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Original Article

COMPARISION OF DYNAMIC CYCLING VS STATIC CYCLING ON ENDURANCE, BALANCE, AND WALKING ABILITY OF CHILDREN WITH CEREBRAL PALSY

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ABSTRACT

Background: The impairments in cerebral palsy can limit a child's ability to play and exercise at intensities necessary to develop cardio respiratory fitness.

Objective: To compare the effects of dynamic cycling, static cycling and conventional exercises in cardiovascular endurance, balance and walking ability in cerebral palsy children.

Materials and Method: A total of 30 subjects were recruited in an experimental pre-post-test study design. Subjects were randomly assigned to 3 different treatment groups. The following outcome measures were measured: resting Heart Rate, 3 Minute Walk Test, GMFM-66, and Pediatric Balance Scale. All the three groups received conventional exercises. The experimental group 1 in addition received dynamic cycling protocol and experimental group 2 received static cycling protocol. The outcome was again evaluated at 6 weeks.

Results: All the 3 groups showed significant pre to post improvement for the entire outcomes measured but GMFM-66. Results of the studied showed more significant improvement in both the cycling groups compared to the control group; Dynamic cycling group showing better response than static cycling group. Though all the groups showed improvement in GMFM-66, the dynamic cycling group showed better improvement followed by control group.

Conclusion: Dynamic cycling incorporated with conventional exercises improves the cardiovascular endurance, balance and functional abilities than conventional exercises only.

KEY WORDS: Cerebral Palsy, Dynamic Cycling, Static Cycling, Balance, Exercise, Walking, Endurance, Ability.

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INTRODUCTION

Despite the localized CNS trauma in cerebral palsy (CP), the manifestations include: 1. lack of selective muscle control, 2. dependence on primitive reflex patterns for ambulation, 3. abnormal muscle tone, 4. relative imbalance between muscle agonists and antagonists across joints, and 5. deficient equilibrium reactions [1].

From a functional perspective, children with CP have difficulty performing purposeful and efficient physical movements for many reasons, including weakness, abnormal muscle coactivation, involuntary movement, poor selective voluntary motor control, spasticity, contractures, and decreased balance [2]. These impairments can limit a child's ability to play and exercise at intensities necessary to develop cardiorespiratory fitness. The interaction of these factors can lead to a continuous cycle of deconditioning and decreased functional ability.

Dahlback (1985) reported that children with CP became fatigued while working at sub maximal levels less than 50-60% of maximal oxygen uptake during treadmill walking [3]. They concluded that local muscle factors rather than cardiopulmonary factors are responsible for the exhaustion. Furthermore, Unnithan (1996) reported a positive relationship between co-contraction of lower extremity muscles in children with CP and the elevated energy cost of treadmill walking at sub-maximal speeds. A spastic muscle or group of muscles may overpower antagonists that less spastic, normal, or flaccid. This in turn may cause soft-tissue and skeletal changes [4].

Promoting, maintaining and enhancing gait function are the ultimate therapeutic goals in neuro-rehabilitation. To achieve these goals there are many interventions used one of which is cycling. The kinematics of walking and cycling are similar except that cycling demonstrates greater minimum to maximum flexion at the knee, more posterior pelvic tilt, more external rotation of hip, less ankle plantar flexion and overall less ankle excursion than walking. Therefore cycling is a simplified locomotor pattern. There is evidence of shared neural circuitry in cycling and walking and both require reciprocal motor coordination. Also loading is substantially decreased through lower limbs during cycling because of seated support. In cycling all the three joints of lower limb are highly coupled and constrained to move in unison [5].

Muscular activity and coordination may be influenced by movement speed and inertial properties of the limbs. Hence simultaneous strengthening of hip, knee, and ankle musculature may be achieved by cycling. The advantage of cycling is that unlike other aerobic activities like walking or running, cycling is less dependent on balance, coordination and motor control. Hence the aim of the study is to improve the child's overall functional status and also improve his abilities to ambulate in the environment as independently as possible and reduce the delirious effects of using a wheelchair passively.

The aims of this study are therefore to compare the effects of dynamic cycling, static cycling and conventional exercises in cardiovascular endurance, balance and walking ability in cerebral palsy children.

MATERIALS AND METHODS

Present study designed as a 3 Group experimental pre-post-test study; conducted with a sample size of 30 subjects and they were recruited according to the inclusion and exclusion criteria.

