a decrease in time needed to complete the task from all weeks and during all follow up periods (H=33.52). A reduction time to complete the task for the mCIMT was evidenced from the 2nd, 3rd, and 4th week and during all follow up periods (H=60.84). The between-group comparison revealed a higher decrease in task completion time for the group mCIMT in the 4th week (T=423.00) and all follow up periods (T=225.5; T=188.00; T=91.00) (Table 2, Figure 3).

Discussion

We have to consider an important finding in our study. It is possible to rehabilitate the gait of post-stroke patients with chronic hemiparesis by using either mCIMT or mFUT. These techniques influence the movement of the contralateral arm and induce an increase in range of motion and directly modifies the coordination between arms and legs during the gait cycle. These changes produce positive changes in balance and walking in patients affected by hemiparesis.

Taub and Wolf[48] used CIMT for NPUL constriction during 90% of time that patients are awakened. Our study used a similar protocol but with a longer duration of restriction. In association with this restrictive movement, the Taub motor stimulations are performed for 6 hours a day during 14 days consecutively[49,50]. As in Brazil most of physical therapy sessions last an average of 1 hour, we adapted the motor stimulation to one hour.

Table 2. Statistical Data in all scales and groups.

FUT Scales	Values type	Treatment (Weekly)					Follow-up (Monthly)			H value
		Baseline	1st	2nd	3rd	4th	1st	2nd	3rd	p value
SIS	Mean	48.61	-------	-----	--------	54.44	54.27*	54.52	53.78	H=10.13
	SD	7.31	-------	-----	--------	8.41	10.54	8.75	9.42	(p<0.05)
BBS	Mean	51.83	53.05	53.61	54.16	54.38*	54.38*	54.29*	54.57*	H=19.60
	SD	3.11	2.55	2.76	2.40	2.40	2.47	2.49	2.40	(p<0.05)
FM	Mean	28.11	30.05	31	31.58*	31.94*	31.94*	31.56*	31.92*	H=20.84
	SD	3.42	3.36	2.52	2.29	2.22	1.85	1.93	1.70	(p<0.005)
T10	Mean	100	89.91	87.67*	86.70*	84.98*	84.41*	89.03*	81.06*	H=29.78
	SD	0	12.75	14.64	13.25	9.44	14.63	18.02	19.17	(p<0.001)
TUG	Mean	10	86.10	85.75*	82.23*	79.33*	77.86*	79.15*	79.49*	H=33.52
	SD	0	13.31	13.90	17.63	16.11	19.53	15.15	18.94	(p<0.001)
CIMT Scales	**Values type**	**Treatment (Weekly)**					**Follow-up (Monthly)**			**H value**
		Baseline	**1st**	**2nd**	**3rd**	**4th**	**1st**	**2nd**	**3rd**	**p value**
SIS	Mean	42.63	---------	---------	--------	58.78#	58.47#	58#	57.90#	H=34.41
	SD	8.23	---------	--------	--------	4.66	6.26	5.44	8.08	(p=0.001)
BBS	Mean	45	51.15	54#	54.94#∞	55.68#∞	55.64#∞	55.52#∞	55.54#∞	H=89.74
	SD	5.43	2.81	1.45	1.02	0.47	0.60	1.23	0.82	(p=0.001)
FM	Mean	21.33	26.20	30.53	32.73#∞	33.73#∞	33.86#∞	33.73#∞	32.09#∞	H=79.99
	SD	3.75	3.32	3.50	2.81	1.03	0.35	0.59	4.39	(p=0.001)
T10	Mean	100	87.13	80.39#	77.29#	70.58#∞	72.86#	71.77#	64.47#∞	H=57.56
	SD	0	12.84	20.00	22.45	15.69	21.20	17.50	5.36	(p=0.001)
TUG	Mean	100	83.52	79.03#	72.25#	67.12#	62.19#	63.35#	61.45#	H=60.84
	SD	0	13.58	22.34	17.92	17.05	19.30	14.11	11.37	(p=0.001)

SIS: Scale used on admission of the patients. BBS and FA: Scales used for assessing function and balance. 10 meters and TUG: Scales used for assessing gait performance. Baseline = initial evaluation; 4th= final evaluation; 1st, 2nd, and 3rd = follow-up evaluations. *Statistical significance for baseline evaluation in the FUT group. #Statistical significance for baseline evaluation in the CITM group. ∞Statistical significance for 1st evaluation in the CITM group. +Statistical significance between FUT and CITM. Level of significance (α=0.05). The number of subjects = 19 (CITM) and 18 (FUT).

