Effectiveness of Proprioceptive Training over Strength Training in Improving the Balance of Cerebral Palsy Children with Impaired Balance

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Abstract: *This is an experimental study with same subject design. Proprioceptive training and strengthening exercises is a promising therapy to improve the balance in CP subjects with impaired balance.The study intended to find out the effectiveness of Proprioceptive training and strength training exercises on balance of the CP subjects and which of them is more effective. 30 male or/and female patient of CP with impaired balance will be taken and randomly divided in to two groups. Group A will be treated with by proprioceptive training and group B will be treated with strength training for 12 week. Both group will assess with Timed-Up and Go (TUG) scale and Pediatric Balance Scale (PBS) in starting and at the end of 12 weeks. The result will be statically analyzed using t-test for significance between the two groups. After a 13-week training period, the 't' test and 'p' values were found significant with values 4.747 & 0.003 for TUG&PBS score respectively stating that there is significant effect when using Proprioceptive training than giving strength training for improving balance in geriatric subject with impaired balance. The result states that there is a significant effect when using Proprioceptive Training than giving Strength Training for improving balance in the C.P. subjects. So the proprioceptive training should be emphasized in the daily exercise regime of C.P. subjects to improve their balance.*

Key words: *Balance, fall prevention, Strength training, Proprioceptive training.*

INTRODUCTION

Cerebral palsy is an umbrella term encompassing a group of non-progressive [1], non-contagious motor conditions that cause physical disability in human development, chiefly in the various areas of body movement.[2] It is a non-progressive disorder of motor function.[3] It is caused by damage to the motor control centers of the developing brain and can occur during pregnancy, during childbirth or after birth up to about age three.[4] The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception,

cognition, communication, and behaviour, by epilepsy, and by secondary musculoskeletal problems.[5] It used to describe diverse group of disorders of movement, posture and tone due to central nervous system insult.[4] In developed countries, the overall estimated prevalence of CP is 2-2.5 cases per 1000 live births. [34] The prevalence of CP among preterm and very preterm infants is substantially higher.[6]

Balance can be defined as a complex process revolving the reception and integration of sensory input, and the planning and execution of movement, to achieve a goal required in upright posture.[7] The control of balance requires the integration of information from multiple sensory and motor systems by the central nervous system (CNS).[8] Balance receptors in the inner ear (vestibular system) provide information to CNS about the head and body movements.[9] The eye (visual system) provides input regarding the body's orientation and motion within the environment.[7] The position and motion sensory of the muscle and joints, and the touch receptors of the extremities (proprioceptive system) send signals regarding bodily position particularly in relation to the supporting surface.[7]

The balance disorder of cerebral palsy (CP) is expressed in a variety of ways and to varying degrees in each individual. Impairments present in children with CP as a direct result of the brain injury or occurring indirectly to compensate for underlying problems include abnormal muscle tone; weakness and lack of fitness; limited variety of muscle synergies; contracture and altered biomechanics, the net result being limited functional ability.[10] Other contributors to the motor disorder include sensory, cognitive and perceptual impairments.[10]

Proprioception is a sense produced by the sensory receptors that are sensitive to pressure in the tissues that surround them.[11] They are also present in the bones of the legs, arms or other parts of the body and these receptors response to stretches of the muscle surrounding them and send impulse through the sensory nerve fibers to the brain.[11] Decline in dynamic position sense is associated with decrease in the balance of C.P. children and this decline in proprioception can be prevented or improved by Proprioceptive training.[12] In a study Edward R Laskowski et al (1997) shown that proprioception based rehabilitation programs improved objectives measurements of functional status, independent of changes in joint laxity and proprioception can be improved through Proprioceptive training.[12]

Muscle strength is another factor that plays an important role in balance and mobility.[7] Muscle weakness can be major problem for many young people with cerebral palsy.[7] Training of muscle strength and coordination has been recommended to improve motor function. [13] Bobath considered spasticity to be the main problem in spastic C.P. and suggested that resistance training should be avoided, but Carr stated that it is not the presence of spasticity but the negative feature of weakness and loss of skills which are the major barriers to improve function. Many studies have reported positive result in strength training in spastic children.[14] Possible factors interfering with normal gait pattern in cerebral child includes spasticity, muscle contracture, bony deformities loss of selective motor and muscle weakness.[15] Recent research has focused on muscle weakness. 'Wiley and Damino' and Ross and Engsberg' described muscle is more pronounced distally and found imbalance across joints. Balance control is important for competence in the performance of most functional skills, helping a child to recover from unexpected balance disturbances, either due to slips and trips or to self induced instability when walking a movement that brings them towards edge of their limit of stability.[16]

