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Research Report

Effect of Training Weight Transfer Phase of Sit to Stand on Weight Shifting on Paretic Lower Limb, and Sit to Stand Activity in Patients with Hemiplegia

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Abstract: Background: Though there is clear biomechanical understanding of different phases of sit to stand, effect of training focused on specific phase of sit to stand could not be clearly understood from the literature.

Aim: To study the effect of training specific to weight transference phase of sit to stand on weight sifting ability on paretic limb and sit to stand performance in patients with hemiplegia.

Method: Fifteen first time cerebral hemispheric stroke patients with hemiplegia were trained to recruit lower extremity muscles specific to weight transference phase of sit to stand. Fifteen other patients with similar characteristics were the controls. Both the group received physiotherapy based on their impairments. The outcomes were tested with weight shifted over paretic lower limb in weight transference phase, Brunnstrom stages and sit to stand component of Motor Assessment Scale after 14 sessions of treatment. The results were tested with parametric and non-parametric tests with $p<0.05$.

Results: The patients in experimental group improved better than control group in all the outcomes. In experimental group patients were able to shift 6.91 kg compared to 3.82 kg by control group ($p=0.01$). Six patients in experimental group were able to stand up without using upper extremity while none of the patient in the control group achieved this based on MAS. Around 50% of the patients in both groups reached stage III of Brunnstrom scale.

Conclusion: Training specific to weight transference phase will improve weight shifting ability on paretic lower limb and sit to stand performance in patients with hemiplegia.

Key words: Sit to Stand, Hemiplegia, Auditory feedback, Motor assessment scale, Brunnstrom stages.

Introduction

The Sit to Stand (STS) task is an important skill related to functioning and mobility, as well as prerequisite for walking. In biomechanical terms, it is a transitional movement to the upright posture requiring movement of the center of mass from a stable to a less stable position over extended lower extremities[1]. Performance of sit to stand is influenced by various factors like seat height, foot position, lower extremity muscle strength, and neurological conditions like stroke [2-4].

Hemiplegia resulting from stroke can have a profound effect on the execution of the STS movement[2-5]. Biomechanically, the STS movement can be divided into four phases: 1) flexion momentum phase (momentum created by flexion at hip), 2) momentum/weight transfer phase (preparation of lower limb muscles to support body weight), 3) extension phase (extension of lower limb to rise center of gravity), 4) stabilization phase. Hemiparesis/plegia will disrupt all these phases[6]. Earlier studies have reported improvement in sit to stand performance with therapies like repetition task training [7], postural configuration[8], augmented feedback[9] in stroke patients. Biomechanical analysis states that momentum transfer phase is crucial in moving centre of mass over new base of support and upward thrust produced in this phase influences successive phases [6,10]. Inability to activate lower limb muscles during second phase limits the ability to shift weight to paretic lower limb. Patients learn to use normal lower limb as a part of compensation. Carr and Shepherd (2002), claims that patient learn to not to use affected part of the body and compensate with normal side-learned nonuse[11]. Empharical evidence for efficacy of methods to correct individual phase sit to stand is not available. We felt as each phase is biomechanically identical, strategies to correct deviations in individual phase needs attention. In this study we planned to focus on momentum transfer phase of sit to stand activity.

We hypothesized that training lower limb muscle for second phase of STS movement will improve weight bearing symmetry during STS movement. We tested effect of exercise focused on training paretic lower limb muscle activity, augmented with auditory feedback on paretic limb weight transference in second phase of STS movement, STS performance and motor control of paretic lower limb.

Methods

University ethical committee approved the study (REF:CSP/13/OCT/31/178). Thirty patients with hemiplegia from the neurology inpatient department were recruited for this study. Patients with first time hemiplegia due to non-traumatic vascular origin within a week of onset, with a comprehension to understand the instructions given were screened for the study. Patients with a score of less than/equal to 2 for sitting to standing component of Motor Assessment Scale (MAS), and Brunnstrom's grading of less than 3 for hemiparetic lower limb were included.

