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INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI: 10.21474/IJAR01/14391
DOI URL: http://dx.doi.org/10.21474/IJAR01/14391

RESEARCH ARTICLE

EFFECTS OF LOWER LIMB PROGRESSIVE RESISTANCE TRAINING ON BALANCE IN CHILDRENS DIAGNOSED WITH SPASTIC DIPLEGIC CEREBRAL PALSY

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Manuscript Info

Manuscript History
Received: 10 January 2022
Final Accepted: 15 February 2022
Published: March 2022

Key words:-
Cerebral Palsy, Spastic Diplegic, Strength, Balance, Progressive Resistance Exercises

Abstract

Background and objectives: Balance is the ability to move or to remain in position without losing control or falling. Control of body balance is a complex involving postures, movements, sensation, vision and vestibular system. There is 2 types of balance – Static and dynamic. Both static and dynamic balance are very important for body to maintain equilibrium in standing or sitting position and able to perform without falling. Cerebral palsy happens due to abnormal brain development before birth of child which affects childs ability to move, maintain balance and posture and walking ability, resulting in ataxia. Diplegic cerebral palsy is also knows as spastic diaplegia. It is one of the three types of cerebral palsy which presents with lot of muscle stiffness and spasms and loss of Range of Motion. Spastic diplegia mostly affects the legs and sometimes the arms, making them stiff and contracted. This makes crawling and walking difficult and most often, children will walk on their toes or with a wide scissoring gait. Legs can also turn inwards and cross at the knees due to excessive muscle contractions. Other children may not be able to walk at all. The upper extremities of the body may not be affected at all and may function normally. The purpose behind this study was to find out whether progressive resistance exercises of lower limbs affects balance of children's affected with spastic diplegic cerebral palsy, because balance is the biggest issue with diplegic cerebral palsy. The objective of the study is to analyze strength using FTSST (Five Time Sit to Stand Test) and balance using PBS (Pediatric Balance Scale).

Design: Experimental study

Method: Total 30 spastic diplegic Cerebral Palsy childrens, both boys and girls from the age group of 6-12 years were taken. Subjects were divided into experimental group (n=15) and control group (n=15). Pre and post values of FTSST (Five Time Sit to Stand Test) and PBS (Pediatric Balance Scale) were taken. Control group were given conventional treatment and the experimental group underwent progressive resistance exercise for 6 weeks.

Strength training was given to quadriceps and hamstrings muscles using weight cuffs with 8 RM. Resistance was increased after every 2 weeks. At the end of 6^{th} week post values were noted and compared with pre values.

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Result: PBS (Pediatric Balance Scale) was significantly improved in experimental group. FTSST (Five Time Sit to Stand Test) was also significantly improved in experimental group

Conclusion: Result concluded that Progressive Resistance Exercises have significant beneficial effects on balance in spastic diplegic cerebral palsy patient preventing falls and improving walking ability.

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Introduction:-

Martin Bax et al (2005) proposed the definition for cerebral palsy (CP) as a well recognized neurodevelopmental condition beginning in early childhood and persisting through the lifespan. It describes a group of disorders of development of movement and posture causing activity limitation that are attributed to non-progressive disturbances that occurred in developing fetal or infant brain.[1]

Description of GMFCS according to Robert Palisano et al.[2]

LEVEL I	**Walks without Limitations**
LEVEL II	Walks with Limitations
LEVEL III	Walks using a Hand-Held Mobility Device
LEVEL IV	Self-Mobility with Limitations; May Use Powered Mobility
LEVEL V	Transported in a Manual Wheelchair