Many studies have been conducted to show the individual effect of Proprioceptive training and strength training to improve the balance of C.P. subjects. Hence this studies aims to analyze the effectiveness of both treatment technique and prove the better effectiveness by comparing Proprioceptive training and Strength training.

METHODOLOGY

Sample selection

The selection criteria are listed below.

Inclusion Criteria: CP subjects with age group of 8-14 years, With normal I.Q. (assessed by psychologist), Can follow commands, Both boys and girls subjects, CP subjects who had fall at least twice a day, Subject who scored greater than 20 second in TUG test. **Exclusion Criteria:** Children below 8 years and above 14 years, Children with any other neurological impairment, Children with audio visual impairment, Non ambulatory patients.

Measurement tools

Timed up and go scale

Timed up and go scale provides a reliable quick screening measure. Many researches indicate that most adult can complete the test in 10 seconds. A score of 11 to 20 seconds are considered within normal limit for frail elderly or individual with a disability whereas score over 20 seconds are indicative of impaired functional mobility. To perform this, the subject is in sitting position and a visible object is placed 3 meter away from the patient. The subject is instructed to get up and walk down till the object and return to the seat. During this task timing is maintained with a stopwatch and the time taken for it is recorded. A score greater than 20 seconds is associated with high risk in community dwelling older adults.

Berg Balance Scale

The Pediatric Balance Scale (PBS), a modification of Berg's Balance Scale, was developed as a balance measure for school-age children with mild to moderate motor impairments.It is used to assess balance and mobility which has 14 functional tasks commonly performed in everyday life with scores ranging from 0-4, with a maximum score of 56.

Procedure

Patients were selected on the assessment and diagnosis of their condition and put on the inclusion and exclusion criteria after they were referred to physiotherapy department by neurologist.

Method

The children were randomly divided in two groups of 15 children each. All the subjects were measured for functional balance using Timed Up & Go Test and Pediatric Balance Scale before start the training period and at the end of thirteen weeks of training.

Group A was trained with the Proprioceptive training whereas the Group B was trained with the Strength training.

Protocol

Strength training

All the subjects were treated with lower extremity strengthening exercises using weight cuff. A standardized weight of one repetition maximum (1RM) was considered for the subjects. 1RM was determined before the training for all the subjects.

A repetition of 8 to 15 times were done for all the strengthening exercises for duration of 30 minutes per session; with 5 minutes rest period in between for five days a week and were continued for 13 weeks.

The following exercises were then given and it was ensured that the position

of subjects in all form of exercises were comfortable.

1. Side leg rising

Subjects were made to lie in side lying position and instructed to abduct the upper leg tied with weight cuffs slightly about 6-12 inches. This position was held for sometime and then the leg was lowered. Same exercise was repeated with the other leg.

2. Knee flexion exercise

Subjects were made to sit on high chair or table, the knee was bent slowly as far as possible, so that the foot with the weight cuff was bent behind. The subject was asked to hold the position and then the foot was lowered slowly all the way back down. The same procedure was repeated with the other leg.

3. Hip Extension Exercise

Subjects were made to lie on prone position and one leg with weight cuff was lifted slowly straight upwards. The subject was asked to hold the position and then the leg was lowered. The same procedure was repeated with the other leg.

4. Knee Extension Exercise

Sitting on the chair with back support, the subject was asked to rest the balls of the feet & toes on the floor. The hands were kept on the thigh or on the side of the chair, and then the right leg with the weight cuff was extended slowly in front, parallel to the floor for a period of 3 seconds. With right leg in that position, the foot was flexed so that the toes were pointing towards head; the foot was held in that position for 1-2 seconds. Duration of 3 seconds was taken to lower the leg back to the starting position, so that the balls of the foot rested on the floor again. The same procedure was repeated with the other leg.

