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THE EFFECT OF SWISS BALL THERAPY ON SIT-TO-STAND FUNCTION, PARETIC LIMB WEIGHT BEARING AND LOWER LIMB MOTOR SCORE IN PATIENTS WITH HEMIPLEGIA

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ABSTRACT

Background: Swiss ball is used as a tool in stroke rehabilitation. It is commonly used to improve postural control. Sitting on unstable surfaces can provoke lower extremity muscle contractions as a component of postural control. Effect of unstable surface sitting on lower extremity control and functions following stroke is not clear from available literature. Hence this study was planned to study the effect of Swiss ball training on sit to stand function, weight bearing through paretic lower limb and motor control of paretic limb in patients with hemiplegia.

Methods: First-time stroke patients with hemiplegia were recruited from an acute stroke care set up in a University teaching hospital and assigned to control (n=34) and experimental group (n = 33). Along with physiotherapy based on impairments, patients in control group were trained for sitting to standing and sitting activities on a stool, and from in the experimental group were trained with Swiss Ball. Both the groups underwent 40 minutes of training for ten days. 30-second sit to stand, Percentage of weight bearing through the paretic limb and Brunnstrom stages were recorded. Parametric and non-parametric tests were used based on the outcome tested.

Results: The baseline characteristics between the groups were similar statistically. Post-intervention experimental group had better weight bearing ability and motor control of lower limb ($p < 0.05$), than the control group. The difference in 30-second sit to stand did not reach statistical significance ($p = 0.059$).

Conclusion: Training with Swiss ball results in greater improvement in weight - bearing ability and motor control of paretic lower limb, compared to conventional training. The Swiss ball training does not enhance the sit to stand performance more than conventional training.

Keyword: Hemiplegia, sit to stand, Swiss ball, Rehabilitation, Brunnstrom stages.

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INTRODUCTION

Instability Resistance training (IRT) is a new concept in sports training and fitness regimes. IRT involves training on an unstable surface with the resistance offered by body mass or external objects such as dumb-bells [1]. This concept is widely used in healthy individuals and sports personals. The efficacy of this concept in the rehabilitation of neurological conditions is less studied. Studies related to use of unstable surfaces is more in the rehabilitation of stroke than other conditions. The Swiss ball is commonly used unstable surface in stroke rehabilitation. Effect of Swiss ball on trunk control and postural stability is widely studied and reported to be effective in improving the postural control in sitting [2-4]. Karthikbabu et al. (2011) state that trunk exercises performed on a Swiss ball is more effective than exercises performed on a plinth in improving trunk control and functional balance in acute stroke patients [2].

Literature by Davies (1990) and Carrière (2012) explores the use of Swiss ball in improving various functions after stroke [5,6]. However, the effect of Swiss ball training on functions other than postural control in a sitting is not clear from literature. In this study, we aimed to study the effect of Swiss ball training on sit to stand performance, weight bearing through the paretic lower limb and lower extremity motor control. Earlier studies state that lower extremity contributes to the postural control in sitting. Dean et al. (1997) reported that sitting and reaching in patients with stroke facilitated lower extremity muscle contraction and weight bearing [7]. The study also revealed an improvement in sit to stand performance, though it is not part of the training. The authors state that biomechanical similarities between reaching task and early phase of sit to stand would have resulted in a positive change in sit to stand in the study population. We hypothesized that sitting activity on Swiss ball would have a greater impact on lower limb muscle control and thereby lower extremity function compared to a conventional training on stable surfaces like stool.

The 30-second sit to stand the test, Brunnstrom stage of motor recovery and weight bearing measured with weighing scale were considered as outcome measures for the study. 30-second sit to stand is a commonly accepted tool for evaluation of the functional ability of lower body [8-10]. We used it because it is an easy bedside examination for sit to stand performance. Brunnstrom stages of motor recovery were widely accepted and used to group patient based on their motor control [11-14]. Using these outcome measures the study was aimed to identify the effect of Swiss ball training on sit to stand performance, weight bearing through paretic extremity and motor control of paretic extremity.

