Physiotherapy and Occupational Therapy Journal
Volume 2 Number 4, October - December 2009

Comparison between long reach balance training versus short reach balance training on the functional performance of spinal cord injury patients

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ABSTRACT

Background and purpose: Impaired sitting balance in people with spinal cord injury is related to defective motor performance. For individuals with paraplegia, most functional activities, such as eating, dressing, and transferring, is performed in a seated position. Thus ability to balance while reaching a variety of objects both within and beyond arm's length is critical to independent living. The purpose of this study was to evaluate the effect of long reach balance training and short reach balance training and to compare these training programs to see how these affect the functional performance of spinal cord injury patients.

Methods: 30 subjects with low thoracic spinal cord injury were recruited into two groups randomly. Group one participated in long reach balance training and group two participated in short reach balance training. Functional performance of these patients was measured using seven items of the Spinal Cord Independence Measure including dressing, mobility in bed, transfers-bed to wheelchair, transfers-wheelchair to toilet tub, mobility indoors, mobility moderate distances, mobility outdoors. Modified Functional Reach Test scores for both the groups were also taken prior and after the training.

Results: After training both the groups showed significant improvement in all the seven items of Spinal Cord Independence Measure and also significant improvement in Modified Functional Reach Test. Long reach balance training group was found to be better in improving dressing, mobility in bed, mobility outdoors and modified functional reach test score. In other four items of Spinal Cord Independence Measure both groups were found to be equally effective.

Conclusion: This study provides evidence that both the training programs are effective in improving functional performance of patients with spinal cord injury. For improvement in dressing, mobility in bed and mobility outdoors long reach balance training is more effective.

Keywords: Sitting Balance, Long Reach Balance Training, Short Reach Balance Training

INTRODUCTION

The ability to balance while reaching a variety of objects both within and beyond arm's length is critical to independent living.[1,2] Impaired sitting balance in people with spinal cord injury is related to defective motor performance. To maintain postural stability the center of body mass should be maintained over the base of support in a position or during changes in position.[4]

For individuals with paraplegia, most functional activities, such as eating, dressing, and transferring, is performed in a seated position. Any limitations in the ability to safely shift the centre of gravity toward stability limits may limit wheelchair mobility and activities of daily living. So sitting balance is very important for functional independence for people who cannot stand. While

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(Received on 24.6.09, Accepted on 14.05.2010)

sitting balance is important to assess, clinical measures have been neglected.[5]

Performance of seated reaching tasks requires the coordinated motion of the trunk and upper limbs.[8,9] The lower limbs play an active role in sitting balance while reaching. Several factors have been identified that influence the contribution of lower limbs to balance in sitting and they are reach distance, direction of reach, seat height, and extent of thigh support.[10,11,12]

Healthy subjects are able to reach significantly further when the feet are in contact with the ground compared with when they are not.[9] In Spinal cord injury patients the postural muscle function loss is compensated by using parts of sensorimotor system which is still intact. In complete paraplegics since their lower limbs are not active they adopt different postural adjustments to face the balance changes due to reaching movements. Spinal cord injury subjects make alternative use of non-postural muscles like Latissimus Dorsi and Trapezius muscle to maintain sitting balance. High and low spinal cord injured subjects also reveal a difference in the way they control their sitting balance during reaching. High thoracic spinal cord injury subjects use more alternative postural muscles than low thoracic spinal cord injured subjects during reaching.[13,14,15]

Reach distance also has a significant impact not only on the active contribution of lower limbs but also on spatiotemporal coordination of body segments. Thus there are different control strategies while reaching within and beyond arm's length. For reaching to targets placed within arm's length requires only elbow and shoulder movements and for targets placed beyond arm's length movement of elbow, shoulder, along with trunk takes place.[16]

Although balance training in spinal cord injured subjects has been done in the previous years but studies on comparison of the effect of long reach balance training and short reach balance training in this population is lacking. So the current study focuses on long reach balance training and short reach balance training of spinal cord injured subjects. Individuals with spinal cord injury have to spend most of their time in a wheelchair and they have to perform everyday activities from a sitting position so this study tries to determine how long reach balance training and short reach balance training affect the functional performance of spinal cord injured subjects.