5. Ankle Dorsiflexion

Sitting on the chair with back support, the subject was asked to lift the foot tied with a weight cuff so that the toes were pointing towards the head. Then the subject was asked to hold and slowly return to the original position. The same procedure was repeated with the other leg.

Proprioceptive Training

Subjects in Group A were given proper warm up for 5-10 minutes before starting the treatment in the form of simple stretching (Quadriceps and hamstring stretch) and free exercises (knee flexion and extension in side lying and high sitting).[63]

All the proprioceptive exercises were performed for duration of 30 minutes per session; with 5 minutes rest period in

between for three days a week and were continued for 13 weeks.

The Proprioceptive training included the following exercises

1. Stair climbing up and down (a regular 3 steps staircase).
2. Standing with feet approximately shoulder-width apart and arms extended out slightly forward lower than the shoulder, then lifting both heel off the floor and to hold the position for 10 seconds, followed by climbing regular steps staircase. This procedure was performed with eyes closed also.
3. Standing with feet side by side & holding the arms in same position as described above, one foot is placed on the inside of the opposing ankle and to hold the position for 10 seconds. Followed by climbing regular steps staircase. This procedure was performed with eyes closed also.
4. To perform one leg standing with one foot raised to the back and to maintain the position for minimum 3 seconds. This procedure was performed with eyes closed also.
5. Same exercise as above performed but with one foot raised to the front. This procedure was then performed with eyes closed.
6. Walking heel to toes.
7. Rising from a standard chair (4 times) without arm support.

Data analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) for windows version 17 (SPSS Inc., Chicago, U.S.A.). The data were analyzed using parametric (dependent‘t’ test and independent‘t’ test) and nonparametric (Wilcoxon Signed Ranks and Mann-Whitney Test) test to find the significance of the interventions used within and between the group A and B. The significant level set for this study was 95% ($p<0.05$).

RESULTS & INTERPRETATION:

Thirty Cerebral Palsy patients were part of the study. Both the groups (A and B) included 15 patients each, with 11 male and 4 females in group A and 12 male and 3 females in group B. Age group taken was between 8-14 yrs with mean age of 12.33 yrs (SD=1.85).

In Group A, 15 subjects with an average age of 12.4 yrs (SD=1.96) and in Group B, 15 subjects with an average age of 12.1 yrs (SD=1.79) completed the study.

Table 1.1: Comparison of Gender of patients in both groups

	Male	**Female**
Group A	11	4
Group B	12	3
Total	23	7

Table 1.2: Comparison of Mean and SD of Age of Patients in both groups

		Mean	**SD**
Group A	**Male**	12.8	1.25
	Female	11.3	3.20
Group B	**Male**	11.8	1.80
	Female	13	1.73
Total	**Group A**	12.4	1.96
	Group B	**12.1**	**1.79**

Table 1.3 Descriptive statistics of TUG Tests prior to and post study

	Mean	N	Std. Deviation
TUGAPR	23.667	15	1.799
TUGAPS	19.933	15	1.534
TUGBPR	23.333	15	1.676
TUGBPS	21.000	15	1.414

Table 1.4 Descriptive statistics of PBS Tests prior to and post study

	Mean	**N**	**Std. Deviation**
PBSAPR	42.1	15	1.792
PBSAPS	47.3	15	2.086
PBSBPR	43.1	15	1.685
PBSBPS	45.9	15	1.995

Interpretation

The table 1.1 states that total 30 patients including 7 females were kept in two groups A and B. The group A included 11 males and 4 females whereas the group B included 12 males and 3 females. Stating that the mean age of total patients was 12.4 in group A and 12.1 in group B the table 1.2 shows the mean age of male and female in group A and the male and female in group B as 12.8, 11.3, 11.8, and 13 respectively. The table 1.3 shows the pre and post test means values for TUG test It clearly shows that individually both Proprioceptive training and Strength training produced improvement in Cerebral palsy patients with respect to TUG test but the improvement in the A which had had the Proprioceptive training showed more improvement. This is again confirmed with the findings of PBS test in table 1.4 which states that although both the groups showed improvement, the group A had better findings than group B.