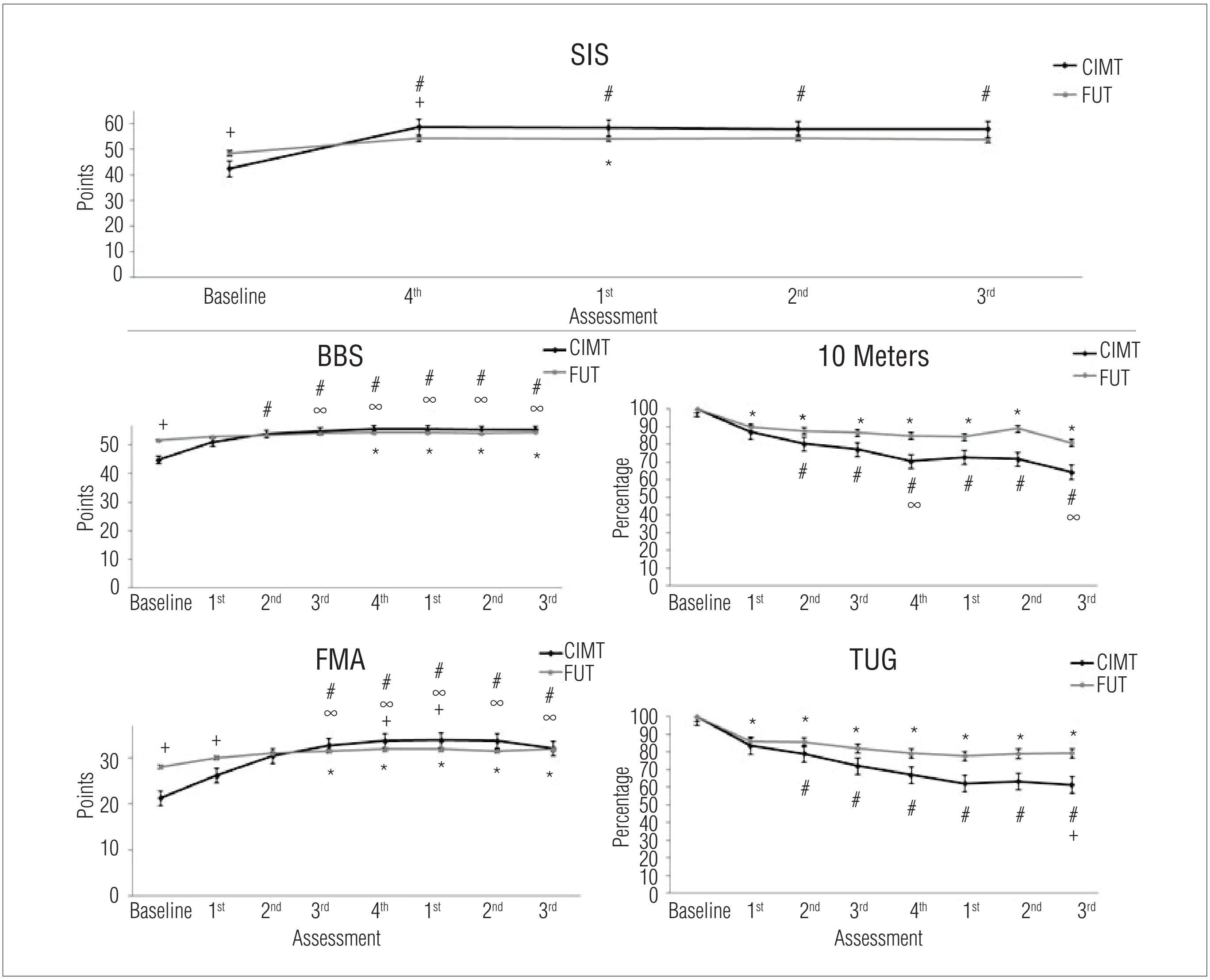

Figure 3. SIS: Scale used on admission of the patients. BBS and FA: Scales used for assessing function and balance. 10 meters and TUG: Scales used for assessing gait performance. The columns represent the mean score and the bars represent the standard error. Baseline = initial evaluation; 4th= final evaluation; 1st, 2nd, and 3rd = follow-up evaluations. *Statistical significance for baseline evaluation in the FUT group. #Statistical significance for baseline evaluation in the CITM group. ∞Statistical significance for 1st evaluation in the CITM group. +Statistical significance between FUT and CITM. Level of significance (α=0.05). Number of subjects = 19 (CITM) and 18 (FUT).

