Effect of Respiratory Training on Ventilatory Functions for Diplegic Cerebral Palsied Children

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ABSTRACT

The purpose of the present study was to investigate the effect of breathing exercise program on ventilatory functions in diplegic cerebral palsied children. Forty diplegic cerebral palsied children from both sexes were included in the study, with age ranging from six to ten years old. They were selected from the Out-patient Clinic of Abou El-Reech Pediatric Hospital, Cairo University. They were divided randomly into two groups of equal number; study (A) and control (B), each included twenty patients. All patients received the traditional treatment program for 30 minutes, while patients belonging to the study group received breathing exercise program for other thirty minutes in addition. Measurement of the ventilatory functions and chest expansion were done for all patients before and after the treatment program, which continued for twelve successive weeks, on three times per week basis. Before starting the treatment program, no significant difference was recorded between the two groups in any of the evaluated parameters. At the end of treatment, the results of the study group showed significant improvement in the percentage of VC, PEFR and MVV, with no significant difference in FEF_{25-75}, when compared with the pre-treatment results. There was also significant improvement in all evaluated parameters when comparing the post-treatment results of both groups, in favor of the study group. These results signify the importance of adding breathing exercise program in treatment of such patients in order to improve their ventilatory functions.

Key words: *Cerebral palsy, Breathing exercises, Ventilatory functions.*

INTRODUCTION

Cerebral palsy (CP) is considered to be a life-long neuromuscular disability, which influence the interactions with the environment. Physical deterioration that occurs with cerebral palsy children is due to abnormality in muscle tone, delayed reflex maturation and presence of associated abnormal patterns of posture and movement, disuse muscles atrophy, which results in scoliosis and improper movement of the thorax, limb contractures and deformities[12].

In a study of the dynamic and static lung volumes of school children with cerebral palsy; the children's total lung capacity was significantly reduced. Those children behaved like patients with obstructive lung disease, but because they have no signs of obstruction, the increased residual volume must have been the result of the neuromotor disturbance. The subjects could not voluntarily force the thorax back to its normal size presumably because of

disturbed function of their respiratory muscles[6].

It has been noticed that cerebral palsied children vary in levels of breathing functions ability, depending on the degree of neurological deficit. The problem of decreased ventilation occurs as a result of decreased strength, decreased thoracic mobility and inadequate bronchial hygiene. Cerebral palsied children are liable to have limited postural control due to lack of head and trunk control, poor development of lateral trunk flexion, trunk elongation, increased lordosis and kyphosis. These defects seem to be major factors which may affect their ventilatory functions[22].

Cerebral palsy children may be prone to respiratory infections because of the alteration of the ventilatory capacity. This alteration is a result of involvement of the neuro-motor control; hence muscles used for breathing may be affected. The alteration of the ventilatory capacity may result in decreased efficiency and poor coordination of the breathing mechanism[3].

Breathing exercises for children with diplegic cerebral palsy have a dual purpose. First, they are designed to teach the child better control of respiration and second to strengthen the muscles of respiration. Prior to the breathing exercise program, all patients demonstrated abnormal breathing patterns and an in-coordination of the muscles involved in respiration. The in-coordination of muscle action and the abnormal movement patterns were common characteristics of a child with diplegic cerebral palsy[4].

With an increasing number of children with severe neurological impairment living in their houses, there is growing demand for medical care and support in school and community life. In such cases, respiratory disorder is a common feature. To improve such disorder, appropriate rehabilitation and daily managements, such as posture control, is very important. Social and educational support is also necessary for improvement of the quality of life of these children and their family[11].

Aim of the study

The aim of this study was to investigate the effect of a breathing exercise program on ventilatory functions of diplegic cerebral palsied children.

