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To Compare two Strengthening Protocols to Improve Gait in Spastic Diparetic Cerebral Palsy Subjects

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Abstract

Introduction: Cerebral palsy is the most common neurological condition in pediatric age group. The worldwide incidence being 1.5 to 2.5 per 1000 live births [4,7,8]. Cerebral palsy in developing countries in most often attributed to birth asphyxia and birth Trauma and indeed birth asphyxia is still a leading cause of cerebral palsy in India [4]. Gait is one of the most important functional activity. It may be described as translatory progression of body as whole produced by coordinated rotatory movement of the body segment. Normal gait is rhythmic and characterized by alternating propulsion and retropulsion motions of the lower extremity and depends on the muscle strength of the lower extremities [1]. *Need for Study:* To compare two strengthening protocols to improve gait in spastic diparetic cerebral palsy subjects. *Methods:* 30 spastic diparetic cerebral palsy children took part in the study. The subjects were divided into two groups, group A and group B. Group A was given both closed kinematic and open kinematic chain exercise and group B was given only open kinematic chain exercise. Spasticity was evaluated by the Modified Ash worth scale. Following this, the subjects were asked to perform in randomized order. *Discussion:* Some studies proved that both closed kinematics chain and open kinematics chain strengthening exercise improve function in children and adolescents with Spastic cerebral palsy. Therefore, selecting different activities for training in both open and closed kinematics chain exercise improve more gait variables that using similar activities only in one kinematics chain exercise. *Conclusion:* The study concluded that although both groups group A and group B improves gait parameters, but Group A exercises shows better improvement in gait parameters as compared to Group B. Thus, the hypothesis that there is significant effect in improvement of gait parameters by using combined closed and open kinematic chain exercise in spastic diparetic cerebral palsy children holds true. *Limitation of study:* 1. Duration of gait training was small i.e. 5 weeks. 2. Time constrains meant that patients were only followed up for one month. *Future research:* 1. Further studies can be done with wider sample size including different subjects with different age groups. 2. Closed and open kinematic chain exercises can be applied in patient with different neurological condition such as muscular dystrophy, stroke, and multiple sclerosis. 3. Study can be conducted on cerebral palsy subjects with spasticity more than 1+.

Keywords: CP; Closed Kinematic & Open Kinematic Chain Exercise; Stop Watch; Marker; Measuring Tape; Oil and Socks; Paper Walkway & Rowing Machine.

Introduction

Gait is one of the most important functional activities. It may be described as translatory progression of body as whole produced by coordinated rotatory movement of the body segment. Normal gait is rhythmic and characterized by alternating propulsion and retropulsion motions of the lower extremity and depends on the muscle strength of the lower extremities [1].

Patient with various neurological conditions show variation in gait. These may be due to insufficient force generation, lack of co-ordination of body segment, weakness, postural balance deficits, and pain etc [2,3,5].

Cerebral palsy is the most common neurological condition in pediatric age group. The worldwide incidence being 1.5 to 2.5 per 1000 live births [4, 7, 8].

Cerebral palsy in developing countries in most often attributed to birth asphyxia and birth Trauma and indeed birth asphyxia is still a leading cause of cerebral palsy in India [4].

It is described as an "umbrella term covering a

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group of non progressive but often changing, motor impairment syndrome, secondary to lesions, or anomalies of the brain arising in the early stage of its development". This includes spasticity, muscle hypertonia, hyperreflexia, muscle weakness, and loss of selective motor control. The functional consequences are varied and can affect all activity of daily living [5,6].

Recent research shows that functional therapy program leads improvement in motor abilities of children with cerebral palsy, which is based on sound scientific principles of motor learning and motor control. Literature suggests that closed kinematic chain exercise are part of functional circuit training and strength training [10] but not study has been done showing the effect of closed kinematics chain exercise on the physical functional improvement in children with cerebral palsy.

So the present study thereby is a novel attempt to analyze the combined effect of closed kinematics and open kinematics chain exercise in gait function of children with cerebral palsy thereby increasing functional independency.

Operational definitions

Open Kinematic Chain Exercise

Open chain exercise refers to movement that occurs in an open kinematic chain, in which the distal segment moves freely in space [12].