.**Timed Up and Go Test:**

Table 2.1 Dependent 't' test performed with the pre & post values of TUG test for significance within the groups

Within Group	Paired Differences					T	Df	P
				95% Confidence Interval of the Difference`				
	Mean	SD	Std. Error Mean	Lower	Upper			
TUG A Pre – TUG A Post	3.73333	.88372	.22817	3.24395	4.22272	16.362	14	**0.003***
TUG B Pre – TUG B Post	2.33333	.72375	.18687	1.93254	2.73413	12.486	14	**0.002***

*-Significant

Table 2.2: Independent 't' test performed with the pre & post values of TUG test for significance between the groups

Independent Samples Test										
Between Group		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	T	Df	P	Mean Diff.	Std. Error Diff.	Lower	Upper
TUG A-TUG B	Equal variances assumed	.429	.518	4.747	28	**0.003***	1.4000	.29493	.79586	2.004

*-Significant

Interpretation

The table 2.1 shows that the value of 't' as 16.362 and 12.486 for TUG Test in Group A and Group B respectively in dependent 't' test. The 't' value is significant at $p<0.5$. Graph 4 representing the mean values of Pre and Post values of Timed Up & Go test show improvement within the group A and B respectively. Hence individually both Proprioceptive training and Strength training produced significant improvement in Cerebral palsy patients within their group with respect to TUG test.

The table 2.2 shows that the value of 't' as 4.747 in independent 't' test. The value of 't' is greater even at $p<0.05$, which is significant. Hence there was significant difference in improvement between Proprioceptive training and Strength training in Cerebral Palsy patients with respect to TUG test.

Pediatric Balance Scale test:

Table 3.1: Wilcoxon Signed Ranks Test

Within Group	PBSAPR - PBSAPS	PBSBPR – PBSBPS
Z	-3.442	-3.432
P	**0.002***	**0.002***

*-Significant

Table 3.2: Mann-Whitney Test

	GROUP	N	Mean Rank	Sum of Ranks
PBS	A	15	21.97	329.50
	B	15	9.03	135.50
	Total	30		

*-Significant

Table 3.3: Mann-Whitney and Wilicoxon test performed with the pre & post values of PBS test for significance between the group

Between Group	PBS
Mann-Whitney U	15.500
Wilcoxon W	135.500
Z	-4.083
P	**0.003***

*-Significant

Interpretation:

The table 3.1 shows that the value of 'p' as 0.002 for Group A and Group B when compared within the group respectively. Graph 5 representing the mean values of Pre and Post values of PBS show improvement within the group A and B respectively. Thus there is significant improvement on PBS in Cerebral palsy patients after Proprioceptive training and Strength training within their group respectively.

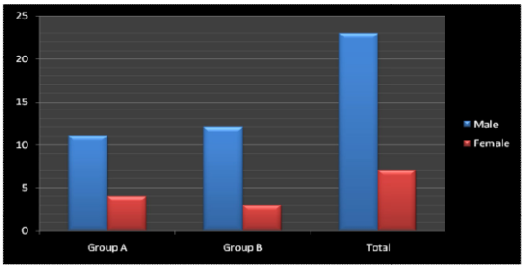
The table 3.3 shows that the value of 'p' as 0.003 and hence significant. Hence we can state that there was significant difference in improvement between Proprioceptive training and Strength training in Cerebral Palsy patients with respect to PBS test.

Table – 4.1 Mean of improvement in all the parameters between group a & Group B

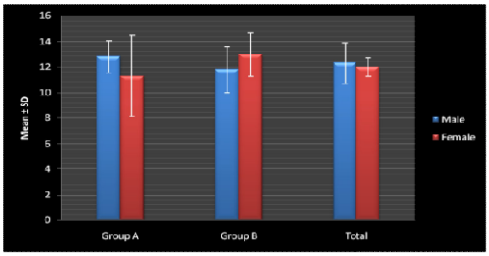
Parameters	Group A	Group B
TUG	3.73	2.33
PBS	5.19	2.73

Interpretation:

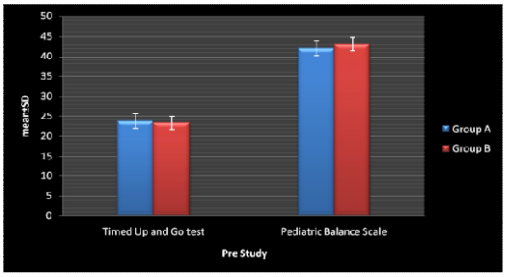
The above table 4.1 and the graph 6, clearly indicates that the Proprioceptive training produced more improvement in the selected parameters (TUG, PBS) when compared with Strength training in Cerebral palsy patients.