SUBJECTS, INSTRUMENTATION AND METHODS

Subjects

Forty spastic diplegic cerebral palsied children (23 boys and 17 girls) participated in this study. Their age ranged from 6 to 10 years (mean 7.2 ± 1.24 years). They were selected from the Out-patient Clinic of Abou El-Reech Pediatric Hospital, Cairo University, according to the following criteria:

- They were ambulant without assistive devices.
- All of them had ventilatory function affection at the beginning of the study, ranging from mild (value equals to 60 - 79 % of normal predicted value) to moderate affection (value equals to 40 - 59 % of normal predicted value).
- They had no significant perceptual defects, with within-normal intelligence quotient.

The subjects included in this study were divided randomly into two groups of equal number; study (A) and control (B), each comprised 20 subjects.

Instrumentation

- ***For evaluation:***

- Vitalograph: Compact spirometer no 42000, utilized for measuring the ventilatory function parameters for all subjects before and after treatment. It is an electronic spirometer with a built-in mini-computer. It was chosen for this study because it is a light-weight instrument that can easily be carried. In addition, it is an instrument, which is not visually frightening to children, a point which must be considered.
- Nasal clip: It was used during measuring the ventilatory parameters.
- Tape measure: It was used to measure the chest expansion at the upper and lower chest levels.
- Weight-height scale: It was used to measure each patient's weight and height in order to detect the predicted normal values of the tested parameters.

- ***For treatment:***

- Tumble forms: Rolls, wedges and balls.
- Ping-pong balls.
- Belts.

Methods

- ***For evaluation:***

I) Ventilatory function tests:

Before testing the ventilatory functions, each patient's weight and height were measured in order to determine the predicted normal values of the tested parameters. The ventilatory function tests were done for both groups (study and control) before and after the treatment program. The procedures were done while the patient was in sitting position with his/her back well supported. A nasal clip was used during spirometric procedures. Ventilatory function tests were carried out for:

1- Vital capacity (VC): The patient was asked to inspire maximally, then exhaling lung air completely into spirometer. It decreases in restrictive lung disease.
2- Peak expiratory flow rate (PEFR): It is the maximum flow of air over 10 msec at the beginning of respiration. It decreases in large airway limitation.
3- Forced expiratory flow rate (FEF_{25-75}): It is the maximum mid-expiratory flow rate (MMFR) or it is the flow of air during forced expiration between 25 – 75 % of forced vital capacity. It decreases in small airway obstruction.
4- Maximum voluntary ventilation (MVV). The patient was asked to breath as rapidly and deeply as possible. The test was conducted for specific interval (15 sec). It is measured in liters / min. This is to determine the status of the respiratory muscles and airway function[15].

Each test was conducted three times. The highest score was recorded by the computerized spirometer.

II) Chest expansion tests:

Tape measure was used to determine the chest expansion at two levels:

- Upper Chest Level (UCL), just below the axilla.
- Lower Chest Level (LCL), at the level of lower floating rib.

The inspiratory and expiatory movements were measured in centimeters; also the differences between them were calculated and recorded. Three successful measurements were taken and the mean was recorded.

Evaluation for all patients was performed before and after the treatment program (12 successive weeks, 3 times per week).

- ***For treatment:***

- Traditional treatment program:

All patients of both groups received the traditional treatment for half an hour. The program aimed at inhibiting abnormal patterns and facilitating the normal patterns. The exercise program lasted for 30 minutes.

- Breathing Exercise Program:

The exercises were easy to follow and understand when accompanied with a diagram. These exercises were:

1) Diaphragmatic breathing: It was considered the most important exercise and was performed routinely as a part of the program.
2) Expiratory exercise utilizing the abdominal musculature: The child was instructed while seated to blow a ping-pong ball across the table at different distances. This exercise was important for enhancing cough production and forced expiration.
3) Inspiration and expansion of the thorax: In the supine position, the child was instructed to inhale as he elevated his arms above his head and to exhale as he lowered his arms to his sides.
4) Stimulation of inspiration: A belt was placed around the lower ribs and crossed in front of the child while seated. The child was instructed to exhale as the belt was tightened and to inhale as the belt was loosened.
5) Strengthening of the anterior abdominal musculature: The child was supine and instructed to bring each knee to the chest while exhaling and to inhale as the knees were lowered. It concentrated on strengthening the rectus abdominus.
6) Strengthening the lateral abdominal musculature: The child was supine and instructed to bring each elbow toward the opposite knee while exhaling. It concentrated on strengthening the external and internal obliques.