Subjects were randomly assigned to 3 different treatment groups after obtaining their parents' consent.

Inclusive Criteria includes: Children diagnosed as Spastic diplegic cerebral palsy, with an age group between 4 years to 10 years, children who could sit without foot or arm support, cognitive function was normal or near normal, could follow instructions and were cooperative.

Exclusion Criteria: Mental retardation, children with spastic quadriplegia, spastic hemiplegia, athetoid, ataxic cerebral palsy, behavioural disorders, musculoskeletal or neurological surgery within one year, Botulinum toxin injections within 6 months, Significant hip and knee contractures making it difficult to cycle.

As the children included in the study ranged from 4-10 years with mean age of 7.4 years. The mean age of children in group 1 was 6.3 years and there were 5 girls and 5 boys in the group. The mean age of children in group 2 was 6.2 years and there were 4 girls and 6 boys in the group. The mean age of children in group 3 was 6.1years and there were 4 girls and 6 boys in the group.

Dependent Variables

· The resting heart rate at the beginning of intervention and at the end of 6 weeks.

· 3 Minutes walk test - A normal tailor tape calibrated from 0-152 cms was used to measure the distance covered during 3-Minute walk test

· GMFM-66 Section D and E score - A standardized observational instrument, valid and reliable to be used for measuring change in gross motor function abilities in cerebral palsy children

· Pediatric balance scale score- A modification of berg's balance scale was used to measure balance in spastic cerebral palsy children

PROCEDURE:

1. After meeting the inclusion and exclusion criteria through an assessment performa, informed consent was taken from the parents/ caregivers of the patients and then children were randomly allocated to either of the three groups:-

Group 1: dynamic cycling (experimental 1) group

Group 2: static cycling (experimental 2) group

Group 3: conventional (control) group

2. All participants underwent an initial baseline assessment of Resting Heart Rate, 3 Minute Walk Test, GMFM-66, and Pediatric Balance Scale.

3. All the three groups received conventional exercises. The experimental group 1 in addition received dynamic cycling protocol and experimental group 2 received static cycling protocol**.**

The intervention period was of 6 weeks duration, 5 days/week, 60 minutes/session. After completion of 6 weeks all participants received follow up assessments.

Prior to initiation of treatment and completion of treatment, children were scored for:

a. Resting Heart Rate: The children were called in morning and their pulse rate was measured manually for three consecutive days and their mean was noted.

b. Three Minute Walk Test: With a tape a walking course was marked in the department with no barriers in between and two stools were kept at the start and end and the child has to walk for three minutes along the track at his own comfortable speed wearing his/her footwear. Verbal encouragement was provided every 30 seconds. At the end of 3 minutes the number of laps completed was noted and therefore the distance walked was calculated.

GMFM Dimension D and E: Children were assessed for GMFM score in a quiet room without distraction, using a mat, and benches of variable height; according to the instructions given in GMFM manual.

Conventional Exercises Protocol:

i. Sustained stretching of tight muscles like hip adductors, hamstring and gastrosoleus, for 2 minute each, in each treatment session.

ii. SUPINE- BRIDGING- 10 times with 10 seconds hold

iii. KNEEL Standing with activity of upper limb 10 – 15 minutes.

iv. SITTING- REACH OUTS- Forward, sideways

v. SIT TO STAND- 20 times

Static Cycling Group Exercise Protocol:

The protocol of exercises for this group was the same as conventional group with the addition of riding a static cycle at the end of the session starting initially at the child's maximum capacity with rest interval in between and gradually progressing till one hour with decrease rest intervals. The feet of the children were secured by straps. Encouragement was given by the parent and the therapist time to time.

Dynamic Cycling Group Exercise Protocol:

The protocol of exercises for this group was the same as conventional group with the addition of riding a dynamic cycle at the end of the session starting initially at the child's maximum capacity with rest interval in between and gradually progressing till one hour with decrease rest intervals. The feet of the children were secured by straps. The children were given helmet and knee guards for safety. The children ridded the bicycle in the campus of SVNIRTAR on a triangular path. Encouragement was given by the parent and the therapist time to time

Both the **Static cycle and outdoor cycle** were modified, seat width, pedals, belt for trunk support, helmet and knee guards.