METHODS

Selection and description of participants

Thirty spinal cord injury patients were recruited from Indian Spinal Injury Center, New Delhi, in the study. To participate, subjects had to meet the following criteria: (1) Subjects with age between 20-60 years.[18] (2) Subjects with ASIA impairment grade A and B. (3) Subjects with level of injury from T7 to T12.[18] (4) Subjects should be able to maintain static balance atleast for 30 seconds.[18] (5) The subject's upper extremity should be without any deformity.[7] (6) Each subject should have an active 90 degrees of shoulder flexion.[7] (7) Subjects with Spasticity of grade 1+ or less on the Modified Ashworth Scale.[19] Exclusion criteria for the subjects included: (1) Subjects with any orthopedic conditions and any other neurological conditions. (2) Subjects with any psychiatric disorder. (3) Subjects with complications such as pressure sores, autonomic dysreflexia, orthostatic hypotension, contractures and heterotopic ossification. There were no significant differences between the groups in terms of age, weight, level of injury, arm length, trunk length.

Technical information

A pretest and posttest experimental design was used. The subjects were invited to participate in the study and then were randomly assigned to the two groups. A detailed explanation of the procedure was given to the patients after which they signed the informed consent. Subjects were then assessed on the seven items of Spinal Cord Independence Measure including dressing, mobility in bed, transfers- bed to wheelchair, transfer wheelchair to toilet tub, mobility indoors, mobility moderate distances and mobility outdoors, and subjects were also assessed on Modified Functional Reach Test prior the training and at the end of two weeks of training.

For the sitting balance training the subjects in both the groups were given the same set of reaching activities but at different reach distances. For the long reach balance training group the objects for reach activities were placed at 140% of the arm's length. And for short reach balance training group the objects for reach activities were placed at 50% of arm's length. During the activities, subjects reached to contact or grasp, transport, lift, or maneuver objects. The activities include –

1. Grasping/transporting/lifting a glass of water;
2. Grasping/transporting/lifting a cylinder (35 mm diameter and 95 mm height).
3. Grasping/transporting/lifting a cone (7cm diameter and 17.5 cm height).
4. Maneuvering a pen and paper.

When performing the tasks the patients were instructed to reach with one hand at one time whereas other hand was not allowed to take support. Also the patient was free to use any strategy for balancing. Each training session lasted for half an hour. Training program consisted of 10 sessions spread over a period of two weeks.

STATISTICS

Statistics was performed using SPSS software version 10.5. A student's t-test was used to analyze the difference between Group one (Long Reach Balance Training Group) and Group two (Short Reach Balance Training Group) on seven functional items of Spinal Cord Independence Measure and Modified Functional Reach Test. Intra-group analysis between pre-intervention scores and post-intervention scores was done using paired t-test for both the groups. A significance level of <_0.05 was fixed.

RESULTS

The analysis of the pre-intervention scores of the seven items of Spinal Cord Independence Measure and Modified Functional Reach Test between group one and group two showed no significant difference indicating that the two groups were matched in the seven items of spinal cord independence measure and modified functional reach test prior to training. The comparison of the pre-intervention scores and post-intervention scores of group one showed significant difference in all the seven items of spinal cord independence measure – dressing (t= -12.13, p= 0.00), mobility in bed (t= -14.64, p= 0.00), transfer- bed to wheelchair (t= -8.26, p= 0.00), transfer- wheelchair to toilet tub (t= -6.96, p= 0.00), mobility indoors (t= -4.00, p= 0.00), mobility moderate distances(t= -3.23, p= 0.00), mobility outdoors (t= -4.58, p= 0.00) (Table 1.1, figure 1.1,1.2,1.3) and also there was significant difference in the scores of Modified Functional Reach Test(t= - 17.59, p= 0.00). (Table 1.1, figure 1.4)