The exercise schedule was set up with the exercises increasing in difficulty. The length of time for performing these exercises was about 30 minutes a day. The short period of time was decided upon because of the factors of attentions span and boredom[4].

Treatment for both groups continued for 12 successive weeks, 3 times per week.

RESULTS

The data collected were statistically treated to show the mean and standard deviation of the selected ventilatory function tests of all patients, before and after 12 weeks of treatment. Comparing between the two groups using t-test (table and fig. 1) revealed non-significant differences in ventilatory function parameters pre treatment ($P > 0.05$).

Table (1): Mean percentage of ventilatory function tests pre treatment of both groups.

Test	Study	Control	MD	t	P
VC	54.1 ± 3.29	53.9 ± 3.57	0.2	0.657	> 0.05 (N.Sig.)
PEFR	68.8± 3.26	68.6 ± 2.50	0.2	0.363	> 0.05 (N.Sig.)
FEF_{25-75}	88.2 ± 2.82	88.6 ± 3.10	0.4	0.421	> 0.05 (N.Sig.)
MVV	52.2 ± 2.50	52.3 ± 2.83	0.1	0.111	> 0.05 (N.Sig.)

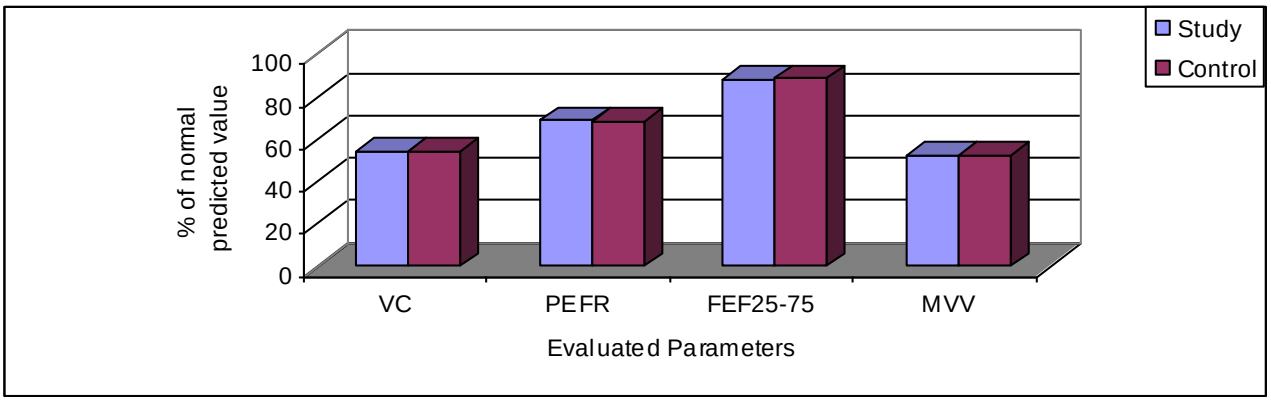

Fig. (1): Mean percentage of ventilatory function tests pre treatment of both groups.

As shown in table and fig. (2), there was an increase in mean percentage of all ventilatory functions of the study group patients. Such increase proved to be significant in VC, PEFR ($P < 0.05$) and MVV ($P < 0.001$), while it was not significant in FEF_{25-75} ($P > 0.05$).

Table (2): Mean percentage of ventilatory function tests pre and post treatment of the study group.

Test	Pre	Post	MD	t	P
VC	54.1 ± 3.29	59.3 ± 7.00	5.2	2.392	< 0.05 (Sig.)
PEFR	68.8 ± 3.26	74.1 ± 9.61	5.3	2.447	< 0.05 (Sig.)
FEF_{25-75}	88.2 ± 2.82	90.7 ± 2.32	1.4	1.710	> 0.05 (N.Sig.)
MVV	52.2 ± 2.50	61.9 ± 9.13	9.7	4.132	< 0.001 (H.Sig.)