Data Analysis:

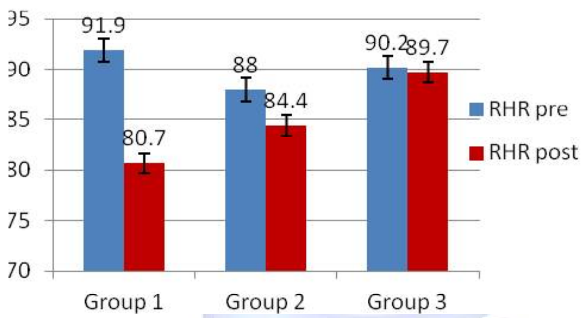
Data was analyzed using 3 X 2 ANOVA with one between factors manipulated 3 levels and one within factor done with 2 levels for heart rate & 3 minute walk test. Between groups difference for GMFM and PBS was done byusing Kruskal-Wallis test.

Analysis was performed using SPSS package 16 version.

RESULTS

Resting Heart Rate: The Graph 1 shows that there was a decrease in resting heart rate in both the experimental groups than the control group, with decrease in resting heart rate in Dynamic cycling group is being significantly more than and static cycling group**.**

Graph 1: Resting heart rate.



Repeated measure analysis for resting heart rate revels that there is main effect for time as F=122.0 and p=0.000**.**

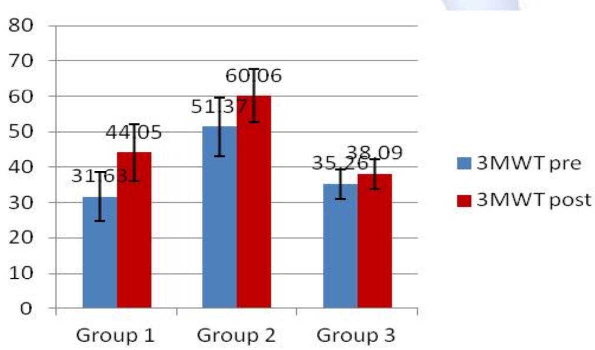
There was no significant main effect for group as F=1.041 and p=0.367.

There was a significant effect for time x group as F= 51.070 and p=0.000.

Tukey's HSD analysis revealed that experimental group1 improved to a greater extent than experimental group 2 which was also better than the control group.

3 Minute Walk Test: The Graph 2 shows that there has been a increase in distance covered in 3 minute walk test in both the experimental groups than the control group, with increase in distance covered in 3 minute walk test in Dynamic cycling group is being significantly more than static cycling group.

Graph 2: Three Minute Walk Test.



Repeated measure analysis for 3MWT revels that there is main effect for time as F=64.262 and p=0.000.

There was no significant main effect for group as F=2.57 and p=0.095.

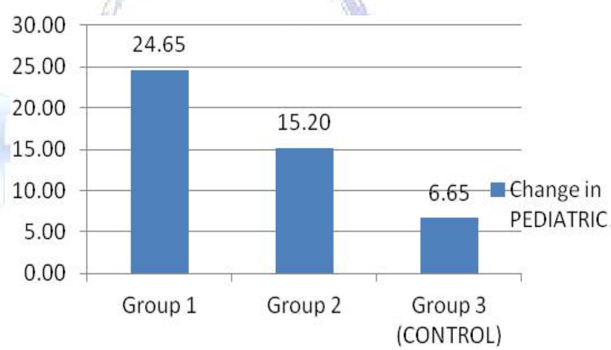
There was a significant effect for time x group as F= 7.86 and p=0.002.

Tukey's HSD analysis revealed that experimental group1 improved to a greater extent than experimental group 2 which was also better than the control group.

Pediatric Balance Scale: PBS was analyzed using Kruskal-Wallis test to see the change in groups.

The graph 3 shows there was a significant change in all the three groups with the Dynamic cycling group is being significantly more than static cycling group**,** which is more than the control group.

Graph 3: Change in Pediatric Balance Scale scores.

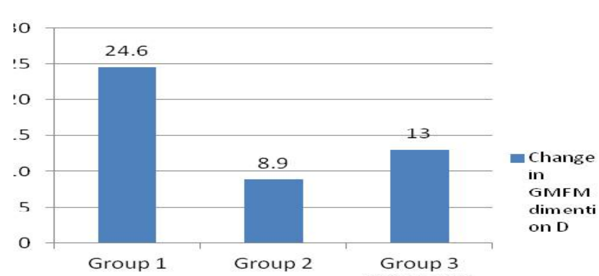


Kruskal-Wallis test showed mean rank of 24.65, 15.20, 6.65 of dynamic cycling group, static cycling group and control group respectively, indicating significant difference in change scores between groups.