1. Spastic CP is the most common form of CP (accounting for approximately 70–80% of cases of CP) and 50% of children with spastic CP have diplegia. In spastic diplegic CP, the lower extremities are severely affected but the upper extremities are only mildly impaired, intelligence is usually normal, and epilepsy is not common.[3]
2. Muscle strength can be defined as the ability of skeletal muscle to develop force for providing stability and mobility within musculoskeletal system so that functional movement can take place.[4]
3. Journal of American Academy Of Pediatrics defined muscle strength as methods to increase one's ability to exert or resist force.[5]
4. Most investigators believe that the low power production is related to the inadequate coactivation of antagonist muscles, decreased or inadequate motor unit discharge, secondary myopathy and disturbed muscle physiology.[6]
5. Quadriceps and hamstrings muscles have a key role in knee joint control and have been found to be adversely affected in CP.[7,8,9]
6. Balance is a state in which different thing occur in equal or proper amount or have equal or proper amount of importance. It is the ability to move or to remain in a position without losing control or falling. Also is the state of having weight spread equally so that person do not fall.[10]
7. Balance may get affected if there is vestibular dysfunction, cochlear dysfunction, trauma low level of physical activity, musculoskeletal problems, disturbance in cognition, neuro-motor abnormality etc.[11,12.13]
8. Many children with cerebral palsy (CP) have poor walking abilities and manipulation skills. One contributing factor to their problems with gait and reaching movement is poor balance control because the maintenance of stability is critical to all movements.
9. As balance skills are an integral part of gross motor abilities, poor balance causes difficulties with functional tasks involved in activities of daily living.[14]
10. There is no conclusive evidence on the effect of strength training over balance in children with spastic diplegic cerebral palsy. So, the aim of this study was to determine the effect of strength training on balance in these children**.**

Significance Of The Study

1. **Cerebral palsy is non-progressive neurological disorder.**
2. **CP has been associated with weakness of muscles.**
3. **Quadriceps and Hamstrings muscles have been found to be adversely affected in CP.**
4. **In CP there is crouch gait, and in this gait quadriceps and hamstrings contribute to the most.**
5. **So this study is to investigate muscle strength and balance in spastic diplegic CP.**
6. **Thus, this study is to establish the strength and balance improvement in spastic diplegic CP.**

Aim And Objectives:-

Aim:

To find the effect of progressive resistance training on balance for children with spastic diplegic CP.

Objectives:-

1. To assess the strength with FIVE-times-sit-to-stand test in children with spastic diplegic CP.
2. To assess balance using Pediatric balance scale in children with spastic diplegic CP.
3. To perform PRE with 8RM by weight cuffs in children with spastic diplegic CP.

Hypothesis

Null Hypothesis (H_0):

Null hypothesis (H_0): There is no effect of progressive resistance training on balance in spastic diplegic CP.

Alternate Hypothesis (H_1):

Alternative hypothesis (H_1): There is significant effect of progressive resistance training on balance in spastic diplegic CP.

Research Method:-

1. Study design: Experimental study
2. Study setting: Hospitals and OPDs
3. Study population: Spastic diplegic CP (6 years to 12 years)
4. Duration of study: Study was completed over a period of 1 year
5. Sampling technique: Simple Random sampling
6. Sample size: N=30

Group A: 15 subjects (Experimental group)
Group B: 15 subjects (Control group)

Criteria Of Selection

Inclusion Criteria:

1. Spastic diplegic CP with MAS scoring 1-2
2. GMFCS level I, II and III
3. Age group 6-12 years
4. Both boys and girl

Exclusion Criteria:

1. Illness during or before the study
2. Surgical or orthopaedic procedures during, or up to six months prior to the study
3. Cardiac or respiratory conditions that may be affected by exercise
4. Subjects unwilling to participate

Materials & Method:-

1. Adjustable height bench
2. Chair with back supported with arm rest
3. Chair with back supported without arm rest
4. Masking tape 1 inch wide
5. Step stool 6 inches in height
6. Chalkboard
7. Ruler
8. Stopwatch
9. Consent form

Outcome measures

Five-times-sit-to-stand-test

1. This test was used to check the strength in spastic diplegic CP

2. Time spent for standing up from and sitting down on a chair with 5 repetitions are noted.
3. The intra-class correlation coefficient (ICC) for test-retest is 0.91 and inter-rater reliability of FTSST is 0.88.

Pediatric Balance Scale

1. PBS is used to assess balance in children.
2. Subjects are tested on 14 criterias:

1) Sitting to standing
2) Standing to sitting
3) Transfers
4) Standing unsupported
5) Sitting unsupported
6) Standing with eyes closed
7) Standing with feet together
8) Standing with one foot in front
9) Standing on one foot
10) Turning 360 degrees
11) Turning to look behind
12) Retrieving object from floor
13) Placing alternate foot on stool
14) Reaching forward with outstretched arm

1. **Each criteria is scored utilizing the 0 to 4 scale.**
2. **The child's performance is scored based upon the lowest scoring, which describes the child's best performance.**
3. **The intraclass correlation coefficient (ICC) is 0.998.**

Methodology:-

Ethical clearance was obtained from institutional Ethical committee prior to study. Spastic Diplegic Cerebral Palsy patients from different hospitals in Ahmedabad city were screened. A thorough assessment was done to screen the subjects for inclusion and exclusion criteria. Nature and purpose of the study was explained to the subjects in detail, in language they understood. All subjects acknowledged their understanding of the study and their willingness to participate by providing signed consent from their parents. Parent assent was taken from spastic diplegic cerebral palsy patients.

