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Efficacy Of Under Water Exercise on Pulmonary Function in Cerebralpalsied Children.

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Abstract:
***Background**: Cerebral palsy (CP) is the most common motor disability in childhood. Respiratory muscle weakness and a low upper to lower chest diameter ratio are common respiratory dysfunction manifestations in those children which negatively affect their quality of life..*
***Purpose:** The study was designed to investigate the effect of underwater exercise on pulmonary function test (PFT) as forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) and forced expiratory volume at one second divided forced vital capacity FEV1/FVC in cerebral palsied children.*
***Subjects & Methods**: Thirty eligible hemiplegic cerebral palsied children, aged between 5 and 9 years, were randomly assigned into two groups, group A and group B. Both groups A and B received a traditional physical therapy program for 60 min plus inspiratory training twice per session (15 min each). GroupA received also especially designed underwater exercise program. All Children received 36 training sessions (three times/week for 12 weeks).Evaluation applied before and after three months of treatment program by pulmonary function test (FVC, FEV1 , FEV1/ FVC).*
***Results:** according to the current results, a very significant improvement of pulmonary function ratio was observed in group A with significant changes in group B , indicating an augmented therapeutic effect of hydrotherapy training.*
***Conclusion:** Hydrotherapy is an effective intervention that can be added to the traditional physical therapy exercise program for the improvement of pulmonary function of spastic CP children*
***Keywords:** Cerebral palsy, pulmonary function test, underwater exercise program.*

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I. Introduction

Cerebral palsy (CP) is a different group of clinical syndromes that determine permanent disorders of motion and posture. It is characterized by abnormal muscle tone, posture, and movement, thereby limiting the activity of the affected children.[1]

In addition, poor nutritional status, drooling, aspiration, gastroesophageal reflux, impairment of airway clearance due to muscular weakness or incoordination, and poor pulmonary reserve increase the risk of morbidity and mortality as a result of respiratory diseases. [2]

According to children with spastic CP have lower pulmonary function and parameters than normal, healthy children **.** Poor chest mobility, trunk extensibility, and weak respiratory muscle strength are related to poor respiratory function in children with CP. [3]

The shallowabnormal breathing observed in severe CP may lead to an inability to expand the upper chest wall, which may affect upper chest development. This can lead to a lower ratio of upper chest to lower chest diameter in severe CP children compared with those normally. [4]. Developed Early beginning of pulmonary exercises may result in maintenance and increase of respiratory muscle strength, chest expansion, and it can also be suitable programme in comprehensive management of CP children [5].

Incentive spirometer exercise (ISE) is widely used in chest physiotherapyprogramme, itimprove the patient to perform slow and deep breathing through visual feedback, allowing for the stretchinand opening of collapsed airways. ISE is useful as it is inexpensive and simple to use with no known side eaffects. Furthermore, achievement of the visual target encourages the children to try their best and thus enhances patient compliance.[6]

From the perspectives of physics and physiology, aquatic media also are beneficial in the management of a variety of musculoskeletal, neurological, and cardiopulmonary pathologies due to the advantages of hydrostatic forces (buoyancy) and drag impedance unique to the water effective modes for cardiorespiratory training include running overground, treadmill training, cycle ergometer, and aquatic exercise training[7].

Adapted aquatic exercises have been particularly recommended as a part of physical therapy exercise for children with CP. The buoyant nature of water provides persons with CP patients the opportunity to feel their body free from the constraints they experience on floor [8], [9].

Water-based activity aids in the decrease of pain and muscle spasms, maintenance or enhances of range of motion, strengthening of weak muscles, reeducation of paralysed muscles, improvement of circulation, lung function and improvement of balance, coordination and posture [10]. These characteristics may allow children with CP to exercise in water with more freedom than on land. Weight relief and ease of motions allows safe movement exploration, strengthening and functional activity training with decrease level of joint loading and impact, providing a gentler environment for children who experience persistent abnormal loading. [9].[10]

Accordingly itwas suggested that the analyses of this study provide additional information about effect of under water exercise in improving pulmonary function in CP child as an easy method applied a in fun way to the children that improve pulmonary function which affected in most types of CP.

II. Materials and Methods

2.1. Subjects: 30 eligible spastic hemiplegic CP children from both sexes theiraged ranged from 5 to9 years. The degree of spasticity ranged from 1 to 1+ according to modified Ashworth scale level and I to IV on the Gross Motor Function Classification System (GMFCS), who have the ability to maintain antigravity head and trunk postures. They were selected from the out patient's clinic of National Institute of Neuromotor System .

Exclusion criteria were any uncontrolled clinically significant medical condition, children with cognitive impairment, children with bone deformities of the spine, such as kyphosis or scoliosis and Children with epilepsy, hearing or visual defects.