The comparison of the pre-intervention scores and post-intervention scores of group two showed significant difference in all the seven functional tasks – dressing (t= -6.98, p= 0.00), mobility in bed (t= -17.49, p= 0.00), transfer- bed to wheelchair (t= -6.87, p= 0.00), transfer- wheelchair to toilet tub (t= -5.53, p= 0.00), mobility indoors (t= -3.06, p= 0.00), mobility moderate distances(t= -6.20, p= 0.00), mobility outdoors (t= -7.48, p= 0.00) (Table 1.2, figure 1.5,1.6,1.7) and also there was significant difference in the scores of Modified Functional Reach Test(t= - 17.09, p= 0.00). (Table 1.2, figure 1.8)

Thus indicating that both the groups showed marked improvement in functional performance and in functional reach in sitting following long reach balance training and short reach balance training for group one and group two respectively.

The comparison of post-intervention scores of dressing between group one (Mean= 4.06, SD= 0.79) and group two (Mean= 2.60, SD= 0.91) revealed significant difference with t-value= 4.69 and p= 0.00. Post intervention scores of mobility in bed between group one (Mean= 4.13, SD= 1.35) and group two (Mean= 2.93, SD= 0.79) also revealed significant difference with t-value= 2.95, and p-value= 0.00. (Table 1.3, figure 1.9, 1.10). The comparison of post-intervention scores of

mobility outdoors between group one (Mean= 1.80, SD=0.41) and group two (Mean=1.40, SD= 0.63) revealed significant difference with t-value= 2.50 and p-value=0.05. (Table 1.3, figure 1.11) The comparison of post-intervention scores of Modified Functional Reach Test between group one (Mean= 30.98, SD= 5.08) and group two (Mean= 22.92, SD= 3.11) revealed significant difference with t-value= 5.24 and p-value= 0.00. (Table 1.3, figure 1.12).

Table 1: comparison between pre-intervention scores and post-intervention scores of group one for dressing, mobility in bed, transfer- bed to wheelchair, transfer wheelchair to toilet tub, mobility indoors, mobility for moderate distances, mobility outdoors and modified functional reach test. (paired t-test)

Variable	Pre-intervention scores Group one N=15		Post-intervention scores Group one N=15		t-value	p-value
	Mean	SD	Mean	SD		
Dressing	1.20	1.01	4.06	0.79	12.13*	0.000
Mobility in bed	1.80	1.26	4.13	1.35	14.64*	0.000
Transfer-bed to wheelchair	0.40	0.50	1.66	0.48	8.26*	0.000
Transfer- wheelchair to toilet tub	0.33	0.48	1.40	0.63	6.96*	0.000
Mobility indoors	1.40	0.50	1.93	0.45	4.00*	0.001
Mobility moderate distances	1.26	0.59	1.80	0.41	3.23*	0.006
Mobility outdoors	1.00	0.75	1.80	0.41	4.58*	0.000
Modified functional reach test	17.13	5.27	30.98	5.08	-17.59*	0.000

*significant at 0.05

Group one – long reach balance training group
Group two – short reach balance training group

Table 2: comparison between pre-intervention scores and post intervention scores of group two for dressing, mobility in bed, transfer- bed to wheelchair, transfer- wheelchair to toilet tub, mobility indoors, mobility for moderate distances, mobility outdoors and modified functional reach test. (paired t-test)

Variable	Pre-intervention scores Group two N=15		Post-intervention scores Group two N=15		t-value	p-value
	Mean	SD	Mean	SD		
Dressing	0.86	0.74	2.60	0.91	6.98*	0.000
Mobility in bed	0.86	0.83	2.93	0.79	17.49*	0.000
Transfer- bed to wheelchair	0.33	0.48	1.53	0.51	6.87*	0.000
Transfer- wheelchair to toilet tub	0.26	0.45	1.06	0.45	5.53*	0.000
Mobility indoors	1.40	0.50	1.80	0.41	3.06*	0.009
Mobility moderate distances	1.06	0.45	1.80	0.41	6.20*	0.000
Mobility outdoors	0.60	0.63	1.40	0.63	7.48*	0.000
Modified functional reach test	15.56	3.42	22.92	3.11	17.09*	0.000