Total 30 spastic diplegic cp method both boys and girls from the age group of 6-12 years with GMFCS level I-III were divided in two groups(15 interventional group and 15 control group) by envelope method. A written informed consentt form from each parents were taken in which they allowed them to participate in this study.

Five times sit to stand test was performed and three trials were given for the individual.

Commands given were "I want you to stand up and sit down 5 times as quickly as you can but safely when I say 'Go'.

Timing begins when the examiner says "Go" and stops when the subject's back touches the backrest of the chair on the fifth repetition.

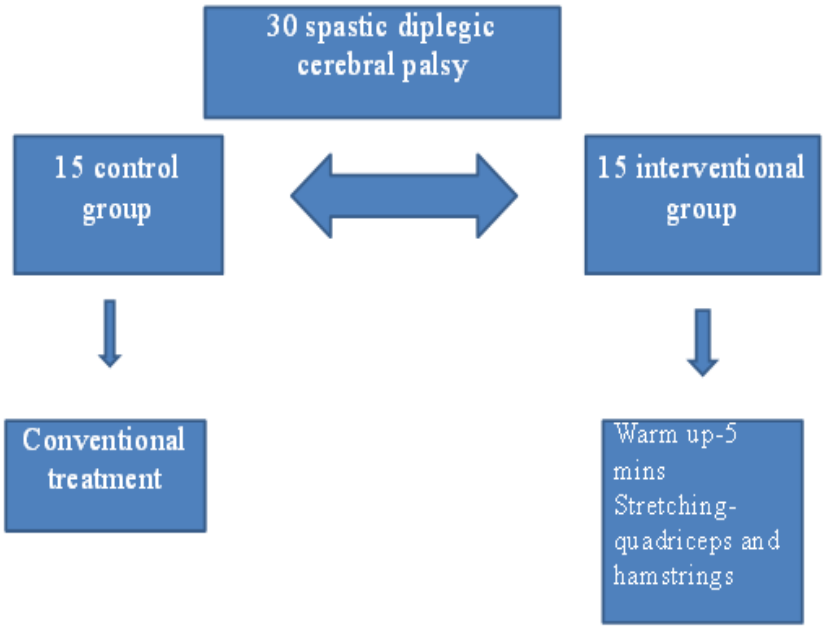
The test was performed 3 times with a 1-minute resting interval between trials.
The average value was used for data analysis.

PBS was then performed.

Three trials were given to an individual.
Best of three trials was taken into consideration.

Scoring was given of individual out of 56.

8RM was calculated and resistance was provided with weight cuffs.



weeks	Frequency	intensity	time
1-2	3sets of 5 rep	8RM-65% of TW	25 mins
2-4	4sets of 5 rep	8RM-65% OF TW+0.25 kg	25 mins
4-6	3sets of 10 rep	8RM-65% 0F TW +0.75 kg	25 mins

Cool down-5 mins
Stretching – quadriceps and hamstrings

Five times sit to stand test

Five times sit to stand test

Standing to sitting

Standing unsupported

Sitting unsupported

Standing with eyes closed

Standing with feet together

Standing with one foot in front

Turning 360 degrees

Retrieving object from floor

Reaching forward with outstretched arm

Quadriceps strengthening

Hamstring strengthening

Result:-

Statistical Software:

The statistical software namely software SPSS 20.0(Demo Version) was used for the analysis of data and Microsoft word and excel have been used to generate graphs, tables etc.

Statistical Tests:

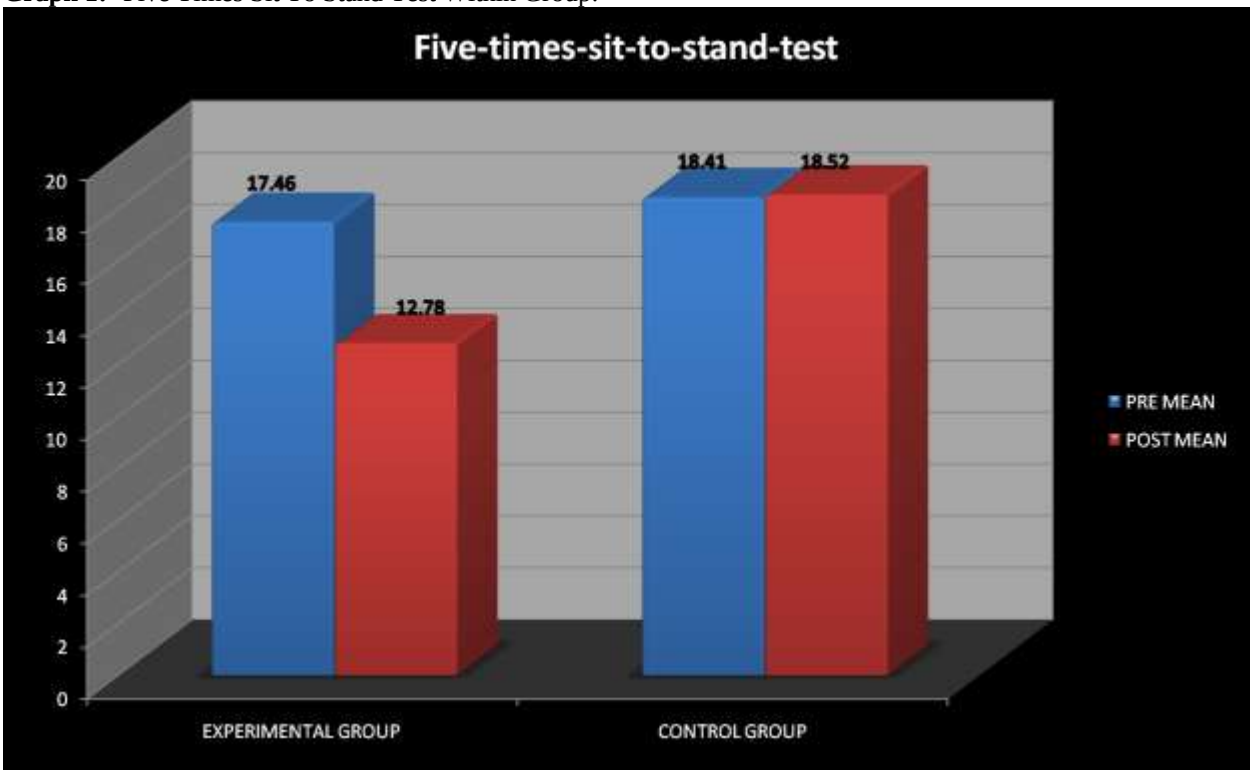
Distribution of the data in both the groups was analysed using TEST OF NORMALITY: SHAPIRO-WILK TEST. For Experimental group and Control group; pre and post data for FTSST and PBS were compared using UNPAIRED 't' TEST. And comparision between both the groups was done using INDEPENDENT 't' TEST for FTSST and PBS.

For all statistical analyses $p<0.05$ with class interval 95% were considered as significant results

Table 1:- Five Times Sit To Stand Test Within Group.

FTSST	PRE MEAN ± SD	POST MEAN ± SD	p VALUE
EXPERIMENTAL GROUP	17.46 ± 4.56	12.78 ± 4.62	<0.001
CONTROL GROUP	18.41 ± 3.78	18.52 ± 3.72	0.856

Graph 1:- Five Times Sit To Stand Test Within Group.



There was significant difference found in experimental group ($p<0.001$) but not control group ($p<0.856$)

Table 2:- Pediatric Balance Scale Within Group.