2.2 Evaluative procedures:

1. Pulmonary function test:a CardioTouch 3000s (BIONET, Tustin, CA, USA).All Children were evaluated by Pulmonaryfunction test before and after 12 weeks of training.The forced vital capacity (FVC) , force expiratory volume at one second (FEV1) and forced expiratory volume at one second divided forced vital capacity (FEV1/FVC) were measured. The children was seat on a chair with the head and trunk straight and the hip and knee joints flexed to 90° with use of external supporting pad..The child received a sufficient education beforemeasurement.The children would be told to inspire as deeply as possible and to blow their entire lung volume through the spirometer. This process repeated at least three times, and the highest value was selected. PFT data will be normalized for age, gender, and height and the predicted FEV1 and FVC values (%) were calculated using certain equations based on values acquired from healthy Korean children.[11].

2.3 treatment Procedures:

Thirty hemiplegic CPchildren were randomly assigned into two groups equal in number and age matched.. Both groups A and B participated in a supervised comprehensive rehabilitation program composed of traditional physical therapy programme(strengthening exercises, stretching exercises, facilitation of equilibrium and protective reactions) for 60 minutes plus Inspiratory muscle trainer using flow-centered incentive spirometer (Triflow II, Respirogram; India) twice per session (15 min each) before the traditional physical therapy program and after 30 min rest period following it for 36 training sessions (three times/week for 12 weeks).group Areceived also especially designed underwater exercise program.Their parents' were informed about the nature and effects of trial.The study had local research and ethics committee approval by the ethical Review Board of General Health Organization of Teaching Hospitals and Institutes (GOTHI). , each child parents were assigned a written consent..

- **Swimming pool, floating device and inflatable toys:** The Swimming pool in the hydrotherapydepartment of National Institute of Neuromotor system was equipped with bed that could beimmersed and controlled in water, pool size was 4.5m× 9.0 m while depth was 1.0m to 1.7m that providing under water exercise(aquatic exercise) in it . Water temperature: 32-34ºC is selected [12]. The underwater exercise program comprised of three steps; warm up, exercise, and cool down. [13].The patients performed the aquatic exercises under one-on-one supervision of a physical therapy Session began with warm up exercises which lasted for three to five minutes in the form of slow controlled kicking movements followed by increasing the rhythm of movement. Lower extremity active free and active resisted exercises are performed from supine, semiprone, sitting and standing positions in addition to walking activities in water which were increased gradually and repeated for 20 minutes. The treatment session would be ended with active or assisted motions activities for cooling down, these activities lasting for three to five minutes. The total treatment session would be 30 minutes

- **Incentive spirometer** : IS training using flow-centered incentive spirometer (Triflow II, Respirogram; India). It was made from plastic material, contains three balls, connected to a tube, and a mouthpiece. When the individual takes deep inspiration, the balls rise. The ball showed the created flow. The procedure of using IS was as follows: (1) Each child would be asked to sit and relax quietly for a few minutes and pay attention to their present breathing. Then, the patient held the flow-based IS by one hand and the tube and mouthpiece by the other hand if he could or with therapist assistance if he could not. (2) Each child would be asked to take three to four slow and easy breaths, and then the child was asked to place the IS in his/her mouth and slowly and maximally inhale through the spirometer to raise the ball in the cylinder as high as he/she can, and then hold the inspiration for at least 2–3 s before expiring normally outside the mouthpiece [14] .These steps repeated for a total of five times, and then he/she instructed to stop and rest for 60 s. This sequence would be repeated for 30 min, 15 min before the conduction of traditional physical therapy exercise program and for 15 min after it.

2.4.Statistical Analysis:-

Data was entered and analyzed by using SPSS (Statistical Package for Social Science) statistical package version 22. Graphics were done using Excel program.. In This study, the mean, the standard deviation and mean difference calculated for all variables in both groups.T- test (Paired and non-paired) was be used to detect the level of significance.

III. Results

1-Pre treatment mean value of FEV1 in both groups A and B.

The pre treatment mean values ±SD of FEV1 for both groups A and B were 67.4± 8.50 and 59.93±17.18 respectively as shown in table (1) which represented a non significant difference between both groups ($P< 0.05$).

2) Pre and post treatment mean values of FEV1 for both groups A and B.

The pre-treatment mean values ±SD of FEV1 for both groups A and B were 67.4± 8.50 and 59.93±17.18 respectively while the mean values +SD after treatment for both groups A and B were 84.27± 9.21 and 70.40 ± 14.76 respectively as shown in table (2) which represent a high significant improvement in both groups after treatment.

