Effect of Aerobic Gait Training on Pulmonary Functions in Children with Cerebral Palsy

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Abstract

Background: Gait improvement is one of the most important goals of physical therapy program in cases of cerebral palsy (CP) because as much as 90% of those children have difficulty in walking. **Purpose**: this study was conducted to investigate the effect of aerobic gait training on pulmonary functions and functional capacity of children with CP. **Subjects and Methods:** Thirty children diagnosed as hemiparetic CP participated in this study. They were selected from outpatient clinic of Faculty of Physical Therapy, Cairo University and Abo El – Reesh pediatrics hospital with age range between 5 and 9 years. The selected sample was divided into two groups of equal number. Group A (control group) that was treated by traditional gait training while group B (study group) received aerobic gait training. All participants were evaluated by Six minute walk test for detecting the functional capacities and impulse oscillometry device that was used for detecting lung functions before and after three successive months of treatment application. **Results:** There was a statistically significant improvement of all measuring variables in each group after treatment and also between both groups after treatment in favor to the study group ($p<0.05$). **Conclusion:** It was concluded that the aerobic gait training improve the functional capacity and pulmonary functions in children with hemiplegic CP**.**

Key words: Aerobic gait training- Cerebral palsy - Pulmonary functions- Functional capacity

Introduction

Cerebral palsy refers to permanent, mutable motor development disorders stemming from a primary brain lesion, causing secondary musculoskeletal problems and limitations in activities of daily living (1). As much as 90% of children with CP has difficulty in walking that may be a result of impairments such as spasticity, muscle weakness, and postural instability represented mainly by reduced walking speed and endurance which are two of the main functional problems especially with increase severity of disabilities (2) so the development of efficient and independent walking is an important therapeutic goal for many for those children. CP commonly involves pulmonary dysfunction due to motor disability of respiratory muscles caused by brain injury, which result in abnormal respiratory pattern induces disruption of motor development and restriction of daily living activities. In hemiparetic children there is reduce in diaphragmatic movement on the paralysed side during volitional inspiration when compared with automatic inspiration (3).

Modern technologies for assessment of pulmonary functions are not routinely applied in children with intellectual disability and young children as recognition and assessment of respiratory dysfunction might not be adequate in this group of children. In addition to that a simple forced breathing test as peak expiratory flow (PEF) measurement is difficulty for application in children. The impulse oscillometry system (IOS) was introduced as a technique to assess air flow obstruction in patients who are not able to perform forced breathing as CP children because IOS doesn't require active cooperation from the patient (4).

Functional capacity evaluation (FCE) is a systemic method of measuring an individual's ability to perform meaningful tasks on safe and dependable basis. It can assess all impairments and collect information about the functional limitation of person with medical impairment, it is used in work rehabilitation programs, for disability determination and return to work recommendations (5). 6 Minute walk test (6MWT) it is a self-paced, sub-maximal exercise test used to assess functional capacity in patients with chronic diseases. It has been used widely in adults, and is being utilized increasingly in pediatric populations; also it has been used as an estimate of physical fitness in children with severe cardiopulmonary disease and children with chronic disability (6) (7).

Historically, exercise programs that included aerobic or muscle strengthening components were often contraindicated for persons with CP because of the concern that increased effort and exertion during exercise would result in increased muscle tone, a decrease in range of motion, and/or an overall decrease in function. Concerns about the safety of progressive resisted muscle strengthening for children with CP have been negated by recent studies that demonstrate no increase in spasticity and no loss of range of motion following a resistance training program. Current theories of motor learning suggest that task specific repetitive practice can improve activities such as walking in those children (8). Consequently, there has been growing interest in the effects of

aerobic training particularly using treadmill for people with neurological disorder(9), because aerobic exercise showed benefits for person with disabilities include increased cardio vascular capacity and endurance, Weight management , lower blood lipid levels, preservation of bone mass, and overall maintenance of function ,but there is still a need for more research concerned with the efficacy of aerobic exercise as a safe and beneficial intervention option for children with CP(10), Therefore, the need to measure the effect of aerobic gait training on pulmonary function and functional capacity is important.