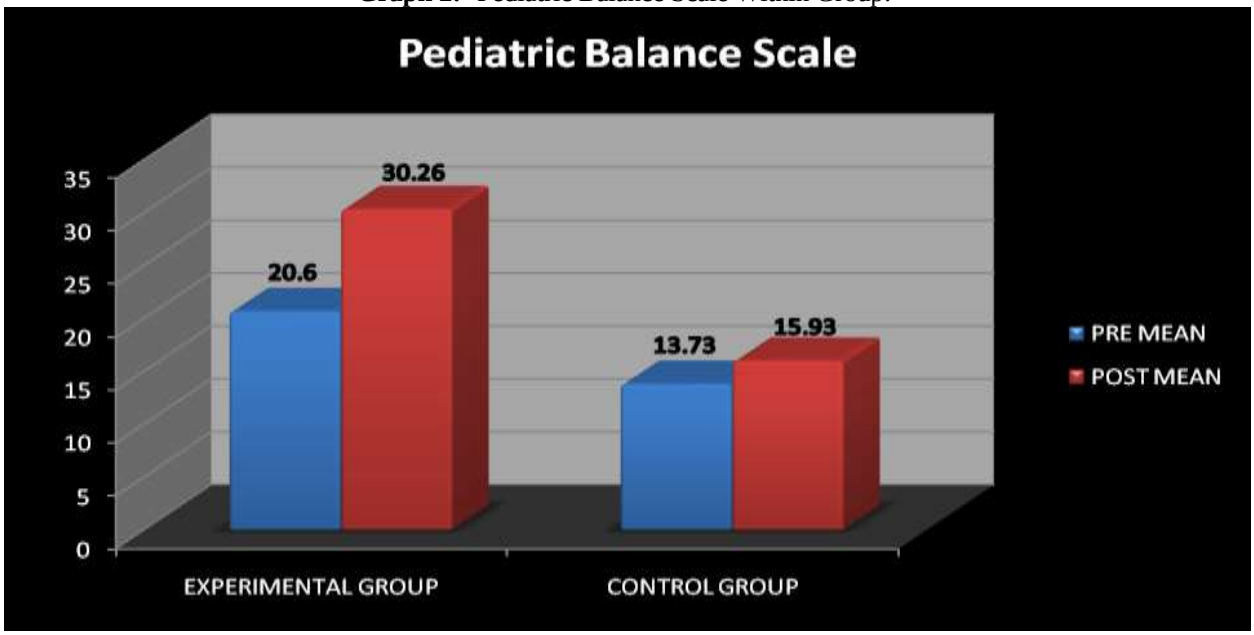
PBS	PRE MEAN ± SD	POST MEAN± SD	p VALUE

Table 2:- Pediatric Balance Scale Within Group.

PBS	PRE MEAN ± SD	POST MEAN± SD	p VALUE
EXPERIMENTAL GROUP	20.60 ± 7.73	30.26 ± 7.56	<0.001

CONTROL GROUP	13.73 ± 5.44	15.93 ± 4.97	<0.001

Graph 2:- Pediatric Balance Scale Within Group.



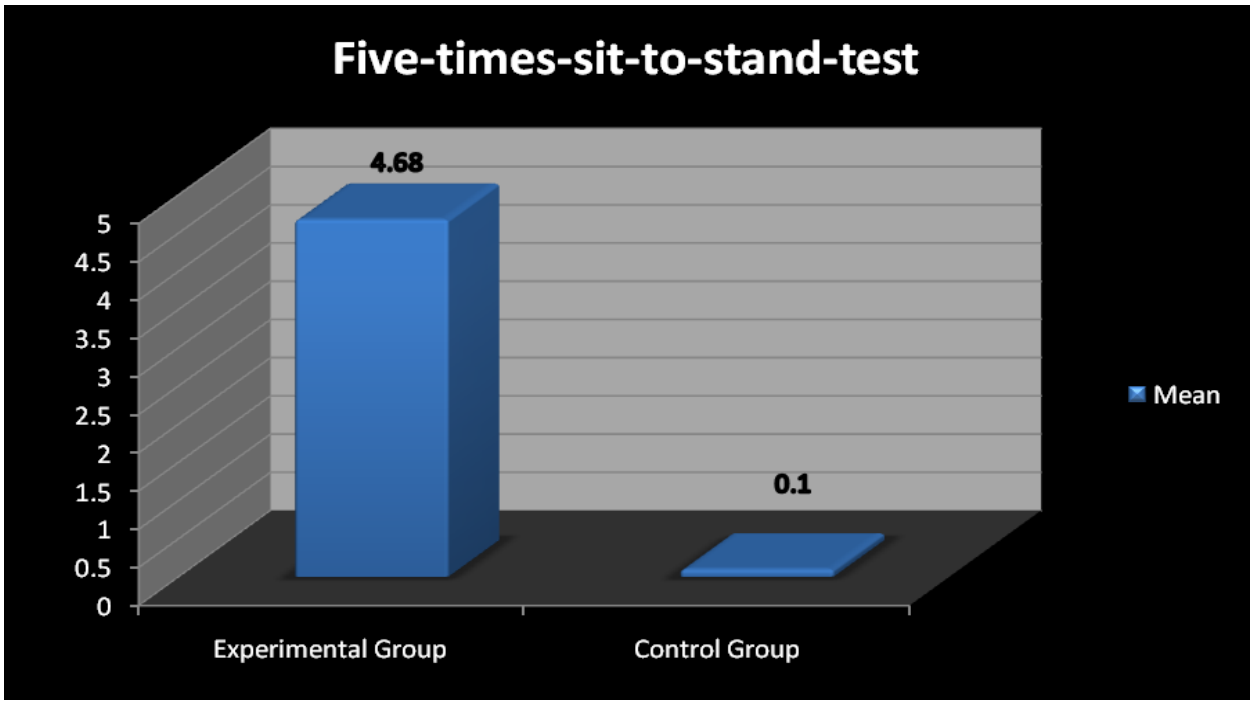
There was significant difference found between experimental group (p<0.001) and control group (p<0.001)