Several authors have modified the original treatment protocol as well as the material used for restriction[50-54] and also the daily and total periods of immobilization[32,33]. The most commonly used materials for the movement restriction are gloves[52], arm slings[54], and UL orthoses[50,53].

In our study, we have used a tubular mesh, which allowed immobilization of the NPUL to the trunk, which was another adjustment to the Brazilian reality, since it is an affordable material. Our daily motor stimulation time corresponded to the patterns of a common physical therapy session performed in Brazil. Similarly, restricting the NPUL for five days a week facilitated the physical therapists' work. Moreover, it is possible that restricting the NPUL to the body might be a differential modification of the original technique, which can explain both functional improvement and increased gait speed in the subjects who had participated in our study.

Hemiparetic patients do not use their PUL spontaneously, but they achieve high score in the functional tests[55,56]. Because of our inclusion criteria, the included participants had already both reasonable functioning and good general health status. However, our study showed that the need to use the PUL because of the immobilization of the NPUL produced additional benefits to these patients[57].

There is a greater interaction between the LL during gait. However the coordination between UL and LL seems to be task-dependent[58]. Such an interaction between limbs during the gait can be altered by hemiparesia, since the NPUL has to exert more balance to compensate the poor balance on the paretic side[59].

Hemiparetic patients have difficulty in bearing their body weight through the paretic LL and in positioning the center of mass between the supporting base[60,61]. It is possible that their center of mass and equilibrium is located only in the NPUL. In our study, restriction of the NPUL to the trunk interfered with such an equilibrium, thus demanding a re-organization of the body center of mass. Thus, we can justify the improvement obtained in BBS and FM scales because they are correlated to the level of patient's independence, decrease in LL disability, and improve in static and dynamic balance.

Disability in UL causes a reduction in its range of motion during gait and decreases both frequency and arm/leg phase interaction. These features produce a slower gait due to lack of coordination between arms and legs[59]. In our study, we changed the behavioral pattern regarding the non-use of the PUL balance during gait, favoring gains in LL. Like mCIMT and mFUT, this approach causes an increase in the range of motion of the PUL, which improves the synchronism between the limbs and increases the speed during gait[59]. The gait speed has been used as a parameter of coordination between the limbs[44].

Both mCITM and mFUT interfere with the movement of a PUL. These treatment approaches increase the range of motion during gait, and modify the coordination between arms and legs, thus producing positive changes in balance and locomotion[59]. Our treatment protocol generated a greater balance in the PUL while the NPUL was immobilized to the trunk. The TUG and T10 showed are higher speed in gait rehabilitation corroborating this concept.

The mFUT group measured by the scales SIS, BBS and FM had a lower early motor impairment than subjects allocated to the mCIMT group, but during the study this difference disappeared. This difference did not impact on the results, since no between-group differences were observed from the second assessment on. In this way, from this time-point the groups were considered similar and their evolution from this time-point was comparable. This improved performance was evident in the FM assessment after the 3rd week showing a better motor pattern when compared to the mFUT. These results are consistent with other studies that show that an intensive rehabilitation is important for motor learning[20,27].

All participants from this study had completed conventional physical therapy treatments at different times after stroke. At the time of discontinuation of these treatments at different physical rehabilitation services, the subjects could no longer reach functional evolution. As we did not have their baseline functional data of these subjects, it was not possible to compare their conventional physical therapy to our two treatment groups. However, our results show that participants who do not have more functional changes can have additional benefits from the proposed treatment approaches tested in our study.

Our study is based on functional scales, which can be considered a limitation factor regarding the full understanding of the motor acquisitions. however the scales were efficient in demonstrating both clinical and functional improvements. In addition, many patients could not participate in the study due to our very specific inclusion criteria, which can make the application of these instruments difficult in clinics and physical therapy rehabilitation centers on a daily basis.

In this study, we have shown for the first time that mCIMT and mFUT produce changes in the motor performance of LL. We also shown that mCIMT generates an improvement of the motor behavior pattern and produced higher scores on functional scales than mFUT, this finding confirms the need of a specific approach by neuro-functional physical therapy.

Acknowledgements

To FAPESP for a Master Scholarship (reference number 2007/05710-5).

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