Subjects, Instrumentations and Methods

Subjects:

Study design and participants: This study was a randomized controlled trial (A pre – post – test design.), that was conducted after its approval by the ethical committee of the Faculty of Physical Therapy, Cairo University, and after gaining a parents signature on the consent form for each child about their agreement to participate in this study. Thirty hemiparetic CP children of both sexes (19 girls & 11 boys) participated in this study, they were recruited from out clinic of Faculty of Physical Therapy, Cairo University and Abo El – Reesh hospital, according to certain inclusion criteria including: age range from 5-9 years with diagnosis of hemiplegic CP, they were able to walk alone even with an abnormal pattern (at level II of Gross Motor Functional Classification System (GMFCS), also they were able to follow simple verbal command. Exclusion criteria were children with cardio pulmonary problems, or visual or auditory problems, structural changes of fixed deformities that restrict the ambulation and children who had seizures. The selected sample was divided randomly by using sealed envelope into two groups of equal numbers, control group (A) that was treated by a traditional gait training program while study group (B) was treated by aerobic gait training technique, each child in both groups was evaluated by 6MWT and IOS device before and after three successive months of treatment application.

Procedures: For Evaluation

Pulmonary functions measurement: Pulmonary functions were measured for each child in both groups A & B by IOS system (a device Master Screen IOS Care fusion Germany 234 GmbH Leibnizstrasse 7 D-97204 Hoechberg SN 737390 IP 20) which is a simple, non invasive tool requiring only passive patient cooperation that allows the evaluation of lung function through measurement of both airway resistance and reactance (11). It consists of: Loud speaker, Y-adapter, Terminal resistance, mouthpiece, Micro Gard II filter, P-tube elbow piece, Pneumotach and Computer unit that feed with software required to manipulate and analyze the measured parameters.

The evaluation procedures were explained to each child including assuming sitting position with legs kept uncrossed (in order to reduce extra thoracic pressure) and nose clip was worn. The arm of mouth piece of IOS system was placed in a suitable height that allowed the neck to be slightly extended. Ensure that there was a tight seal between the mouth piece and lips to prevent air leak. Cheeks were held firmly either by the child hands or by an assistant and the child was asked to breath normally in a relaxed manner through the mouth piece (Y – piece), while loud speaker in the head of the system emits sound impulses every

0.25s. The recording was performed for at least 30-45s. During this period, around 120-150 sound impulses were pushed into the lungs from which the mean reactance and resistance values were determined at frequencies from 5 to 20 HZ (12). The impulse generated by loud speaker travel through the large and small airways. Higher frequencies (>20Hz) travel shorter distances (generally up to the large air way) while lower frequencies (< 15Hz) travel deeper till reach to small airway (13). The following primary parameters were detected by the IOS system:

- Total Air way resistance (R5): Resistance at 5HZ
- The resistance of large airway (R20): Resistance at 20 HZ.
- The resistance of small air ways: subtracting R20 from R5 (R5-R20).
- The elastic recoil of peripheral airways (X5):
  The reactance at 5HZ (X5) reflects the combined effect of peripheral tissue elastance and intertance.
- The resonant frequency (Fres): At one intermediate frequency, the magnitude of capacitative and intertive pressure components are equal since they are opposite in sing, the total reactance at this frequency is zero. This frequency is called resonant frequency (12)

The spectral ratio of amplitude of the pressure wave signal to the resulting flow signal constituted the impedance (Z) of the total respiratory system, from which the total resistance (R) and reactance (X) of respiratory system were calculated (4).

Functional capacity measurement:

The functional capacity was measured for each child in both groups A & B by six minute walk test in which a 22 meters walk way (Flat and hard surface), Stop watch and chair were used. The child was asked to worn fit clothes and shoes; a light meal was accepted one hour before test. The child was asked not to do any vigorous exercise at least 2 hours before testing. The test was conducted according to a standard protocol (14), using an internal hallway with 22 meters marked by colored tape on the floor. Each child was asked to start walking in his/her normal speed as long as 6 minutes detected by the stop-watch also he/she could rest if got tired or feel uncomforted (15).