*significant at 0.05

Group one – long reach balance training group
Group two – short reach balance training group

Table 3: comparison between post-intervention scores of group one and group two for dressing, mobility in bed, transfer- bed to wheelchair, transfer- wheelchair to toilet tub, mobility indoors, mobility for moderate distances, mobility outdoors and modified functional reach test. (unpaired t-test)

Variable	Post intervention scores Group one N=15		Post intervention scores Group two N=15		t-value	p-value
	Mean	SD	Mean	SD		
Dressing	4.06	0.79	2.60	0.91	4.69*	0.000
Mobility in bed	4.13	1.35	2.93	0.79	2.95*	0.007
Transfer- bed to wheelchair	1.66	0.48	1.53	0.51	0.73N.S	0.473
Transfer- wheelchair to toilet tub	1.40	0.63	1.06	0.45	1.65N.S	0.110
Mobility indoors	1.86	0.51	1.80	0.41	0.39N.S	0.410
Mobility moderate distances	1.80	0.41	1.80	0.41	0.00N.S	1.00
Mobility outdoors	1.80	0.41	1.40	0.63	2.05*	0.051
Modified functional reach test	30.98	5.08	22.92	3.11	0.80*	0.000

*significant at 0.05 N.s – not significant

Group one – long reach balance training group
Group two – short reach balance training group