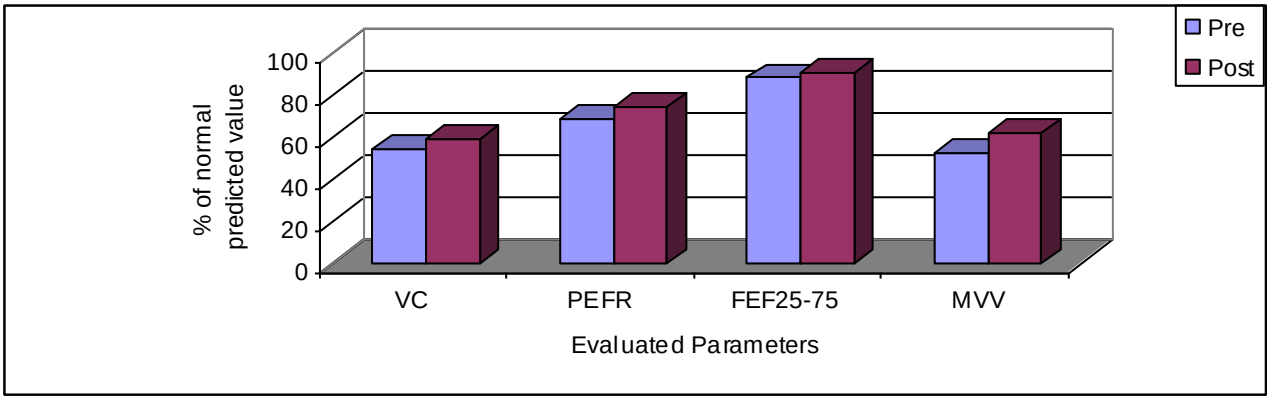

Fig. (2): Mean percentage of ventilatory function tests pre and post treatment of the study group.

On the contrary, it is evident from table and fig. (3) that a decrease occurred in mean percentage of all measured ventilatory parameters of the control group patients. This decrease was not significant ($P > 0.05$).

Table (3): Mean percentage of ventilatory function tests pre and post treatment of the control group.

Test	Pre	Post	MD	t	P
VC	53.9 ± 3.57	52.9 ± 4.28	1.0	1.429	> 0.05 (N.Sig.)
PEFR	68.6 ± 2.50	67.9 ± 2.06	0.7	1.759	> 0.05 (N.Sig.)
FEF_{25-75}	88.6 ± 3.10	87.9 ± 2.36	0.7	1.337	> 0.05 (N.Sig.)
MVV	52.3 ± 2.83	51.7 ± 2.93	0.6	1.371	> 0.05 (N.Sig.)