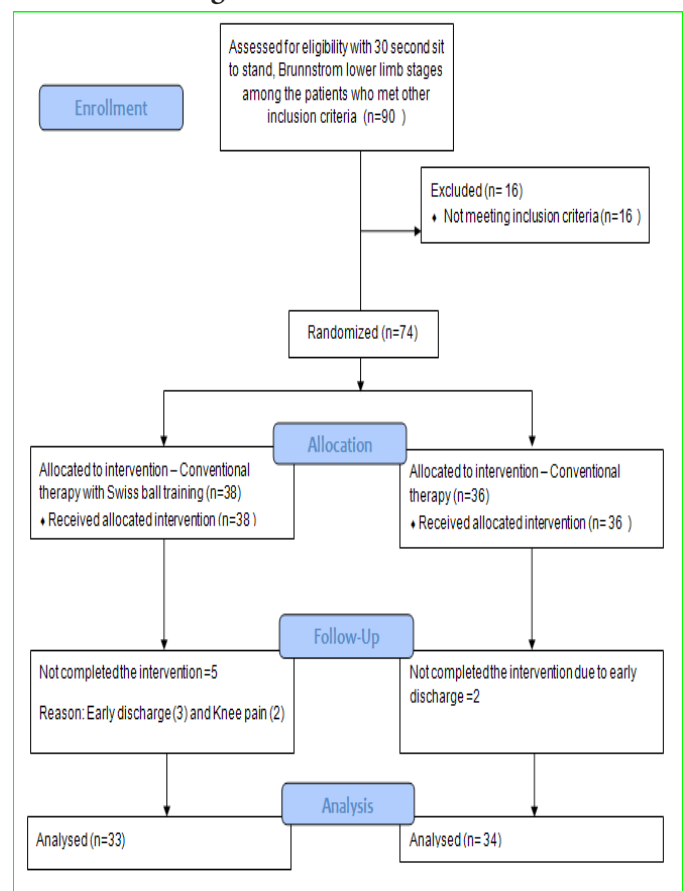
MATERIALS AND METHODS

Study design and setting

The study was approved by ethics committee of Sri Ramachandra University (CSP/11/AUG/18/50). Stroke patients

admitted to the stroke ward of inpatient facility of university teaching hospital was screened for inclusion criteria. Patients who met the following criteria were included: (1) first ever ischemic stroke; (2) presence of hemiplegia or paresis; (3) within 5 days post stroke; (4) comprehension adequate to understand the command, (5) able to maintain sitting on a stool; (6) able to stand for 30 seconds without support; (7) orthopaedic problems in lower limbs, cardiopulmonary problems and any other neurological problems limiting their sit to stand performance; (8) able to perform less than 3 sit to stand in 30 seconds; and (9) having lower limb motor control in Brunnstrom stage 3 or less. Patients who met inclusion criteria were randomly assigned to control group (n = 36) and experimental group (n = 38) using block randomization.

Figure 1: Consort flow chart



PROCEDURE

Patients in both the group received conventional physiotherapy based on motor learning concept advocated by Carr and Shepherd, (2002) [15]. All the patients received 40 minutes physiotherapy session for ten days. Patients were blinded by the difference in the treatment provided. The first researcher handled the therapy sessions.

The conventional physiotherapy was designed to improve paretic lower extremity control with isolated lower extremity muscle contractions in supine and side-lying positions, turning in bed, supine to sitting, and weight shifts in sitting. In addition to these training sitting to in standing training was given to both the group. The patients in control group received sit to stand training and sitting activities using a stool, and experimental group received

sit to stand training and sitting activities using Swiss ball. The experimental group patients were not given training in stool in addition to Swiss ball to avoid additive effects of training. In control group, the height of the stool was adjusted to have hip and knee in 90 degrees in sitting, with foot on the floor. Patients were trained to sit symmetrically, reach beyond arm's length with normal and affected upper extremity in different directions, and sit to stand. Patients in the experimental group were given training with a Swiss ball. The exercise methods were chosen from earlier literature from Davies, (1990), Carrière (2012) and Karthikbabu et al., (2011) [2,5,6]. Patients were trained to maintain the sitting on the Swiss ball, reaching beyond arm's length with normal and affected upper extremity in different directions, controlling the ball in anteroposterior and lateral directions, and sit-to-stand training from the ball. The intensity of training was increased using one or more of the following method: (1) reducing the manual guidance, (2) increasing the number of movement performed (3) increasing the limits of balance.

