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## A COMPARATIVE STUDY ON EFFECTIVENESS OF OPEN VERSUS CLOSED KINETIC CHAIN EXERCISES TO IMPROVE GAIT IN SPASTIC DIPLEGIC CEREBRAL PALSY

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## ABSTRACT

**Background:** Cerebral Palsy (CP) describes a non- progressive but not unchanging disorder of movement and posture due to an insult to or anomaly of the developing brain. People with spastic diplegia typically walk slowly and have difficulties in performing activities such as walking running or jumping. Children with spastic diplegic cerebral palsy are relied more on cadence to increase speed. Hence, the purpose of this study is to compare the effectiveness of open and closed kinetic chain (OKC and CKC) exercises in improving gait in spastic diplegic cerebral palsy.

**Methods:** 30 children with spastic diplegic cerebral palsy of both genders with age 4-12 years was taken. Cadence and distance covered in 1Minute Walk Test was calculated before and after the test. The intervention for group A was CKC exercises and group B was OKC exercises for 3 days a week for 6 weeks and each session lasted for 30-45 minutes was given for both the groups.

**Results:** Paired t-test was performed to find effectiveness of CKC and OKC improving gait in spastic diplegic CP to see the difference of means of 1minute walk,  $t = 10.789$  which is significant ( $p = 0.000$ ) and for cadence,  $t = 3.37$  which is highly significant ( $p = 0.00$ ) implying that cadence and distance covered in 1minute walk was more with CKC exercises.

**Conclusion:** Based on the result it is concluded that CKC exercises are effective in improving gait than OKC exercises in spastic diplegic cerebral palsy.

**Keywords:** CP, CKC, OKC, 1MWT, Cadence, GMFCS.

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## INTRODUCTION

Cerebral palsy (CP) refers to a group of permanent disorders of the development of movement and posture, causing activity limitations, which are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. Damage to the central nervous system (CNS) cause disorders in neuromuscular, musculoskeletal and sensorial system. These disorders results in posture and movement deficiencies .The causes of motor disorders are developmental retardation, abnormal muscle tone, muscle weakness postural control deficiencies, sensorial problems, behavioral problems, musculoskeletal problem, abnormal movement pattern and reflex. Spastic CP is the commonest and accounts for 60%-70% in all cases, Ataxia- 10% to 15%, Athetoid -10%to 15%, Mixed is 10% in all cases [1]. In most studies, diplegia is the commonest form (30%-40%), hemiplegia is (20%-30%), and quadriplegia accounts for (10%-15%).

Spastic Diplegia is the most prevalent form of cerebral palsy, is characterized by motor incoordination, primarily in the lower extremities ,that impairs many functional abilities ,mostly the ambulation [2]. In this condition, lower limbs are more severely affected than the upper limbs Abnormal gait is a common problem in children with cerebral palsy(CP).These children are at great risk of deterioration in their walking ability as they grow up.Balance disturbance, muscle weakness, spasticity and deformities results in abnormal gait patterns. Most diplegic children start cruising at 2 years of age and walk by age 4.Neuromotor function improves until age seven [3]. Development of gait in the individual with spastic diplegic cerebral palsy shows a pattern similar to that of the average developing child.People with spastic diplegia,typically walk slowly and have difficulty in performing activities such as walking,walking up and down steps or running [4]. An excellent idea for classifying gait patterns in spastic diplegia was given by Sutherland and Davids (1993)They describe the patterns of knee involvement in spastic diplegia .The sagittal plane is considered as a whole;ie. pelvis,hip,knee and ankle.The muscle groups which exhibit spasticity and then contracture are psoas,the hamstring,the rectus femoris and the gastrocnemius.Spasticity and contracture in these two-joints muscles ,results in characteristics gait patterns Conventional physiotherapy is given for this kind of cerebral palsy. Both open and closed kinematic chain exercises are proven to be effective in improving gait but there are no studies comparing the effectiveness of open and closed kinematic chain exercises.

## MATERIALS AND METHODS

A Comparative study design with two groups-Group-A(-conventional physiotherapy and closed kinematic chain exercises) and Group-B(conventional physiotherapy and open kinematic chain exercises).A total of 30 subjects were included by Simple Random sampling and each group consist of 15 subjects. Subjects included in the study were with the age group between 4-12 years, both male and female

subjects with good or fair selective motor control of lower limb [5], ability to follow the simple verbal commands and able to walk independently indoors with or without walking aids (Level i. ii and iii of the Gross Motor Function Classification system) and spasticity 1+ or below in MAS [14]. Subject were excluded with previous surgical procedures to the lower extremities [11,12], Spasticity >1+ in MAS, visual and hearing problems ,mental retardation interfering in understanding and performing the task and had medical condition such as cardiac disease or uncontrolled seizures [6]. Subjects were recruited from Shishu Sarathi-Centre for Rehabilitation and training for Multiple Disability, Birubari-Guwahati and outpatient department of College of Physiotherapy and Medical Sciences, Bamanimaidan-Guwahati.