For treatment

- **Traditional gait training** for groups A for three consecutive months. Group A was treated by traditional gait training for one hour including: Forward, backward and sideway walking in front of a large mirror, weight bearing on the affected side was encouraged during standing and walking, walking in closed environment by placing different obstacles across the walking track between parallel bars and also using the stepper between parallel bars, training of walking in open environment and on different floor surfaces.
- **Aerobic gait training program** for Group B by using treadmill for three consecutive months, training for one hour. Each child was asked to start walk on the treadmill with slow rhythm for 5 min as warming up till

reach to speed of 1.5 kilometers /hour and 0 degree of inclination for 10 minutes, increased gradually to reach 3 kilometer / hour and 10 degree inclination for 20 minutes at the end of the study, also in the end of session the speed should decreased again for 5 min in form of cooling down.(16)

- Before starting each session both resting heart rate and blood pressure were measured for each child, patient only was allowed to perform the exercise if his\her resting heart rate and blood pressure were within normal
- Before the beginning of the treadmill training the physical therapist provided manual help to correct gait deviations. The therapist sat at the level of paretic side to facilitate the swing of paretic limb, determining that its initial contact will make with the heel, preventing knee hyperextension during midstance, and encouraging symmetry of step length and stance duration

Data analysis:

Data were analyzed using IBM SPSS advanced statistics (Statistical Package for Social Sciences), version 21 (SPSS Inc., Chicago, IL). Numerical data were described as mean and standard deviation or median and range. Categorical data were described as numbers and percentages. Data were explored for normality using Kolmogrov-Smirnov test and Shapiro-Wilk test. Comparisons between two groups for normally distributed numeric variables were done using the Student's t-test while for non-normally distributed numeric variables were done by Mann-Whitney test. Comparisons between categorical variables were performed using the chi square test. P-value less than or equal to 0.05 was considered statistically significant. All tests were two tailed.

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RESULTS

Thirty children with hemiparetic CP were included in the study (19 girls and 11 boys).

Demographic data

Analysis of base line values between the two groups revealed non- significant difference regarding age (P=0.78), and height (P=0.12), although there was significant difference regarding weight (P=0.001), and BMI (P=0.006). The demographic data of children in the two groups are listed in table (1).

Table (1): Demographic data of children in the two groups

	Group B (n=15)	Group A(n=15)	Mean Difference	t- test/X^2 value	P value
Age /Year	6.9±1 a	6.8±1 a	0.13	0.275c	0.785
Range	(5-9)	(5-9)		-	
Height/cm	119.7±6.2 a	116.6±4.4 a	3.1	1.572c	0.127

Range	(109-130)	(107-124)			
Weight(kg)	28.2 ±4.2 a	22.8 ±4.1 a	5.4	3.554c	0.001
Range	(22-36)	(17-30)			
BMI (kg/m2)	19.7 ±2.8a	16.7 ±2.7 a	3.0	2.975c	0.006
Range	(15.5-24.4)	(12.8-20.8)	-	-	-
Sex					
Boys	7(46.7)b	4 (26.7)b	-	1.292d	0.256
Girls	8 (53.3)b	11(73.3)b			-

Range: minimum value- maximum value a: mean ± SD b: (count) percent c:t-test value
d:chi square n:Number p:Probability

Six minute walk test

There was statistically non- significant difference in the mean values of pretreatment data of 6MWT between the two groups (P>0.05). a statistical significant difference in each group was detected when comparing the pre treatment to post treatment values (P<0.001). On the other hand, there was a statistically significant difference in 6MWT between group A and group B post treatment (P=0.025) in favor to group B as shown in table (2).