Patients with orthopedic or cardiopulmonary problems, limiting ability to do perform sit-to-stand were excluded. The nature and purpose of study was explained to patients before recruiting them in the study. Informed consent was taken from every patient. All recruited patients were randomly assigned with lot method into the control group or experimental group.

Weight shifting through paretic extremity was measured with two digital weighing scales placed under lower limbs with patient in sitting position. Initial reading on the scale was noted as it could be due to the weight of the leg. Patients were asked to attempt getting up from the stool, but not to stand, as we wanted to measure their ability to shift weight through paretic limb during momentum transference phase of sitting to standing. The maximum reading under paretic and normal side was noted. The difference between the initial reading and maximum reading was noted during the standing attempt as the amount of weight shifted. Three trials were performed and average of three trials was considered for analysis.

Both the groups received 14 sessions of exercises over a two-week period. Each session was for 45 minutes with exercises based on upper and lower limb motor impairments. In lower extremity exercises to facilitate muscles around hip, knee and ankle were given. Hip extensor contraction were given specific attention, as it is the key muscle to initiate weight transfer to the lower limb. Training midrange hip extensors contraction in side lying and supine was given emphasis, as it is identical to range of extensor work in weight transference phase of sit to stand. Sit-to-Stand training was done for both the groups.

Experimental group received focused training in sitting, augmented with auditory feedback along with other exercises based on their impairments. Two symmetrical squeeze balls which can create sound were used as auditory feedback tool (Figure 1). The squeeze balls were attached to the footwear, one to the heel part of the sole of the footwear and other to the toe side of the same footwear. The patients were made to wear the footwear while sitting and asked to press hard to produce the sound. They were also encouraged to do the movement as fast as possible to improve rate of force production in lower limb muscles. Ten movements of 3 sets were trained during each session of treatment.

Patients were assisted to lift the thigh of the paretic lower limb just to clear the seat and were asked to attempt to forcefully push the foot on the ground strong enough to produce sound from the ball. In progression, they were asked to do lifting by themselves and push the foot down, and attempt to move the trunk forward mimicking the second phase getting up.

At the end of 14 sessions, weight shifted over paretic lower limb during second phase of sit to stand, score of the sit-to-stand component of Motor Assessment Scale, Brunnstrom grading for lower limb were noted in both control and experimental groups.

The change in amount of weight shift through paretic limb was tested with unpaired t test for between group analyses and with paried t test for within group analysis. The change in MAS and Brunnstrom stages within the group was tested with Wilcoxon sign rank test. The change in MAS and Brunnstrom stages between the groups were tested with chi-square test for a minimum change of one Brunnstrom stage and one score increase in MAS. The alpha for all the tests was set at 0.05.

Figure 1: Auditory feedback using squeeze ball under paretic foot

Results

In pre training period the mean weight bearing in control group was higher than experimental group and statistically not similar. After the training both the group showed improvement in weight. The control group improved by 3.82 kilograms (95% CI: 3.1, 4.5) and the experimental group improved by 6.91 kilograms (95% CI: 6, 7.7). The amount of improvement in experimental group was greater compared to control group. The patients in experimental group can transfer 3.09 kg (95% CI: 2, 4.18) more than control group after the training. (Table 1) Number of patients who showed changes in Brunnstrom stages and sit to stand component scores of MAS were more in experimental group than control group (Table 2). Within groups change was tested with Wilcoxon sign rank test, which showed a statistically significant difference. The frequency table (table 3) for Brunnstrom stage reveals that patients in both groups have improved to stage 3. The frequency table for MAS scores (table 4) shows that quality of sit to stand has improved in experimental group better than in control group. Patients in experimental group improved in greater number in MAS, Brunnstrom grade than patients in control group.