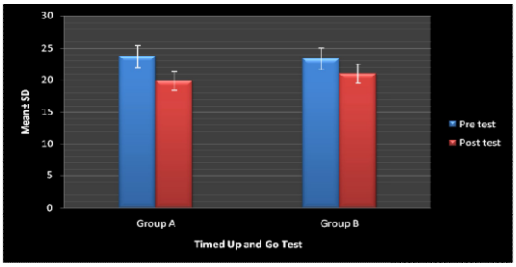
Graph 1: Comparison of both the groups and the total on the basis of gender of Patients



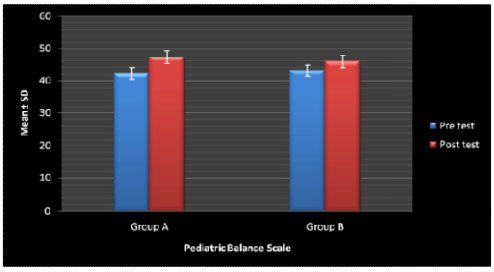
Graph 2: Comparison of Mean and SD of Age of Patients between both groups and total.



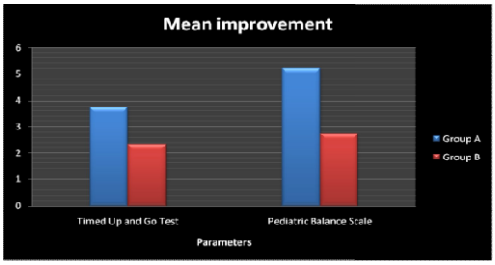
Graph 3: Comparison of Mean and SD of pre study values of both groups



Graph 4: Comparison of Mean and SD of Pre and Post values of Timed Up & Go test



Graph 5: Comparison of Mean and SD of Pre and Post values of Pediatric Balance Scale



Graph 6: Comparison of 'Mean of Improvement' in all the parameters between Group A and Group B.

DISCUSSION:

In this study, better improvements in balance outcome were analyzed using proprioceptive training and strength training. This study was done on 30 CP children with impaired balance who were divided in to experimental Group-A treated with Proprioceptive training and Group-B with Strength training.

The balance was taken as the dependant variable which was measured using Timed Up & Go test (TUG) and Pediatric Balance Scale (PBS). Both this tool are standard tools to analyze balance. Proprioceptive training exercises were given to improve the balance by improving the decreased sense of proprioception in older age group where as Strength training was given to improve the balance by improving the strength of lower extremity muscles.

The improvements in functional balance due to Proprioceptive training may be attributed to the improvement of mechanoreceptor activation. Structural

changes in the muscle, bone and joints during old age accounts for the decreased efficiency of the proprioceptors. Researchers reason that proprioceptive training can improve the joint and kinesthetic sensation to a greater extent that the falls and risk of fall can be reduced among the subjects.

Edward R Laskowski et al also stated that the decline in dynamic position sense is associated with decrease in the balance of C.P. children and this decline in proprioception can be prevented or improved by Proprioceptive training.My study confirms the study by Edward R Laskowski et al (1997) which showed that proprioception based rehabilitation programs improved objectives measurements of functional status, independent of changes in joint laxity and proprioception can be improved through proprioceptive training. [68]

These results were in accord with Gauchard GC et al (1999) to improve balance by proprioceptive training. Studies done by Pierre Gangloff et al (2003) also supports our results, which prove that proprioceptive training exercises, improve balance in subjects with impaired balance. This supports the experimental hypothesis hence the null hypothesis was rejected.

The result of the present study indicates that effect of proprioceptive training had a proven effect over strength training. All participants in the proprioceptive training group declared that their balance had improved and most of them were motivated to continue with the training. Hence proprioceptive training should be emphasized in the daily exercise regime of CP subjects to improve their mobility and functional status.

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