Figure 1.1

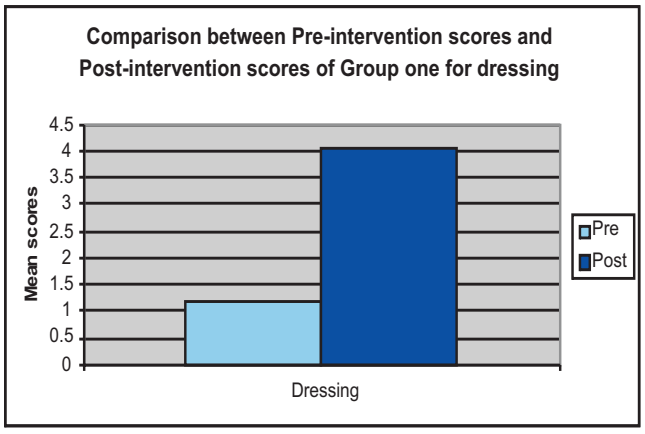


Figure 1.2

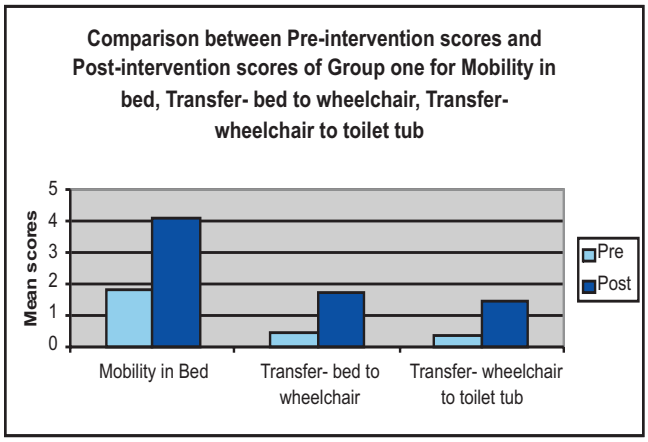


Figure 1.3

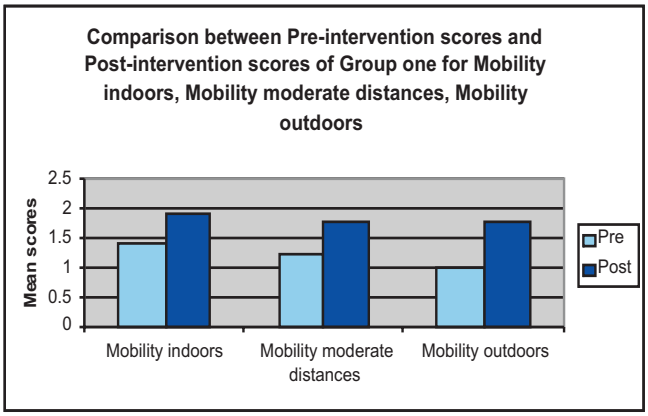


Figure 1.4

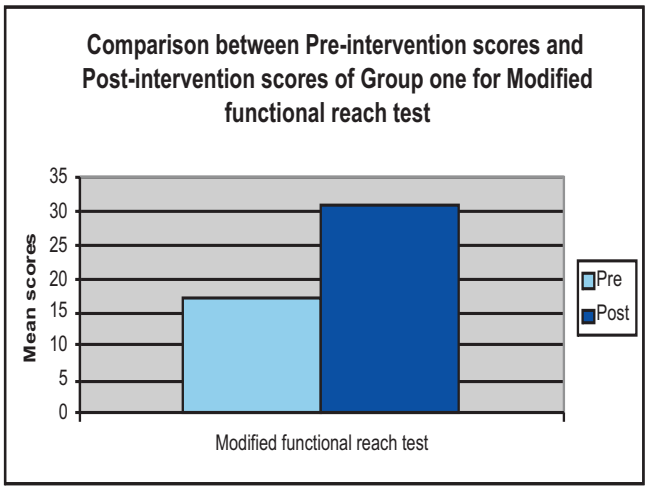


Figure 1.5

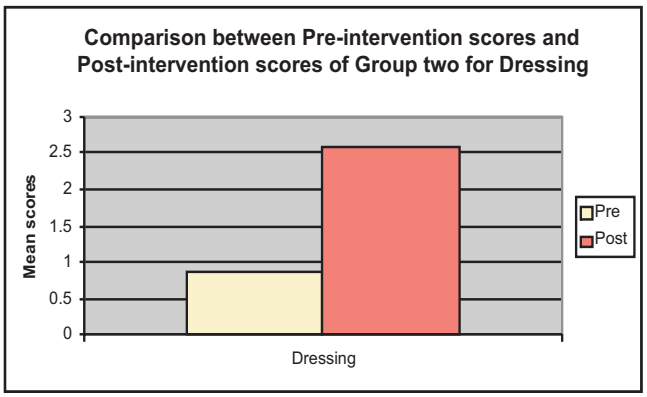


Figure 1.6

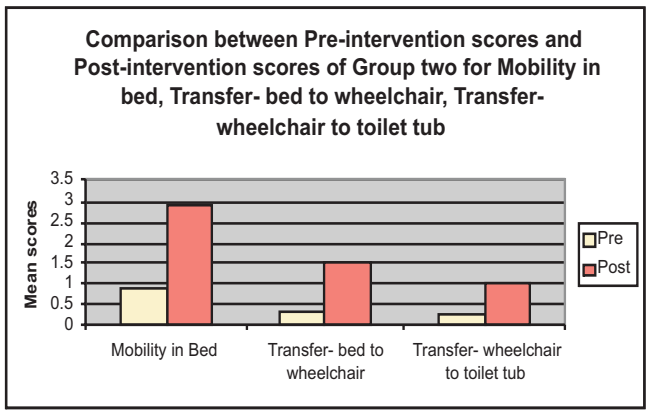


Figure 1.7

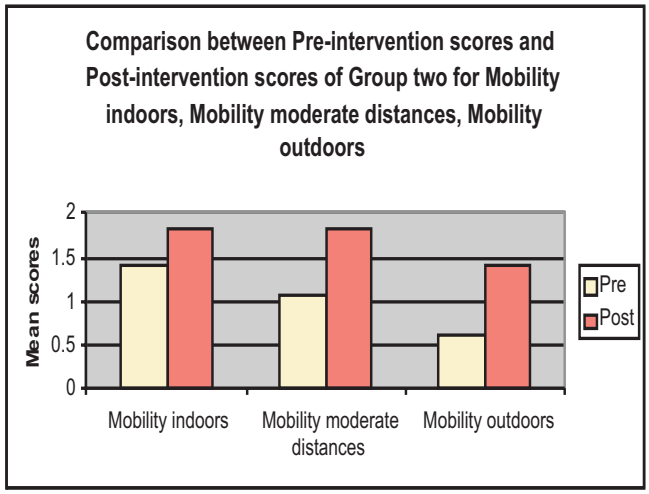


Figure 1.8

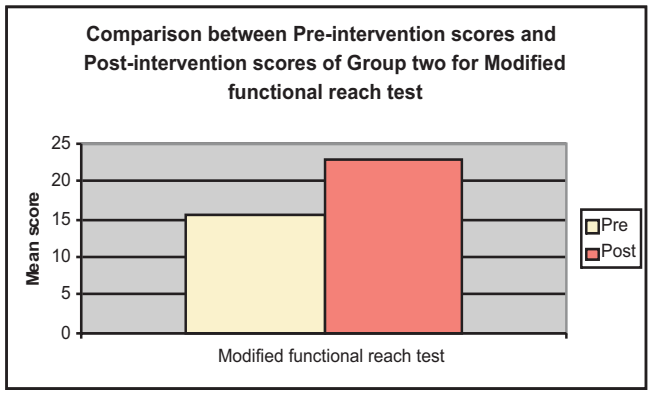


Figure 1.9

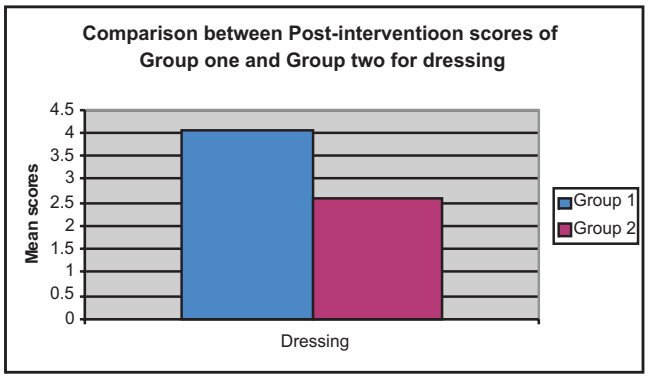


Figure 1.10

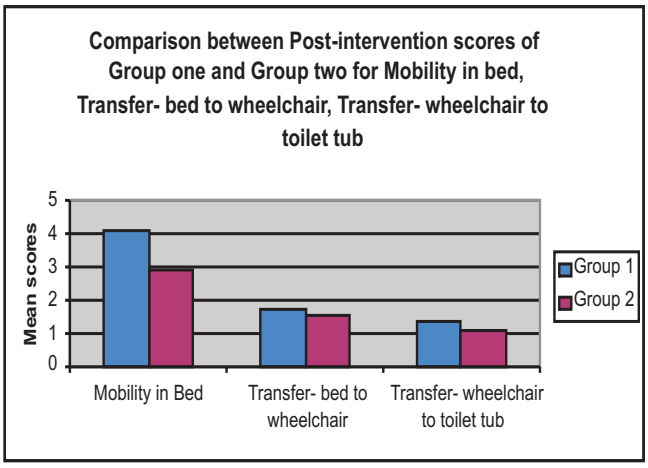


Figure 1.11

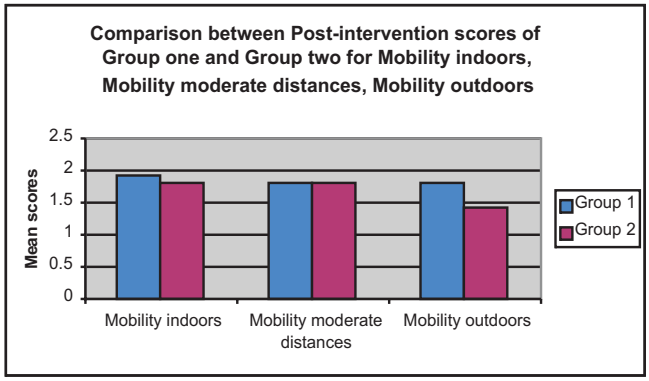
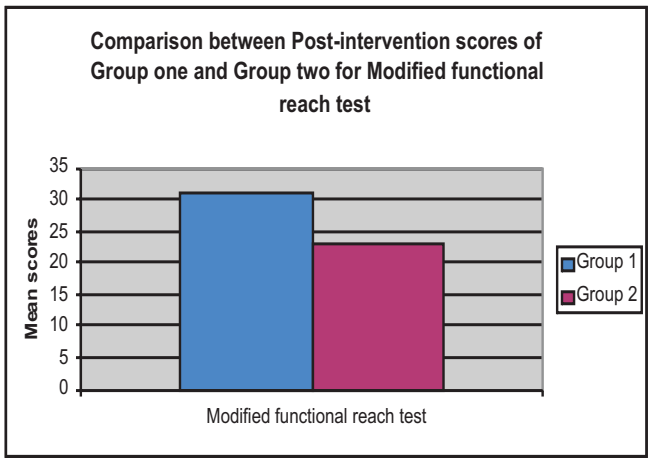


Figure 1.12



The comparison post-intervention scores of transfer- bed to wheelchair between group one (Mean= 1.66, SD= 0.48) and group two (Mean= 1.53, SD= 0.51) revealed no significant difference with t-value= 0.73 and p-value= 0.47. The comparison of post-intervention scores of transfer-wheelchair to toilet tub between group one (Mean= 1.40, SD= 0.63) and group two (Mean= 1.06, SD= 0.45) revealed no significant difference with t-value= 1.65 and p-value= 0.11. The comparison of post-intervention scores of mobility indoors between group one (Mean= 1.93, SD= 0.45) and group two (Mean= 1.80, SD= 0.41) revealed no significant difference with t-value= 0.84 and p-value= 0.41. The comparison of post-intervention scores of mobility moderate distances between group one (Mean= 1.80, SD= 0.41) and group two (Mean= 1.80, SD= 0.41) revealed no significant difference with t-value= 0.00 and p-value= 1.00.