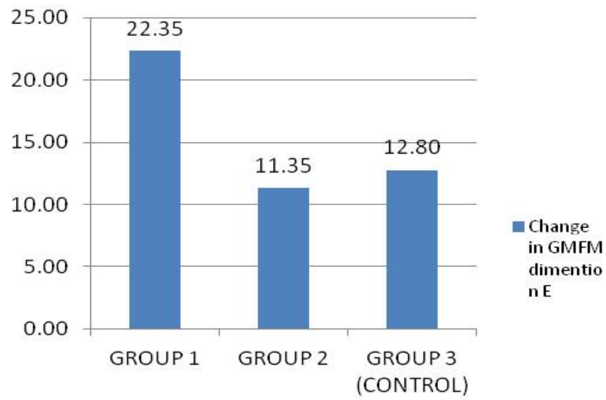
GMFM-D and E: These were analysed using Kruskal-Wallis test to see the change in groups.

The graph 4 and 5 shows there was a significant change in all the three groups with the Dynamic cycling group is being significantly more than static cycling group and control group showing significantly more change as compared to static cycling group**.**

Graph 3b: Change in GMFM-D scores.



Graph 4: Change in GMFM-E scores.



Kruskal-Wallis test showed mean rank of 24.60, 8.90, 13 for dimension D and 22.35, 11.35, 12.80 for dimension E of dynamic cycling group, static cycling group and control group respectively, indicating significant difference in change scores between groups.

DISCUSSION

Overall results of the study showed that, Resting heart rate, Three minute walk test and Pediatric balance scale of both dynamic and static cycling group significantly improved at 6 weeks period and the improvement was significantly more in dynamic cycling group than static cycling and also improvement in static cycling group was significantly more than the control group. Improvement in Gross Motor Function Measure (GMFM) in two dimensions i.e. standing, walking, running and jumping was significantly more in dynamic cycling group than the control group and improvement in control group was more than static cycling group.

Resting Heart Rate: The improvement in outdoor cycling group was significantly more than the static cycling and the reason may be that the static cycling group was not provided with resistance for pedaling. Children were encouraged to cycle with their best effort. But outdoor cycling group improvement could have to do with the type of mechanical resistance that is applied (air, rolling, friction, and gravitational resistance)[6] and riding a bicycle in community. So the prime factor for improvement in the endurance capacity in the outdoor cycling group was the opportunity for prolonged stimulation of cardio-respiratory system which resulted in change in the resting heart rate. Also the children in dynamic cycling group were adapting active posture in their home environment and played with peers for longer time as reported by their parents.

The improvement in static cycling group was significantly more than the control group and the reason may be that in the static cycling group the children repeated low resistance high repetitions of lower limb reciprocal movements which challenged their aerobic capacity (Cardio-respiratory system) better than the children in control group who only did conventional exercises which mainly focused on maintaining static postures thereby improving strength capacity (musculoskeletal system) only.

Research has indicated that children with CP display low levels of Cardio-respiratory fitness, as evidenced by a reduced peak VO_2 or a higher sub maximal energy demand of walking. [4,7,8] Children with CP have difficulty performing purposeful and efficient physical movements for many reasons, including weakness, abnormal muscle co activation, involuntary movement, poor selective voluntary motor control, spasticity, contractures, and decreased balance. These impairments can limit a child's ability to play and exercise at intensities necessary to develop Cardio-respiratory fitness [2,8]. And cycling is a tool which can be used for endurance training in children who cannot walk independently. Also children with cerebral palsy have disturbance in autonomic regulation [9]. Endurance exercise causes a physiological perturbation that significantly affects autonomic nervous activity. So endurance exercises modify cardiac and respiratory functioning. The cardiovascular adaptation to acute exercise involves integration of neural and local factors. Hence endurance training increases parasympathetic activity and decreases sympathetic activity in the human heart at rest. These two training-induced autonomic effects are coupled with a possible reduction in intrinsic heart rate, decrease resting heart rate and increase heart rate variability at rest [10].