3) Pre and post treatment mean values of FVC for both groups A and B.

The pre-treatment mean values ±SD of FVC for both groups A and B were 60.53± 7.55 and 53.60±16.91 respectively while the mean values +SD after treatment for both groups A and B were 80.27± 11.40 and 62.13 ± 11.98 respectively as shown in table (3) which represent a high significant improvement in both groups after treatment.

4) Pre and post treatment mean values of FEV1/FVC for both groups A and B.

The pre-treatment mean values ±SD of FEV1/FVC for both groups A and B were 111.33± 1.72 and 113.78±9.34 respectively while the mean values +SD after treatment for both groups A and B were 105.46± 6.15 and 110.87 ± 4.62 respectively as shown in table (4) which represent a high significant improvement in both groups after treatment.

5) Post treatment mean values of FEV1 for both groups A and B.

The post treatment mean values ±SD of FEV1 for both groups A and B were 84.27± 9.21 and 70.40±14.76 respectively as shown in table (5) which represented a very significant difference between both groups ($P< 0.05$)

6) Post treatment mean values of FVC for both groups A and B.

The post treatment mean values ±SD of FEV1 for both groups A and B were 80.27± 11.40 and 62.13±11.98 respectively as shown in table (6) whichrepresented an extremely significant difference between both groups ($P< 0.05$).

7) Post treatment mean values of FEV1/FVC for both groups A and B.

The post treatment mean values ±SD of FEV1/FVC for both groups A and B were 105.46± 6.15 and 110.87 ± 4.62 respectively as shown in table (7) whichrepresented a significant difference between both groups (P< 0.05).

IV. Discussion

This study was designed to investigate the efficacy of using hydrotherapy on pulmonary function test in hemiplegic cerebral palsied children. According to the current results post treatment revealed the high efficacy of the intervention in measurement of pulmonary function ratio (FVC , FEV1 , FVC/ FEV1) were observedin group A with significant improvement in group B , indicating an augmented therapeutic effect of hydrotherapy training.

The significant improvement in these measurements in both groups could be attributed to respiratory muscle training. It improves inspiratory muscle strength and lung expansion and raises production of surfactant, which results in decreasing surface tension, improving lung compliance, better aeration of the alveoli, and decreasing the work of breathing.. IS allows slow maximal inspiration. During inspiration, there is elevation of balls, which encourages the patients, through a visual feedback, to make slow and deep inhalation to their best. This pattern determines the increase of inspiratory volumes, increase of transpulmonary pressure, stretching and opening of collapsed airways, improving the performance of inspiratory muscles, and thus reestablishing the pattern of pulmonary expansion [15] , [16]

The current study findings are supported by the findings of previous studies. In a randomized controlled trial by **Choi et al.(2016)** [17]**,** IS training combined with comprehensive rehabilitation therapy in spastic CP children lead to significant improvements in pulmonary function in the experimental group, but not in the control group, which received comprehensive rehabilitation therapy only. Although they did not measure the current study variables, they suggested that the use of IS training benefits inspiratory and expiratory muscle strengthening, which supports our present results.

Choi et al.(2016)[17] **and Lee et al (2014)** [5] **.** have reported the effect of using incentive spirometer training in CP children in improving respiratory function, endurance for exercise capacity, dyspnea perception, and especially motivating for children ,IS was considered an easy and an inexpensive technique that could be used in feedback respiratory training on the ventilatory functions of children with spastic CP.

Lee et al ., (2012) [18] reported that water immersion training significantly increase vital capacity (VC) in spinal cord injury (SCI). . **alsoGass et al ., (2002)** [19] reported that aquatic training improved VO2 that referred to hydrostatic pressure and is the second property of water. When child who is standing or sitting is immersed in water to the shoulder level, the hydrostatic pressure exerted will assist the VC while at the same time resisting inspiratory capacity. This effect will result in strengthening of the diaphragm and intercostal muscles**.**

Lee et al. (2014) [5] used feedback respiratory training using a device known as the SpiroTiger (Idiag AG, Volketswil, Switzerland), which allow exercise for both inspiration and expiration. Training using this device resulted in significant improvement in forced vital capacity and forced expiratory volumeat 1 s with nonsignificant changes in other measured pulmonary function variables probably because of the small sample size. Although they concluded an augmented therapeutic influence of feedback respiratory training but not a comprehensive training method for improvement of pulmonary function of CP children, it has worth it, as a pilot trial supports the use of respiratory muscles training by using visual and auditory feedback .