Thus indicating that the long reach balance training group, group one, performed better than short reach balance training group in functional tasks of dressing, mobility in bed and mobility outdoors. Also there was better performance of long reach balance training group than short reach balance training group in modified functional reach test. In all the rest of the functional tasks there was no significant difference between the two groups.

DISCUSSION

The ability to perform reaching tasks while seating is fundamental to an individual's independence and quality of life.[20] Reaching to targets at various distances from the body is common action which perturbs balance since it involves complex interactions between the arm, upper body and the base of support which is provided by the pelvis and thighs on the seat and feet on the floor.[21]

In this study the subjects included in both the training groups were low paraplegic patients with their level of injury from D7 to D12 because low thoracic spinal cord injury subjects differ from the high thoracic spinal cord injured patients in terms of their reaching strategy. High thoracic spinal cord injured subjects use a more passive and simple strategy to compensate for the lost sensorimotor functions whereas low thoracic spinal cord injured subjects use a more active and complex strategy for maintaining sitting balance while reaching.[13,14,21] There is also a significantly greater composite maximal weight shift during reaching activities in low spinal cord injury subjects than high spinal cord injury subjects.[18] Thus it was thought that low spinal cord injury subjects would be better able to perform the training programs. All the spinal cord injury subjects included in the study were of grade A or B according to the ASIA impairment scale. Many studies over the years has supported the fact that lower limbs play an active role in maintaining sitting balance while reaching forward and there is greater contribution of lower limbs in sitting while reaching beyond arm's length.[9,10,11,17] So the present study wanted to investigate how long reach balance training and short reach balance training will affect the sitting stability of a spinal cord injured subject with no muscle power in lower limbs i.e. ASIA grade A and B. Tasks for the pre-intervention and post-intervention assessment of the functional performance were chosen because these are the most essential tasks for self-care and mobility at home and outdoor which require skill and balance. Safety of the subjects was given the utmost importance, the therapist stood besides the patient during the whole training sessions.