There was significant difference found between experimental group (p<0.001) and control group (p<0.001)

Table 3:- Five Times Sit To Stand Test Between Group.

FTSST	MEAN DIFF ± SD	p VALUE
EXPERIMENTAL GROUP	4.68 ± 1.37	<0.001
CONTROL GROUP	0.10 ± 2.23	

GRAPH:3 FIVE TIMES SIT TO STAND TEST BETWEEN GROUP

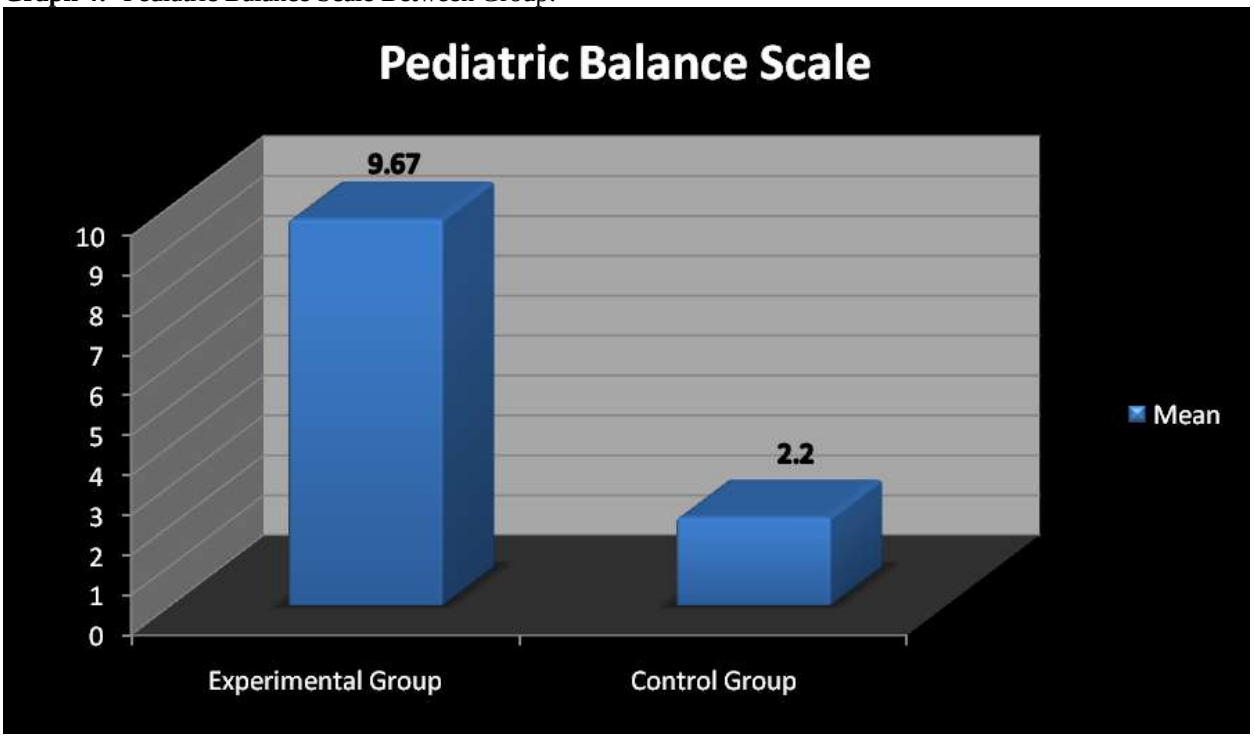


There was significant difference found between both groups

Table 4:- Pediatric Balance Scale Between Group.