In addition, **Lee and Kim ,(2014)** [20] compared differences in respiratory pressures and the effect of biofeedback respiratory training in accordance with walking ability in CP children using the SpiroTiger for respiratory training. Respiratory pressures had significantly improved following training, which supports current study results. **Kim et al, .(2011**)[21] concluded that feedback respiratory training resulted in larger chest expansion of stroke patients, who are neurologically similar to CP patients. **Sartori et al**,.(**2008)** [22] used feedback respiratory training in a group of patients with cystic fibrosis; although they used SpiroTiger feedback respiratory training device and they used different measures of ventilation, their results support the results of the present study, as also IS training gives visual feedback and pulmonary function testing includes both tests for ventilation and tests for respiratory muscle function.

Water-based activity aids in the relief of pain and muscle spasms, maintenance or improving of range of motion, strengthening of weak muscles, reeducation of paralysed muscles, improvement of circulation, lung function and improvement of balance, coordination and posture **.** These characteristics may allow children with CP to exercise in water with more freedom than on land. Weight relief and ease of movement allows safe movement exploration, strengthening and functional activity training with a reduced level of joint loading and impact, providing a gentler environment for children who experience persistent abnormal loading**.** [9],[10]

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V. Figures And Tables

The obtained data within this study was statistically analyzed and compared as shown in Table 1, revealed that there were no statistically significant differences with respect to:
Age (P=0.2824), sex(P= 0.4814), weight (P=0.6843), height (P=0.1698), FEV1 (P=0.1426), FVC (P=0.1581) and FEV1/FVC ratio (P=0.326).

Table1: Demographic and baseline clinical characteristics of children in both groups:

Characteristics	Study Group (Mean ± SD)	Control group (Mean ± SD)	P- Value
Age (years)	7± 1.36	6.47 ± 1.30	0.282
Weight (kg)	26.9 ± 3.96	26.33 ± 3.58	0.684
Height (cm)	121.93 ± 6.03	117.87 ± 7.45	0.117
Sex (Male/Female)	6/9	8/7	0.481
FEV1	67.4 ± 8.50	59.93 ± 17.18	0.147
FVC	60.53± 7.55	53.60±16.91	0.1581
FEV1/ FVC	111.33± 1.72	113.78±9.34	0.326

Table (2): Pre and post treatment mean values of FEV1 of groups A and B.

	Group A		Group B	
	Pre	Post	Pre	Post
Mean ± SD	67.4± 8.50	84.27±9.21	59.93±17.18	70.40±14.76
MD	16.87		10.47	
t- value	6.358		4.797	
p- value	<0.0001		0.0003	
S	Extremely S		Extremely S	

SD: Standard deviation P- value: Probability value MD: Mean difference
t- Value: paired t- test S: Significance

Table (3): Pre and post treatment mean values of FVC of groups A and B.

	Group A		Group B	
	Pre	Post	Pre	Post
Mean ± SD	60.53± 7.55	80.27±11.40	53.60±16.91	62.13±11.98
MD	19.73		9.87	
t- value	7.125		4.006	
p- value	<0.0001		0.0013	
S	ExtremelyS		VS	

Table (4): Pre and post treatment mean values of FEV1/FVC of groups A and B.

	Group A		Group B	
	Pre	Post	Pre	Post
Mean ± SD	111.33± 1.72	105.46± 6.15	113.78±9.34	110.87 ± 4.62
MD	5.87		2.92	
t- value	3.713		0.949	

p- value	0.0023	0.3587
S	VS	NS

Table (5): post treatment mean value of FEV1 in both groups A and B.

	Group A	Group B
Mean ± SD	84.27± 9.21	70.40±14.76
MD	13.87	
t- value	3.087	
p- value	0.0045	
S	VS	

t- Value: unpaired t- test

Table (6): post treatment mean value of FVC in both groups A and B.

	Group A	Group B
Mean ± SD	80.27± 11.40	62.13±11.98
MD	18.13	
t- value	4.246	
p- value	0.0002	
S	ExtremelyS	

t- Value: unpaired t- test

Table (7): post treatment mean value of FEV1/FVC in both groups A and B.

	Group A	Group B
Mean ± SD	105.46± 6.15	110.87 ± 4.62
MD	5.40	
t- value	2.720	
p- value	0.0111	
S	S	

t- Value: unpaired t- test

VI. Conclusion

Hydrotherapy is an effective intervention that can be added to the traditional physical therapy exercise program for the improvement of pulmonary function of spastic CP children.

VII. Recommendations

Further research into the various effects, especially the long term research of IS training and hydrotherapy on children with CP, should be carried out. Comparison with other feedback respiratory training methods may also be needed, taking into consideration the economic cost of each.

The current study has some limitations: the small sample size and.the long-term effects after stopping IS and hydrotheraoy training was not measured; therefore,

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