Both the groups followed a 6 weeks of training program, 3 times a week [7]. Each training session lasted for 30-45 minutes. After completion of each set subject was rested for 5-10 minute .Cadence and distance covered in 1minute walk was calculated before(Day-0) and after the test(6 week) and was documented as Pre test Score and Post test score respectively. This assessment was done by making the child to walk in room with a length of 10 meters and the child was asked to walk around it. Initially the cadence was assessed. Then a rest period of 10 minutes was given and 1minute walk test was performed. A simple method of measuring cadence is by counting the number of steps taken by the subject in a given amount of time [8-10]. 1minute walk test ( 1MWT) assesses the distance (in meters) walk during 1 minute, which was performed on a 20-22m,flat smooth non-slippery oval walking track. The child was instructed to walk around the track for 1 minute at their fastest attainable speed (no running).During this test the distance (in meters) was calculated to measure the fast walking speed.

**PROCEDURE:** Both groups treated with conventional physiotherapy.

**Conventional Physiotherapy:** Passive Stretching of hamstring and calf muscles and Active and Passive Range of motion exercises of lower limb was given to both the groups<sup>9</sup>. Stretching and Range of motion exercise was given prior to the specific exercises. Stretching are the form of conventional rehabilitation for treating spasticity, helps to maintain the range of motion in joint and helps prevent contracture and it must be done regularly,usually once or twice a day.

**Group A:** Subjects in this group were given conventional physiotherapy and also performed closed kinematic chain exercises.The CKC exercises were 1)Static Bicycling 2)Step-up and down and 3) Lateral step-up. Exercises were repeated for 3 sets of 10 repetitions with a rest period of 10 minutes after each exercise.

**1. Static Bicycling:** The seat height was carefully adjusted to minimize the knee flexion movement on the down stroke<sup>10</sup>. Feet were placed comfortably on the pedals by adjusting the straps of the pedals of the Static Bicycle. Sup-

port was given from back when required. After 6 days of intervention resistance was applied by adjusting the resistance knob of the static bicycle. The advantage of stationary bicycling over CKC exercise is that the amount of weight bearing force exerted by the lower extremity can be adapted within subject limitation.

## 2. step - up and step-down exercise:

**Step-up exercise:** The child was in standing position facing a step (2-3 inches in height). The child was asked to lift one leg onto the step. After the foot was on the step, child was asked to lean towards the step being sure that the knee is in line with foot and pelvis was level. This exercise stimulates the hip extensors recruitment of the stance limb.

**Step-down exercise:** Child was in standing position with step. Child was asked to flex the foot of the leg that are stepping down with but not to completely step down, step just short of the floor and hold this position for up to 10 sec. Purpose of this exercise was to strengthen the hip, knee, ankle and foot muscle to improve the balance in single limb support. 3. lateral step-up: Step height was adjusted to child's capabilities to complete the repetition and generally progresses up to about 8 inches. The child stood next to the step and put one leg on the step. The child was asked to lift another leg up and put it on the step, by fully extending the hip and knee of the previous leg. When performing a step-up, entire body weight must be raised and lowered.

**Group B:** Subjects in this group were given conventional physiotherapy and also performed Open kinetic chain exercises. The OKC exercises were 1) Seated leg extension 2) Hamstring curls and 3) Leg abduction exercise (side lying position). Exercises were repeated for 3 sets of 10 repetitions with a rest period of 10 minutes after each exercise. 1. Seated leg extension: Child was in sitting position with back straight and arms resting at sides. The child was asked to slowly straight one leg being sure not to pelvis rock backward. Child was asked to hold this position for few seconds. Purpose was to stretch the hamstring and calf muscle. After 6 days of exercise resistance was applied with free weights in the form of adjustable weight cuffs in the distal part of the knee. 2. Hamstring curls: Child was in standing position, holding onto a solid object for balance. Then instruct the child to raise one foot from the ground and flex the knee and asked to hold this position for few seconds. Maximum resistance occur when the knee was at 90 degree of flexion. 3. Leg abduction exercise: This exercise was performed in couch. Here the child will be in side lying position. Then the child was asked to lift the leg which was free to move and support was given to the other leg for stabilization. When one leg was fixed and other abducted an apparent increase in range of the abducted leg was produced.