Table 1: Pre and Post Training Weigh Bearing in Paretic Lower Limb in Control and Experimental Group

weight bearing in paretic limb (mean Kg and SD)	pre training	post training	Within the group Difference (p value) [c]	Between the group difference (p value) [d]
Control group	9.61(3.7)	13.43(4.2)	3.82[a] (0.01)*	(a and b) 3.09 (0.001)*
Experimental group	6.73(2.3)	13.64(3.2)	6.91[b] (0.01)*	

c- paired t test; d – un-paired t test

Table 2: Number of patients who improved by one stage in Brunnstrom or one score in sit to stand component of motor assessment scale

	Control group	Experimental group	X^2	p
Number of patients who had changes in Brunnstrome grading	6	12	3.98	0.04*
Number of patients who changed by one score in MAS	8	13	5	0.02*

Chi-square test, * p<0.05 significance

Table 3: Number of patients in each Brunnstrom Grade in control and experimental group.

Brunnstrom lower extremity grade	Control group		Experimental group	
	Pre training	Post training	Pre training	Post training
1	4	3	6	1
2	11	7	9	7
3	0	5	0	7
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0

Table 4: Number of patients in each sit to stand component of MAS Score in control and experimental Group

	Control group		Experimental	
Score	Pre training	Post training	Pre training	Post training
1	15	7	8	0
2	0	8	7	9
3	0	0	0	4
4	0	0	0	2
5	0	0	0	0
6	0	0	0	0

Discussion

We found that training with auditory feedback during second phase of sitting to standing improved weight shifting to paretic lower limb, quality of sit-to-stand, and motor control in lower limb. The changes in all these components were minimal. The amount of weight shifting gained due to training was 3 kilograms more than the gain in control group. The minimum improvement in control group was 3.8 kilograms without any focused training during second phase of sitting to standing. Though the results were statistically significant, clinical significance is small with such a minimal gain due to training. A study by Engardt, (1994) states that auditory feedback given with force plate improved weight bearing symmetry in patients with stroke[9]. The study concludes that experimental group improved by 13.2 (10.7) percent total body weight while control group improved by 5.1(6.7) percent. The results showed minimal change similar to the present study. The quality of sit-to-stand was assessed with sit to stand component of MAS. The first three levels of sit to stand component of motor assessment scale describes the strategy used by a patient to stand, but point 4 and above describes primarily about the standing posture and weight bearing. This measure is used to test the quality of sit to stand as we felt improvement in weight transference phase of sit to stand may be shown by absence of use of upper extremity for getting up. The study results showed that 6 (40%) patients in experimental group did not use upper extremity post training while none of the patients in control group achieved that skill. The training given would have improved the ability of the patient to recruit their hip extensors to break the forward momentum created in the first phase of sit to stand aiding the patient to have better vertical momentum. This could be the reason for the patient not using their upper limb to sit to stand in experimental group. Motor ability assessed by Brunnstrom stages revealed improvement in both control and experimental group. In both the groups few patients gained movements in synergy. But more patients showing changes in experimental group could be attributed to the training given. Though statistical significance was found for the difference in number of patients, clinically the difference in number of patients is minimal. A recent Cochrane review on intervention in improving sit to stand ability following stroke mentions only one study on augmented feedback training to improve sit-to-stand performance. Majority of the study were on repetitive sit-to-stand training and exercise interventions. The earlier studies with symmetry in weight shifting as their outcome concluded that the interventions given were effective[12]. However we couldn't find similar training strategy in previous studies. The study supports our hypothesis that training given on muscle activity relevant to second phase of STS will have positive effect on STS performance and motor control. The result also infers that changing initial phases of STS movement improved overall quality of STS, as reflected by MAS component score.

Conclusion

The study provides insight that training weight transference phase of sitting to standing with feedback will improve weight shifting through paretic lower limb, quality of sit to stand and motor control of paretic lower limb in patient with stroke.

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