Closed Kinematic Chain Exercise

Closed kinematic chain exercise refers to the movement that occurs in a closed kinematic chain where the body moves over a fixed distal segment [12].

Step Length

The distance between two consecutive contra lateral heel strikes [13, 14].

Stride Length

The distance between two consecutive ipsilateral heel strikes [13, 14].

Cadence

Number of steps taken by a patient per unit of time [14].

Walking Velocity

The rate of linear forward motion of the body. It is obtained by dividing the distance traversed by the time required to complete the distance. It is measured in either centimeter per second [14].

Research Hypothesis

Experimental hypothesis: open and closed kinematic chain exercise may improve gait parameters in spastic diparetic cerebral palsy subjects.

Null hypothesis: open and closed kinematic chain exercise may not improve gait parameters in spastic diparetic cerebral palsy subjects.

Need for study

To compare two strengthening protocols to improve gait in spastic diparetic cerebral palsy subjects.

Aim of study

The purpose of this research is to study the combined effects of closed kinematics and open kinematics chain exercises in improving gait parameters in spastic diparetic Cerebral palsy.

Review of Literature

This chapter deals with the view of literature associated with combined effects of open and closed kinematic chain exercise to improve gait parameters in spastic diparetic cerebral palsy subjects. This includes the theory and effects.

Cerebral palsy (CP) is described as a group of disorders of the development of movement and posture, causing activity limitation that is attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbance of sensation, Cognition, communication, perception and behavior and or by a seizure disorder [3].

Incidence and Prevalence

Cerebral palsy is a common problem. The worldwide incidence being 1.5 to 2.5 per 1000

live births. The rate of cerebral palsy per 1000 live births has increased in the lowest birth weight groups in recent years [4, 7, 8].

Gait Variations in Cerebral Plasy

V.cimolin et al. (2007) has shown that about 33% of children with cerebral palsy have hemiplegia with weakness and spasticity predominantly affecting one side of the body and deficits concerns the motor ability of the body's side opposite to the site of cerebral lesion. Hemiplegic children often have motor involvement not only on affected side but also on the non-affected side as well. The abnormal gait pattern of the unaffected limb in children with hemiplegia may relate to the non-affected limb strategy, directly connected to the pathology but also to primary growth disturbances of hemiplegic children [5].

Takebe basmajian studied the gait of five hemiplegic patient using cinematography, electromyography and footswitches. They found that the swing phase of the affected limb was prolonged and approach normal value with the recovery function [15].

Shewokis et al. (2004) Studied that the effect of functional electrical stimulation applied to the ankle musculature while walking. After training with functional electrical stimulation, in comparison to base line improvements were noted primarily in the knee and ankle. They found that improvements in walking velocity, cadence, and step length [16].

Shiri Liron Keshet (2001) studied that the effect of therapeutic electrical stimulation in children with cerebral palsy and that showed the some benefits from therapeutic stimulation, such as increase in muscle strength, decrease in spasticity and improvement in motor function and quality of gait like length and stride velocity improved [17].

Hank white (2002) Studied that the effect of clinically prescribed AFOs on the temporal spatial parameters in gait. He concluded that there was statistically significant improvement in stride length, step length and velocity [18].

MacPhail (2005) Studied the direct relationship between knee extensor strength and efficient walking and gross motor ability. They believed that lack of strength in the knee extensors could be one reason adolescents with cerebral palsy are limited in their standing, walking, running, and jumping activities. They stated that "improvements in muscular strength may be associated with improvements in walking efficiency and functional abilities [20].

Eagleton M et al. (2004) studied the effect of strength training on gait in adolescents with cerebral palsy. He concluded that strength training is an important aspect of physical therapy and increasing the gait velocity, step length and cadence of gait [9].

Blundell SW et al. (2003) studied the functional strength training in cerebral palsy with the use of group circuit training and result has shown that isometric strength improved pre to post training and functional strength [10].

Augustsson et al. (1998) studied the effect of weight training of the thigh muscles using closed versus open kinematic chain exercises. They concluded that closed kinematics chain exercises are more effective than the open kinematics chain exercises [22].

Karen J. Dodd et al. (2003) studied the effect of strength training in young people with cerebral palsy. They concluded that strength training programmes could improve muscle strength in young people with cerebral palsy. he also suggestes that strength training may have beneficial effects on activities in walking, running, and jumping as well as stair climbing [2].