On comparing the pre intervention scores and post intervention scores of Group one, results showed that there was significant improvement in dressing (upper body and lower body), mobility in bed, transfer-bed to wheelchair, transfer-wheelchair to toilet tub, mobility indoors, mobility moderate distances, mobility outdoors, and also significant improvement in modified functional reach test score.

Results of Group two also showed significant improvement in the all the Spinal Cord Independence Measure items included in the study and also there was improvement in the modified functional reach test score after the training of two weeks thus training with reaching activities given at 50% of arm's length also improves the functional performance of paraplegic patient.

The results of the post-intervention scores of group one and group two revealed that there was significant difference between the scores of dressing (upper body and lower body), mobility in bed, mobility outdoors and modified functional reach test. For dressing, group one improved in both upper body dressing and lower body dressing whereas group two improved only in upper body dressing. Results of Chiung-Ling Chen et al 2003, supported the results of the present study. Chiung-Ling et al showed a significant correlation between dressing upper body and dressing lower body with sitting balance. Upper body dressing correlated with static sitting balance while lower body dressing correlated with dynamic sitting balance.[18] In the present study group one could have improved in dynamic sitting balance to a greater extent than group two which could be a reason why group one improved both in upper body and lower body dressing and group two improved in upper body dressing only.

The item of mobility in bed also requires a good sitting balance as it includes activities like supine to sit and push-ups in sitting. Group one, long reach balance training group, after the training of two weeks was better able to perform these activities than group two, short reach balance training group.

Group one improved significantly greater than group two in Modified Functional Reach Test scores, which could be a direct result of reaching training at 140% of arm's length which requires the patient to self-perturb their sitting balance to a greater extent than in patients of group two who were given training at 50% of arm's length. Also the reaching at 140% of arm's length requires the patient to use strategy which involves movement of elbow, shoulder and also of trunk which is very similar to the strategy used while performing the modified functional reach test.[16,21] Thus training sitting balance at long reach and short reach both improves the functional performance of paraplegic patients. Both the trainings also improve the modified functional reach test scores. Out of the two training programs long reach balance training program improved dressing, mobility in bed, mobility outdoors and modified functional reach test scores to a greater extent than short reach balance training group.

Clinical implications

Long reach balance training and short reach balance training both improved the functional performance of the patients so both types of training should be included in their rehabilitation. Also the strategies of reaching involved in both types of training are different so both training should be given to patients. Activities used for training in the study were task specific so they should be incorporated in the rehabilitation of Spinal Cord Injury patients.

Future researches

In the present study low paraplegics were recruited, in future studies high and low paraplegics both can be trained with this type of training to see how these training affect performance of high paraplegics, also investigation can be done to examine the difference between high paraplegics and low paraplegics in response to this type of training. Long and short reach balance training can be given to complete and incomplete spinal cord injury patients to see how this training affects their performance. A more elaborate examination can be done using EMG and GRF analysis in incomplete spinal cord injury patients. Also study with a larger sample size can be done. Effect of long and short reach balance training can be seen on other ADL tasks.

Limitations of the Study

1. The sample size of the study is small
2. The effect of trunk orthosis or support worn by the patients during the training sessions was not included.
3. Motivation level of the patients was not assessed.
4. Due to lack of the clinical tools available for measuring balance in sitting, Modified Functional Reach Test was used as one of the outcome variable for measuring balance, the strategy of which bears similarity with the long reach balance training given to group one.

CONCLUSION

The study concludes that the long reach balance training and short reach balance training has an effect on the functional performance of spinal cord injury patients since both the groups improved in their functional performance and also in modified functional reach test after two weeks of training. On comparing the two training protocols long reach balance training was better in three functional items of Spinal Cord Independence Measure – dressing, mobility in bed and mobility outdoors. It was also found to be better in Modified Functional Reach Test. But in other four functional items of Spinal Cord Independence Measure both the training programs were equally effective.

ACKNOWLEDGEMENT

I wish to thank my Guide Ms. Jaskirat Kaur. Also I would like to thank my Principal and all the faculty members of ISIC Institute of Health

and Rehabilitation Sciences. Lastly my thanks to all the participants of my study and my friends without whose support this study would not have been successfully completed.

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