PBS	MEAN DIFF ± SD	p VALUE
EXPERIMENTAL GROUP	9.67 ± 2.16	<0.001
CONTROL GROUP	2.20 ± 1.20	

Graph 4:- Pediatric Balance Scale Between Group.



There was significant difference found between both groups

Discussion:-

1. Balance is maintained by interaction between various systems of body, thus involvement of any one of these system can cause balance impairment. If balance is affected then functional mobility will be affected. Measurement of balance is an important component of balance, both static and dynamic abilities are considered integrate part of flexibility skills and historically have been viewed as vital component of developmental process by physical therapist.[13]
2. Cerebral palsy (CP) refers to the neuromuscular deficit caused by a non-progressive defect or lesion in single or multiple locations in the immature brain resulting in impaired motor function and sensory integrity.[2]
3. The aim of the present study was to analyze the effect of PRE of lower limb on balance in children with spastic diplegic cp.for participants classified as Levels I to III on the GMFCS.
4. **Wannisa kumban** showed that FTSST has an excellent test-retest reliability (ICC=0.912) and good inter-rater reliability (ICC=0.88) in children with CP. FTSST showed an excellent test-retest reliability (ICC=0.97) in children with mild spastic diplegic CP.[14]
5. **Mary Rose Franjoine** determined interclass coefficient of PBS (ICC=0.998), individual items coefficients (Kappa coefficients, k=0.87 to 1.0) and spearman rank correlation coefficient, r=0.89 to 1.0).[15]
6. Study done by **Vanessa A. Scholtes** was unable to confirm the hypothesis of 12 week functional PRE training. They concluded that the increase in muscle strength had no carry-over effect on walking abilities.[16]
7. **Mary Rose Franjoine** et al from their study concluded that girls perform better on static-standing balance compared to boys. Correlations of BMI with PBS were found to be very weak.[48]

8. This is the study that examines the effect of PRE of lower limb on balance in spastic diplegic CP. A total of 30 children, medically diagnosed as spastic diplegia within the age group of 6-12 years were taken. The children were screened for inclusion and exclusion criteria and those who fulfilled the criteria were taken in the study.
9. The results of the present study show that children with spastic diplegic cerebral palsy can increase isolated muscle strength and balance through a short-term resistance training program. The degree of weakness in cp before or after a strengthening program had not been addressed in earlier studies.
10. All participants in the study had consistent and dramatic strength increase in the quadriceps muscles and hamstrings muscles which improved balance, with the majority attaining normal strength values and improving balance.
11. The ability to balance on one leg is very important for many tasks in everyday life, such as negotiating obstacles and climbing stairs. Reduction in antagonistic co-contraction improves gross motor function and also enhanced muscle performance: restoration, improvement, or maintenance of muscle strength, power, and endurance.
12. The most common adaptation to heavy resistance exercise is an increase in the maximum force-producing capacity of muscle strength, primarily as the result of neural adaptations and an increase in muscle fiber size.[35]
13. The central nervous system lesion does not appear to interfere with their ability to increase isometric strength, since the gains were consistent with those found in persons with primary muscle weakness. However, continual training may be necessary to maintain the strength increases.(muscle strengthening)[44]
14. This study demonstrated that in experimental within group analysis of FTSST showed significant result ($p<0.001$), but in control group results were not significant ($p<0.856$)
15. In PBS the result of within group analysis was significant in both experimental group and control group ($p<0.001$).
16. The results were significant ($p<0.001$) in between group analysis for experimental and control group for FTSST and PBS
17. This study concluded that with increase in muscle strength there was increase in balance in spastic diplegic CP.
18. The FTSST is widely used in clinical and research areas, while PBS is gaining attention in the research area. Utilizing FTSST test and PBS may provide an easy and practical definition of the levels of muscle strength & balance limitations in children with CP.

Conclusion:-

FTSST and PBS has been demonstrated to be a quick, low cost, reliable test for children with age 6-12 years. FTSST shows a greater range of scores across strength testing in children with CP and PBS shows greater range across scores of balance across time.

In this study it was found that strength training PRE affects balance in children with spastic diplegic CP. With proper PRE training greater amount of balance can be achieved in children with spastic diplegic CP.

Study leads that there is improvement in balance with PRE of lower limb muscles.

Limitations

1. Only spastic diplegic children were included in the study. Children with other types of CP were excluded.
2. Sample size taken is small.

Further Recommendations:-

1. Age group can be made larger.
2. Heterogeneous group of subjects can be taken.

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