MC Burney H, Taylor NF et al. (2003) investigated the positive and negative outcomes of home based strength training program for young people with treatment cerebral palsy. The exercise include the bilateral half squat, heel raises and step ups. The result have shown that strength, flexibility, posture, walking and the ability to negotiate steps had improved and in addition participants reported psychological benefits such as feeling of increased well being and improved participation in school and leisure activities [11].

Eileen G Fowler, Teresa WHO (2001) Studied the effect of quadriceps femoris muscle strengthening exercises on spasticity in children with cerebral palsy. The result of their study shows no increase in quadriceps femoris muscle spasticity after subjects with cerebral palsy complete4d quadriceps femoris strengthening exercise with maximum efforts. These results, considered along with the result of other studies that have demonstrated improvements in force production in individual with Cerebral palsy [26].

Marjolin Ketelaar et al. (2001) Studied the effect of functional therapy program on motor abilities of children with cerebal palsy. They have shown that effect on the both the child's capability as well as performance of daily functional motor skills improved [6].

Dodd Taylor NF et al. (2003) Studied the effect of a home based, six week strength training programme on lower limb strength and physical activity they have shown that muscle training can improve strength in children with cerebral palsy and also beneficial effects on gait [2].

Norris KD et al. Studied the open versus closed chain strength training in cerebral palsy. He found that both CKC and OCK strengthening exercise improve function in children and adolescents with spastic cerebral palsy [28].

Pheseant et al. Studied the effect of open and closed kinematics chain exercise on strength balance, and functional performance in an elderly population. He found that OKC and CKC were effective for improving knee extensor strength and also improve the balance [15].

Stendotter AK et al. Studied the quadriceps activation in closed and open kinematic chain exercise. Quadriceps is important for stability and optimal joint loading for both tibiofemoral and patellofemoral treatment. They concluded that exercise in closed kinetic chain promotes more balanced initial quadriceps activation than does exercise in open kinetic chain [17].

Pincivero et al. 1997 Studied the relation between open and closed kinematic chain assessment of knee strength and functional performance. They conlcluded that concentric quadriceps and hamstring strength demonstrate significant contribution correlation coefficients statistically greater for the hamstrings than the quadriceps for total work and average power [18].

Anthony C. Miller (1999) Studied the open and closed kinetic chain exercise following Cruciate ligament reconstruction. This study concluded that rehabilitation is the most important stage following ACL rapture. He found that closed kinematic chain exercises are the most beneficial during rehabilitation of the repaired anterior cruciate ligament and prevention of future injuries of the knee treatment [20].

Braden C. Funcing supports hypothesis that controlled Open kinematic chain exercise and closed kinematic chain exercise for rehabilitation of anterior cruciate ligament reconstructed knee should not differ in their effects on graft healing, Clinical studies suggest that both play a significant role in the early rehabilitation of constructed knee treatment [21].

Josper augustsson 1998: Studied the weight training of the thigh muscle using close versus open kinematics chain exercise. They found that 6 weeks of closed kinematics chain exercise weight training exercises resulted in larger improvements in muscle than open kinematics chain exercise [22].

Gait Assessment

Temporal – distance (TD) parameters measurement is a clinically feasible, quantitative approach to gait assessment [15]. The system is inexpensive, is easy to learn, takes little time to administer, and has been well studied in neurologically impaired individuals. Unlike traditional qualitative gait assessments, using measurements such as velocity orr stride length permits easy quantification of change and comparisons of outcomes across different subjects or treatments. The significant relationship of velocity, cadence, step and stride length, and SL: LEL to functional ambulation status supports the validity of their use outcome measures [36].

Gait assessment has become an increasingly important part of physical therapy evaluations. Gait assessment is used to determine whether the patient's gait differs from normal, to quantify the degree of abnormality and to identify the causes of the abnormal gait pattern and it is used as a reassessment tool to evaluate the efficacy of treatment [37].

Objective methods such as force plate studies, electrogoniometry, photography and energy expenditure studies have been developed to obtain quantitative information about gait [38,40,42].