Table (2): Statistical analysis of functional capacity results of both groups

	Group B(n=15)		Group A (n=15)		Mean	t- test	
6MWT	Mean	SD	Mean	SD	Difference	Value	P value1
pre	333.9	25.5	332.6	38.3	1.3	0.109	0.914
Post	396.5	19.9	373.1	32.6	23.4	2.377	0.025
P value2	<0.001		<0.001				

P value1: comparing six minute walk test between 2 groups at each time point,
p value 2: comparing pre and post in each group

Impulse oscillomety

A statistical non-significant difference was recorded when comparing the pre-treatment mean values of IOS (R5) in the two groups (p=0.519).While comparing the pre and post – treatment values of IOS (R5) in each group the results revealed a significant improvement was recorded (P<0.001). Also a statistically significant difference in IOS (R5) between both groups after treatment was recorded in favor to group B (p=0.006). As shown in table (3)

Table (3):Statistical analysis of pulmonary functions results of both groups

-	Group B(n=15)		Group A (n=15)		Mean	T test	-
IOS(R5)	Mean	SD	Mean	SD	Difference	Value	P value1
pre	134.5	10.9	137.5	14.3	3.03	0.653	0.519
Post	106.2	8.39	119.2	14.64	12.9	2.984	0.006
P value2	<0.001		- <0.001		-	-	-

P value1: comparing IOS(R5) between 2 groups at each time point, p value 2: comparing pre and post in each group

The percent change between group A and B revealed that there's improvement in the results of 6MWT of group B about 6.2% with (P=0.025) more than group A, and in the of IOS (R5) results the group B have improvement about 7.5% with P<0.001 more than the group A.As shown in table(4)

Table (4):Percent change between study and control groups

	Group B(n=15)		Group A(n=15)			
Percent change	Mean	SD	Mean	SD	P value	Percent
- 6MWT % increase	19.0	4.0	12.8	9.3	0.025	6.2%
- IOS % decrease	20.9	5.2	13.4	3.9	<0.001	7.5%

DISCUSION

In this study, the effects of aerobic gait training on pulmonary function and functional capacity in children with hemiplegic CP were evaluated. The results showed statistically significant improvements in all measured variables including functional capacity (detected by 6MWT) and pulmonary functions (detected by IOS system) between both groups after treatment programs application in favor to group B.

This statistical significant difference between the two groups may be attributed to the effect of using the treadmill program, that may improved the walking endurance and functional capacity by applying rhythm walking pattern and fixed speed, this allowed alternate weight shift on both sound and affected lower limbs that was reflected on the child's ability to maintain balance. This is supported by the work of Tulchin et al.(2010)[17]who reported that walking endurance will increase to a greater degree in patients receiving treadmill training. He added that gait stability, muscle function, aerobic fitness, habitual activity levels and balance will improve more in subjects receiving treadmill. Tulchin concluded that when using treadmill training, there is a relatively strong stretch applied to the flexors of the ankle at the end of the stance so enhancing muscular activity needed for swing phase.

Improvement of the functional capacity detected by the six minutes walk test may be explained as treadmill gait training had an effect on distributing the weight nearly equal in both lower limbs, which was in turn reflected on child's balance and stimulation of synchronization of contraction between spastic and anti spastic muscle groups. This is supported by the work of Dal et al.(2010)[18], who stated that treadmill intervention improve balance , build muscle strength in the lower limbs and stimulate neuronal connection that are involved in generation of independent balanced walking.

Difference between both groups in the current study is also supported by the work of Greccoet al. (2013)[16], who reported that treadmill training is more effective than over-ground walking training in controlling functional mobility, functional performance, gross motor function and functional balance in children with CP.

The significant improvement of the pulmonary functions in group B that was treated by the aerobic gait

training using treadmill is supported by the work of Rogers et al. (2008)[10], who reported that aerobic gait training can be used for increasing cardiopulmonary fitness in children with CP. Also Cavalho et al(2005)[19]., stated that during treadmill gait, systolic blood pressure significantly increased compared to the initial values, and no change of heart rate(HR) was observed. As diastolic BP did not change after 6 months of training, it indicates that an increase in cardiac output occurred due to the increase in stroke volume. Moreover, as systolic BP increased at rest, it suggested some adaptations of the cardiovascular system and he concluded that treadmill gait training is capable of increasing the metabolic and cardio-respiratory responses. Treadmill training increases peak exercise capacity while reducing the energy cost of hemipareticambulation(20)

Conclusion

From this study it can be concluded that the aerobic gait training in a form of using treadmill shown a more effective effect than traditional gait training, which lead to more improvement in pulmonary function and functional capacity in children with hemiparetic CP.

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