Outcome measures:

30-second sit to stand test, weight bearing through the paretic lower limb and Brunnstrom stage of motor control in lower limb were the outcome measures in the study. The second author (S.R) recorded the outcomes at first evaluation done during the time of inclusion into the study and after ten sessions of physiotherapy. Weight-bearing was measured by two weighing scale, one under each foot. The total weight of the patient was calculated by adding the weight recorded in both weighing scale and percentage of weight through paretic lower limb was derived.

The number of sit to stand and percentage of weight bearing through paretic limb within and between the groups were tested with independent and paired t-test respectively. Motor stage of lower extremity was dichotomized as good (stage 4 and above) and poor control (below stage 4). Brunnstrom stage 4 denotes the presence of isolated movements and decrease in abnormal synergy. The data was tested with Fisher's exact test. Effect of side of hemiplegia on sit to stand performance and percentage of weight bearing in the post-training period was tested using unpaired t-test. Alpha was set at 0.05 for statistical testing.

RESULTS

Thirty-four patients in control group (out of 36) and thirty-three patients in experimental group (out of 38) completed the study. Two patients in control group and three in experimental group discharged ahead of the completion of therapy sessions. Two patients in the experimental group reported knee pain during the study, hence excluded from the study.

In pre-training period patients in both the groups were similar statistically in 30-second sit to stand the test, the percentage of weight bearing and Brunnstrom stage of the paretic lower limb. Patients in control and experimental group improved in 30-second sit to stand the test. Table 2 shows pre and post-intervention 30 seconds sit to stand

test values. Post-training sit to stand number between the groups did not reach statistical significance (p = 0.059).

Table 1: Patient profile

	Control group	Experimental group
Age(mean yrs, SD)	53 (8.9)	55 (9.1)
Male	27	28
Female	7	5
Right hemiplegia	18	18
Left hemiplegia	16	15

Table 2: Pre and post training values in control and experimental groups (Mean and SD)

* Independent t test, significant p≤0.05

Variables	Control group (n=34)	Experimental group (n =33)	Difference between the groups	p
No. of STS/30 seconds, Mean(SD)				
Pre training	1.5 (0.86)	1.39 (0.93)	0.13	0.539
Post training	5(1.4)	6(1.4)*	0.64	0.059
% of weight through paretic lower limb, Mean (SD)				
Pre training	26.62 (9.09)	29.56 (9.91)	2.89	0.216
Post training	34.73 (9.2)	40.48 (9.2)	5.75	0.013*

Weight bearing through paretic extremity improved in both the groups (Table 2). The improvement in the experimental group was greater than the control group (p=0.01). The mean difference between the groups was 5.75 %. The 95% confidence interval for the difference in the percentage of weight shift between groups was 1.27% to 10.23%. Effect size calculated with Cohen's D (0.62) showed a moderate effect size.

After the training patients who recovered isolated movements out of synergy in the lower extremity (Brunnstrom stage 4 and above) in the experimental group was more compared to the control group. The difference reached statistical significance (Fisher's exact test, p = 0.002). Table 2 shows a number of patients in different Brunnstrom stages in control and experimental group. The side of hemiplegia did not influence a number of sit to stand (p =.86) and weight bearing through paretic lower extremity (p=.06). Statistical analysis was done using Openstat program.

Table 3: Brunnstrom stage distribution in control and experimental group

Brunnstrom stage of lower limb#	control group (n = 34)		experimental group (n = 33)	
	Pre training n, (%)	post training n, (%)	Pre training n, (%)	post training n, (%)
1	14 (41%)	1 (3%)	8 (24%)	0
2	15 (44%)	2 (6%)	16 (48%)	0
3	5 (15%)	10 (29%)	9 (28%)	2 (6%)
4	0	16 (47%)	0	15 (45%)
5	0	5 (15%)	0	16 (48%)
6	0	0	0	0

1- minimal movement, 2 – weak synergy, 3 – strong synergy, 4 to 6 – synergy decreases and isolated movements improves

DISCUSSION

The training with Swiss ball resulted in a statistically significant difference in the percentage of weight transfer through paretic lower extremity and lower extremity motor control, compared to conventional training. Though 30-second sit to stand performance improved in both the groups, the difference did not reach statistical significance.