## RESULTS

Analysis was carried out in SPSS windows Version 20.0. An alpha-level of 0.05 was used to determine statistical significance. Paired t-test was performed to find effectiveness of closed kinetic chain exercises and open kinetic chain ex-

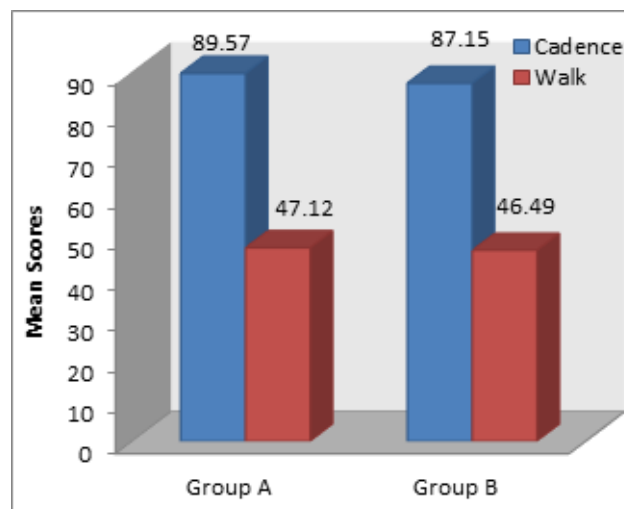
ercises in improving gait in spastic diplegic cerebral palsy. Independent sample t-test was carried out to compare the effectiveness of CKC exercises and OKC exercises in improving gait in spastic diplegic cerebral palsy.

**Table 1:** To compare the effectiveness of open and closed kinetic chain exercises in improving gait in spastic diplegic cerebral palsy

		N	Mean ± SD	t	df	p
Cadence	Group A	15	89.57 ± 2.4	3.37	14	.002
	Group B	15	87.15 ± 1.28			
1MWT	Group A	15	47.12 ± 13.405	5.78	14	.000
	Group B	15	46.49 ± 5.817			

**Inference:** Independent t-test was performed to compare the effectiveness of closed kinetic chain exercises and open kinetic chain exercises in improving gait in spastic diplegic Cerebral palsy. The tests were carried out separately for cadence and 1 Minute walk test. For cadence,  $t = 3.37$  which is highly significant ( $p = 0.00$ ). It has been inferred that cadence was more in subjects where they were treated with closed kinetic exercise. To see the difference of means of 1 minute walk,  $t = 10.789$  which is significant ( $p = 0.000$ ) implying that distance covered in 1 minute walk was more in subjects where subjects were treated with CKC exercises.

**Figure 1:** Showing the comparison of mean cadence and 1MWT test scores of Group A and Group B



**Inference:** It can be inferred from above that both CKC and OKC exercise were effective in improving gait in spastic diplegic Cerebral palsy. However, treatment of CKC exercises was found to be better than OKC exercises.

## DISCUSSION

Children with spastic diplegic cerebral palsy are slower and relied more on cadence to increase speed [11]. The purpose of the study was to find out the effectiveness of Closed kinetic chain (CKC) exercises and Open kinetic chain (OKC) exercises to improve the walking speed in spastic diplegic CP. The result obtained showed that there is significant difference in cadence and 1 minute walk test after performing OKC and CKC exercises in children with spastic diplegic CP. Cadence was improved in subjects treated with CKC

exercises. Andersson et al(2003) concluded in his study that there is good correlation between muscle strength and functional walking ability. He also found improvement in muscle strength, cadence, velocity and gross motor function after performing strengthening exercise.

OKC exercises produced more rectus femoris activity and CKC exercises produce more vastii muscles activity [12]. Noris KD et al concluded in his study that both CKC and OKC strengthening exercise improve function in children and adolescent with spastic cerebral palsy [13]. Few participants in Group A, performing CKC exercises reported that after completing the exercise program they are able to walk up and down the steps easily at school and their balance was also improved during walking. It is possible that participation in strength training program might lead to more permanent changes in everyday physical activities .But subject who performed OKC exercises did not report any improvement in balance. Optimal management of people with cerebral palsy may include physiotherapy approaches in combination with medical management. These CKC and OKC exercises might be viewed as a part of a comprehensive management plan rather than a isolated intervention for cerebral palsy.

## CONCLUSION

Closed kinematic chain exercises are more effective in improving gait than open kinematic chain exercises in spastic diplegic cerebral palsy. These specific exercise programs have played a significant role for improvement of the function and independence of the children with spastic diplegic cerebral palsy.

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