The improvement in outdoor cycling group was significantly more than the static cycling and the reason may be that firstly cycling and walking share similar neural mechanism. Cycling is a simplified locomotor pattern as both involve reciprocal movements [11,12]. Pedaling is a bipedal locomotor task well suited to the identification of functional muscle groups and propulsion strategies in humans. Both pedaling and walking are cyclical at about the same frequency (H"1 Hz) [13,14]. Both tasks require the legs to alternate in flexion and extension with most of the propulsive energy generated in extension. Both demonstrate the same phase-dependent modulation of reflexes [15,16,17]. Two groups alternating in excitation with one another (called a pair of alternating muscle groups) [18] are often anatomic antagonists [19,20] though not necessarily [21]. Alternating muscle groups are a basic tenet in the concept of pattern generation of rhythmic locomotor movements [22,23,24] studied locomotor strategy for pedaling suggest that six muscle groups form a basic strategy for pedaling propulsion and also may be a subset of the elements of a general strategy for human locomotor propulsion. So one explanation of improvement in three minute walk test is motor learning must have occurred in both the groups as it involves multisegmental, complex movements that are generated by the same central neural networks as used during gait, thereby improving the ambulatory status.

Pediatric Balance Scale: The improvement was significantly more in the dynamic cycling group than the static cycling group than the control group with mean rank 24.65, 15.20 and 6.65 respectively.

Balance is a complex process involving the reception and integration of sensory inputs and planning and execution of movement to achieve a goal requiring upright posture i.e. it is the ability to control the COG over the BOS in a given sensory environment. The improvement is also seen in static cycling group as compared to control group which was not seen in GMFM-D measure, the reason might be that the Pediatric Balance Scale assess many of the functional activity a child performs within his/her community: sitting balance, standing balance, sit to stand/ stand to sit, transfers, stepping, reaching forward, reaching to the floor, turning, and stepping whereas GMFM-D only deals with standing components many of which CP children with GMFMCS level II could perform prior to the intervention which caused the ceiling effects.

The reasons for improvement in both the experimental groups is better postural control and ability to transfer body weight through lower limbs with better alignment of the body and improved sensory awareness of the soles of feet. i.e. improved proprioceptive sensitivity in leg muscles, enhanced synaptic efficacy within primary sensorimotor cortex pathways, or higher level adaptations at the level of cerebellum or association cortex [25].

Dynamic cycling gave better perturbations to the child so children developed anticipatory postural control and also with practice there might be motor learning effect. So children in dynamic cycling group improved significantly more than static cycling group. In 2003 recovery stability in six children with spastic diplegia and spastic hemiplegia CP through training and testing on a dual moveable force plate system designed to move as one unit has been studied(26). The results showed that after the training period, all participants showed a decrease in recovery time of stance balance with the improvements still present at post-training data collection. Based off of these results, the researchers suggested that children with CP could adjust their postural control.

Gross Motor Function Measure: In GMFM dimension D the improvement was significantly more in the dynamic cycling group than the control group than static cycling group with mean ranks 24.60, 13 and 8.90 respectively.

In GMFM dimension E the improvement was significantly more in the dynamic cycling group than the control group than static cycling group with mean ranks 22.35, 11.35 and 12.80 respectively.

Strength and function are directly proportional to each other as evident by previous studies, Sandy Ross et al in 2007 studied relationship between strength, spasticity, GMFM and gait and found out that gait function and GMFM are directly related to strength [27]. Similar results were found by Vanessa et al who observed an improvement in standing (Dimension D) and walking and running (Dimension E) of GMFM in CP children after giving exercises like bridging, sit to sand etc [28].

Heather Williams in 2007 studied the effects of static bicycling programme on the functional ability of young people with CP who are non-ambulant and concluded that relatively short training programme on static cycle was associated with clinically relevant improvement in standing and walking abilities in these children [29].

Limitations of the Study: Study sample was small, Carry over effect of the study has not been studied, Energy expenditure index was not calculated for endurance parameter and the resistance was not provided to static cycling group.

Recommendations for Future Studies:

1. Studies with larger sample size should be performed.

2. Follow up study should be done to see the long term effect of cycling on general fitness.

3. Feasible and clinically possible outcome measures to check endurance in non ambulant CP should be studied.

4. Resistance should be added in both static as well as dynamic cycle.

CONCLUSION

Dynamic cycling incorporated with conventional exercises improves the cardiovascular endurance, balance and functional abilities than conventional exercises only.

Clinical Implications: All Cerebral palsy children when needed should be provided an adaptive bicycle in place of wheel chair so that they can move independently in community settings actively along with the benefits of exercise and improve their strength, endurance and function.

Conflicts of interest: None

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