Five-second sit to stand test was commonly used in the stroke population. Thirty-second sits to stand test was developed as a measure of functional lower extremity strength in older adults and to overcome the floor effect of the five times sit to stand test [16]. This test measures the ability of the individual to rise to stand as many times as possible, reflecting their ability to control their lower extremity muscles adequately, and also their ability to control the rate of force production in the muscles. Minimally important clinical improvement (MCID), identified for 30 seconds sit to stand is equal to or greater than two repetitions of sit to stand [17]. In the present study, 98% of patients in control and experimental group had shown an increase of sit to stand repetitions more than two. The result of this study shows that training with both stable and unstable surfaces resulted in clinically relevant improvement in sit to stand performance. Dean & Shepherd (1997) evaluated the effect of sitting activities on the stable surface on sit to stand performance and concluded that such training had a positive effect on sit to stand [7]. We could not identify literature on training with an unstable surface such as Swiss ball on sit to stand performance. The Cochrane review on interventions for sit to stand did not list Swiss ball as a therapy aid [18].

The weight bearing through paretic limb improved in both the group. The Swiss ball therapy resulted in a better outcome. Dean et al. (1999) studied the relationship between reaching in sitting and lower extremity contribution to the activity [19]. They concluded that vertical ground reaction force and electromyographic data demonstrated the contribution of lower limb for reaching in a sitting. Kim et al. (2015) found a correlation between lower extremity muscle activity and forward reaching task [20]. Catherine M Dean et al. (2007) reported that two weeks of sitting training involving reaching beyond arm's length, improved the peak vertical ground reaction force under the paretic lower extremity by around 13% of body weight [21]. These studies reveal the role of the lower extremity in maintaining postural control during sitting activities. In the present study, there was a mean increase of around 8% and 10% weight transference through paretic extremity in experimental group and control group respectively. The effect size calculated was moderate, supporting the effectiveness of the therapy on weight shifting ability. These findings suggest that sitting training improved the weight bearing through paretic lower extremity, as the lower extremity is forced to become a part of postural control system during

reaching activities. Though both groups showed statistically significant improvement, Swiss ball training would have provoked greater activity in the lower limb, as demand for postural control over the unstable surface will be greater than the stable surface. The motor control based on Brunnstrom stage improved in both the group. Ninety-three percent of the patients in the experimental group showed isolated movements out of synergy in the experimental group, whereas in control group 63% of the patients had isolated movements in paretic lower extremity. The Brunnstrom stage 4 denotes a decrease in spasticity and recovery of isolated motor control. The results of this study show Swiss ball therapy may be effective in normalizing the muscle tone; hence resulting in the early development of normal motor control. Controlling the Swiss ball movement in sitting would have forced the use paretic lower limb resulting in a better outcome in motor control in the experimental group than control group. During literature review studies on the impact of unstable surface sitting training on lower extremity muscle control following stroke was hard to find, to compare the outcome of this study.

Use of unstable surface has been recognized as a tool to improve strength and coordination in sports (1). Though the use of unstable surface has been part of the rehabilitation of neurological conditions, studies evaluating its efficacy are scarce. Patricia Davies (1990) in her literature advocates Swiss ball as a therapeutic aid in improving the lower limb control and trunk control in hemiplegics (5). The evidence related to use of unstable surfaces is limited compared to other forms of interventions in stroke rehabilitation [22].

The present study could not prove the superiority of rehabilitation program with Swiss ball as a therapy aid in improving sit to stand performance compared to a rehabilitation program without Swiss ball as a therapy aide. The positive effect of Swiss ball on improving weight bearing ability through the paretic limb and motor control in lower extremity can be supportive evidence identified for its use.

The study was done with acute stroke patients, where the spontaneous recovery can result in clinical improvement, apart from treatment effect [23]. The therapy period was ten sessions in this study, though it seems to be shorter for a clinical change, we identified similar short-term training resulting in significant change [7,24]. However, a longer training program can add value to the results of the similar study. Future studies in a different stage of the post-stroke period or a long-term follow-up may provide more details on the effect of training with unstable surfaces like Swiss ball on sit to stand function, weight bearing and motor control. Future studies adding information on lower extremity muscle activity using electromyography can be of value to know the impact of Swiss ball therapy in sitting on facilitation of lower extremity muscle activity.

CONCLUSION

The present study did not provide support for the superiority of Swiss ball training in the stroke rehabilitation in improving sit to stand function. However, use of Swiss

can be considered as an adjunct to conventional therapy in improving motor control of lower limb and paretic lower limb weight bearing.

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