Unfortunately, many of these methods are not easily used in clinical settings because of equipment cost, requirement and time necessary to administer the tests and reduce the date to clinically meaningful information [39].

Gait evaluation remains based primarily on clinical observations. Footprints can also be used as a method of gait evaluation. It requires application of paints, ink or chalk to the bottom of the patient's foot to make an imprint as they walked along a paper walkway. A stopwatch is used to measure overall trial time that is from start to finish lines. Footprint analysis can be performed quickly, is economical, is quantitative and objective, allows visualization of uneven weight bearing distribution or pressure areas of toe drag and symmetry of anatomical structures and serves as a permanent record for later comparison and to motivate the patient to walk more effectively. The measurements from the footprints include velocity, cadence, angle of the foot from the line of progression, base of support, stride and step length, toe drag and symmetry. The paper and

pencil method has been tested for validity. Excellent paper and pencil and GAIT Rite correlations for spatial measures have been found [41].

Methodology

Sample

30 subjects are taken for the study and divided into two groups, group A and group B. The study was conducted in the Department of Physiotherapy, Asha School, Birpur, gari cant Dehradun (Uttrakhand). A sample of 15 subjects each in 2 groups were selected according to inclusion and exclusion criteria. Inclusion criteria includes Age between 4 to 20 years, Good general health, Able to follow simple verbal commands, Ability to actively extend the knee from 90° to 45° in sitting position, Diagnosis of spastic diparetic cerebral palsy, Able to ambulate independently without walking aids & Spasticity 1+ and below in modified ash worth scale. Exclusion criteria include Previous surgical procedures to the lower extremities, Spasticity >1+ modified ash worth scale, Visual problems and hearing problems, Mental retardation interfering in understanding and performing the task in the exercise protocol regime & Seizure disorder during activity. Instrumentation- Stop watch, Marker, Measuring tape, Oil and socks, Pape, walkway & Rowing machine.

Procedure

The subjects (30) were invited to participate in this study. If they fulfilled the inclusion and exclusion criteria, informed consent was obtained from those willing to participate. Following this, the subjects were given verbal instruction regarding the exercise. The subjects were divided into two groups, group A and group B. Group A was given both closed kinematic and open kinematic chain exercise and group B was given only open kinematic chain exercise. Spasticity was evaluated by the Modified Ash worth scale. Following this, the subjects were asked to perform in randomized order.

Demographic details and history like Name, Age, Gender, Height, Weight, Limb length side affected and spasticity level according to the modified Ash worth scale were obtained. Following this, the assessment of gait parameters i.e. cadence, velocity, stride length and step length was done. The subjects were asked to walk over distance a 10 meters on the paper walkway.

Close kinematic chain exercise program: (Figure 1)

Include - Exercise on rowing machine
Half Squatting Exercise
Step up and down exercise

Open kinematic chain exercise program (Figure 2)

Maximal Static Quadriceps
Contraction with knee in full extension
Straight leg raising with the patient in the supine position
Leg abduction exercise in supine position.

In OKC exercise protocol, each exercise was held isometrically for count of 6 seconds with a 3 seconds rest between repetitions. Each exercise in the CKC protocol was performed dynamically with 3 seconds rest between repetitions. Each exercise in both training groups was repeated for 3 sets of 10 repetitions. The patients rested 1 min. after the conclusion of each set. Exercises were performed for duration of 5 weeks, 3 times a week for 30 to 45 minutes.

Both groups were instructed to perform hamstring, quadriceps, and gastrocnemius static stretching after each training session (i.e., three repetitions of a 30 seconds static stretch)

Foot prints were taken with the help of oil paint applied on the sole of the patients. The subject was asked to move and told not to step outside the margin of the paper. This walking trail was realised on a paper walkway in a well-lit environment at a self selected speed and wearing socks. Oil paint method was obtained footprints. Both the acceleration and deceleration phases of gait were excluded for data analysis. This is initial and final distance of 2 meters was excluded.

Walking time in second was noted with the help of stopwatch.

Stride length was calculated by measuring the distance from heel strike of one extremity to the heel strike of the same extremity.

Step length was calculated by measuring the distance from heel strike of one extremity to the heel strike of opposite extremity.

Velocity was calculated by dividing the distance traversed by the time required to complete the distance. It was measured in centimeters/seconds.

Cadence was measured as the number of steps taken by patients of time.

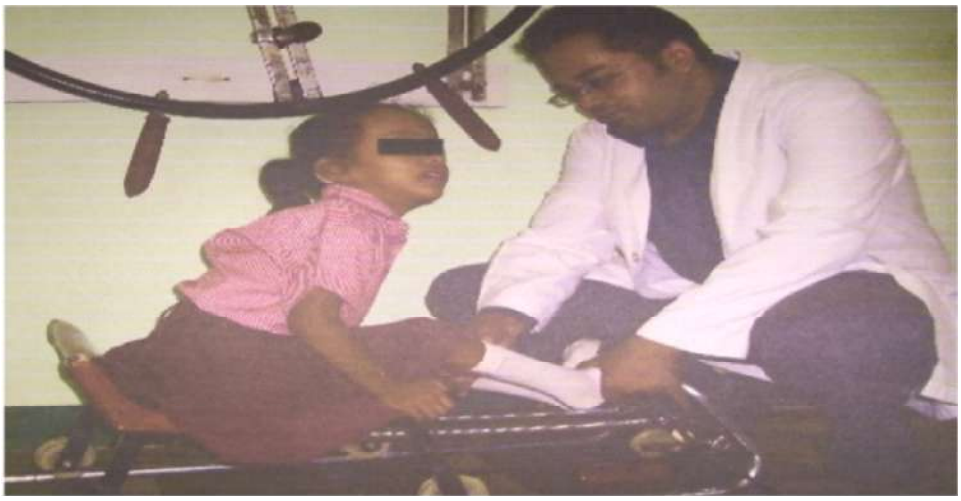

Fig. 1: Close kinematic chain exercise program (CKC)

Fig. 2: Open kinematic chain exercise program (OKC)

Three trials were taken for each assessment and mean for each outcome measure was calculated. After this, the subject was asked to perform the exercise protocol. Group A was given closed kinematic and open kinematic and group B was given only open kinematic chain exercise for a period of 5 weeks, Three times a week, for 30 to 45 minutes. Following this, gait parameters were again calculated as described above.

Data Analysis

Statistics were performed using Graph pad prism. Results were calculated by using 0.05 level of significance. Unpaired t-test was used to compare the score between group A & B.

Results

The chapter deals with the results of the data analysis of the gait parameters between A and B. This course was analysed to compare the effectiveness of treatment protocols. Unpaired t-test was used to compare the gait parameters between group A and B.

Analyzing step length of gait revealded significant changes in group A with mean and SEM (26.33± 0.5989) when compared with group B with mean and SEM (24.60±0.6157). (Table 1 & Figure 3)

Analyzing stride length of gait revealded significant changes in group A with mean and SEM (64.53±0.5679) when compared with group B with mean and SEM (60.73±0.8250). (Table 2 & Figure 4)

Analyzing cadence of gait revealded significant changes in group A with mean and SEM (88.60± 0.6309) when compared with group B with mean and SEM (84.13±0.8330). (Table 3 & Figure 5)

Analyzing velocity of gait revealded significant changes in group A with mean and SEM (69.27±0.6933) when compared with group B with mean and SEM (64.00±0.5434). (Table 4 & Figure 6)

Table 1: mean and SEM of step length of Gait of group A and group B

Group	Mean & SEM	P value
Group A	26.33±0.5989	< 0.05
Group B	24.60±0.6157	< 0.05

Table 2: mean and SEM of stride length of Gait of group A and group B

Group	Mean & SEM	P value
Group A	64.53±0.5679	< 0.05
Group B	60.73 ± 0.8250	< 0.05

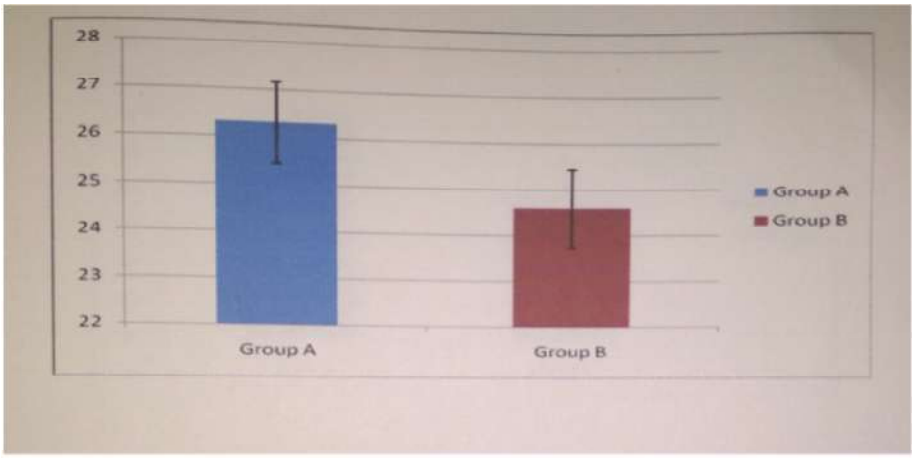

Fig. 3: Comparison of Mean and SEM of step length of Gait of group A and group B

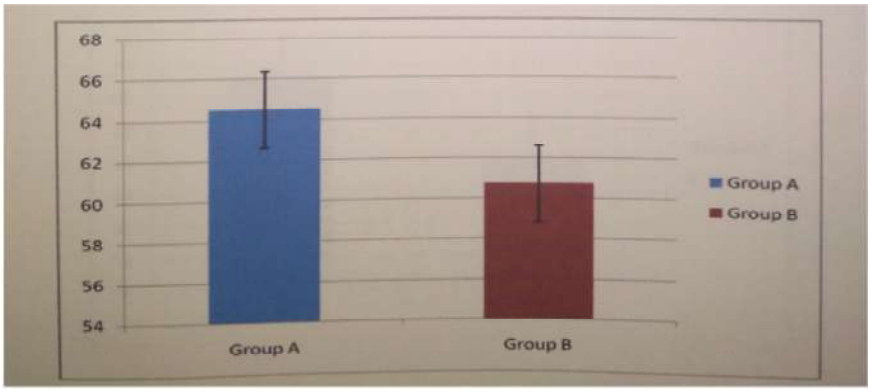

Fig. 4: Comparison of Mean and SEM of stride length of Gait group A and B

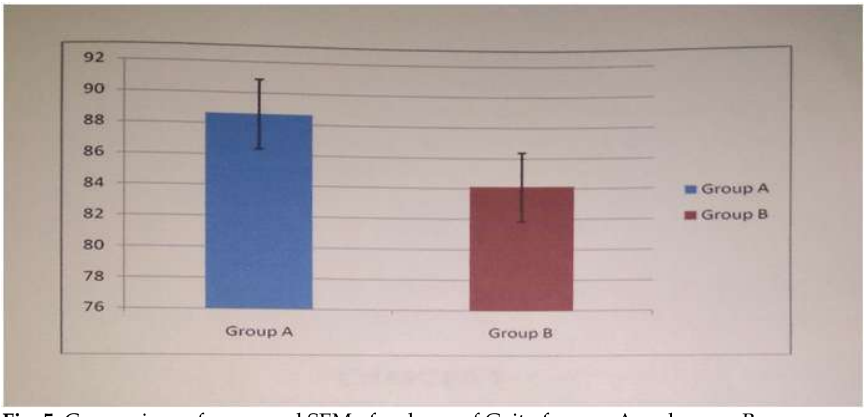

Fig. 5: Comparison of mean and SEM of cadence of Gait of group A and group B

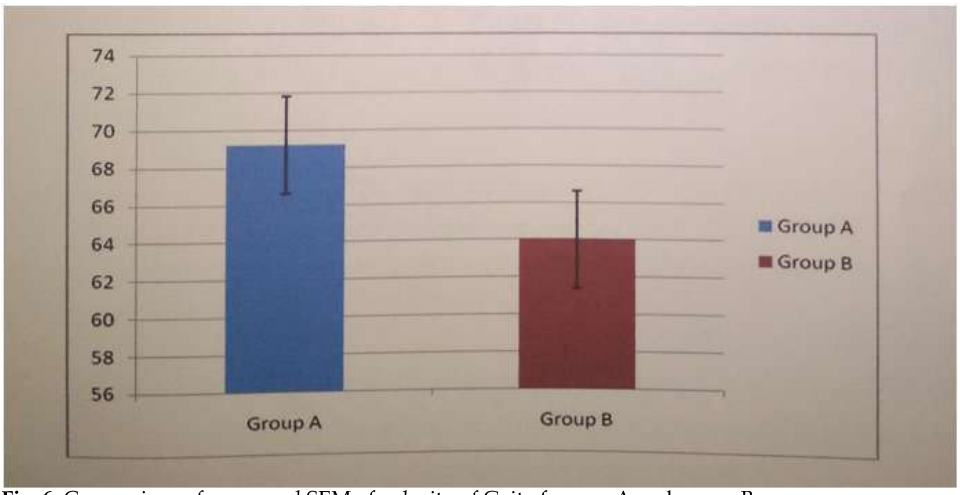

Fig. 6: Comparison of mean and SEM of velocity of Gait of group A and group B

Table 3: mean and SEM of cadence of Gait of group A and group B

Group	Mean & SEM	P value
Group A	88.60±0.6309	< 0.05
Group B	84.13±0.8330	< 0.05

Table 4: mean and SEM of velocity of Gait of group A and group B

Group	Mean & SEM	P value
Group A	69.27±0.6933	< 0.05
Group B	64.00±0.5434	< 0.05

Discussion

Data from this study shows that the control and experimental groups performed at same level for the pretest portion of the experiment.

But experiment group (in which both closed and open kinematics chain exercise was given shows more improvement in terms of stride length, step length, cadence, and velocity than control group. (In which only open kinematics chain exercise given within experimental group, (stride length, Step length, cadence, and velocity all dependent variables were increased more than that of control group. Our findings, like those in the past researchers Demonstrated that progressive strength training Programmed improves the walking ability in terms of step length, stride length, cadence, and Velocity [2, 10, 12, 45,46].

Previous studies have taken different strengthening exercise either in open kinematics chain exercise or in closed kinematics chain exercise.

Different activities like step up and step down, rowing exercise, squatting exercises were done in closed kinematics chain exercise.

Where as straight leg rising, isometrics, leg abduction was done in open kinematics chain. As suggested by our results i.e. experimental Group shows more improvement in gait variables than control groups.

Improvement occurs in both groups (these results may be due to the exercise protocol which we have taken in this study. Researchers have proved that squatting is more effective in improving strength of glutei, hamstring, and quadriceps which are more contributed to improve gait parameters.

Step up and step down done in closed kinematics chain improves the strength of quadriceps and hamstring by co-activation of there two muscles, Towing improves strength, endurance, walking, gross motor functions and gait parameters [7].

Exercises used in open kinematics chain improve strength of quadriceps. Previous studies proved that closed kinematics chain exercise in improving strength of thigh muscles [47].

Some studies proved that both closed kinematics chain and open kinematics chain strengthening exercise improve function in children and adolescents with Spastic cerebral palsy.

Therefore, selecting different activities for training in both open and closed kinematics chain exercise improve more gait variables that using similar activities only in one kinematics chain exercise.

Clinical implication

Closed and open kinematic chain exercises can be used in cerebral palsy subjects for increase

strength, maintaining fitness level, balance and co-ordination, thereby improving Functional independence. Also, closed and open kinematic chain exercise can be used along with other balance training protocols in improving balance.

Limitation of study

1. Duration of gait training was small i.e. 5 weeks.
2. Time constrains meant that patients were only followed up for one month.

Future research

1. Further studies can be done with wider sample size including different subjects with different age groups.
2. Closed and open kinematic chain exercises can be applied in patient with different neurological condition such as muscular dystrophy, stroke, and multiple sclerosis.
3. Study can be conducted on cerebral palsy subjects with spasticity more than 1^{+}.

Conclusion

The study concluded that although both groups group A and group B improves gait parameters, but Group A exercises shows better improvement in gait parameters as compared to Group B. Thus, it is better to consider combined closed and open kinematic chain exercise while designing exercise protocol to improve gait parameters in spastic diparetic cerebral palsy children. Thus, the hypothesis that there is significant effect in improvement of gait parameters by using combined closed and open kinematic chain exercise in spastic diparetic cerebral palsy children holds true.

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