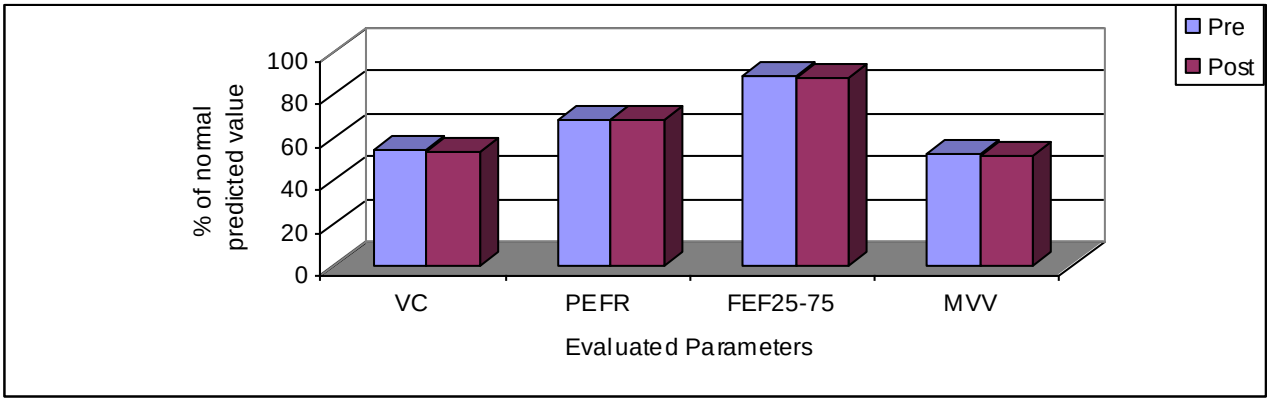

Fig. (3): Mean percentage of ventilatory function tests pre and post treatment of the control group.

Comparing the post-treatment results of the two groups, table and fig. (4) revealed significant changes in VC and FEF_{25-75} ($P < 0.01$) and PEFR ($P < 0.02$), in favor of the study group. Moreover, highly significant change was recorded in MVV ($P < 0.001$), in favor of the study group patients.

Table (4): Mean percentage of ventilatory function tests post treatment of both groups.

Test	Study	Control	MD	t	P
VC	59.3 ± 7.00	52.9 ± 4.28	6.4	3.486	< 0.01 (Sig.)
PEFR	74.1 ± 9.61	67.9 ± 2.06	6.2	2.829	< 0.02 (Sig.)
FEF_{25-75}	90.7 ± 2.32	87.9 ± 2.36	2.8	3.358	< 0.01 (Sig.)
MVV	61.9 ± 9.13	51.7 ± 2.93	10.2	3.021	< 0.001 (H.Sig.)

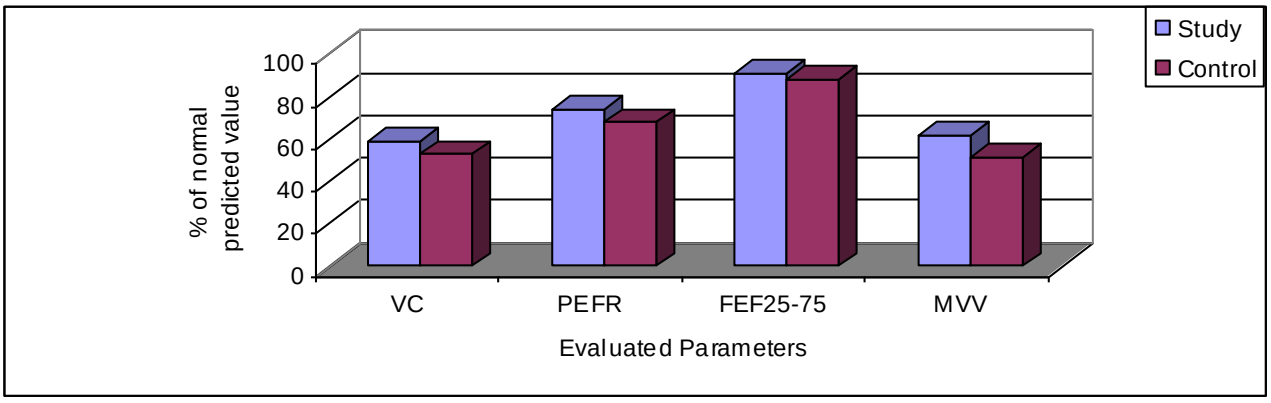

Fig. (4): Mean percentage of ventilatory function tests post treatment of both groups.

Similarly, comparing between the two groups using t-test revealed non-significant difference in chest expansion before treatment (P > 0.05). Post-treatment, significant increase was observed in chest expansion (upper and lower chest levels) in the study group, when compared with the pre-treatment results (P < 0.05). Meanwhile, the increase in chest expansion (upper and lower chest levels) in the control group was not significant (table 5), when compared with the pre-treatment results (P > 0.05).

Table (5): Mean values of chest expansion test (cm) before and after treatment of both groups.

Group	Level	Pre	Post	MD	t	P
Study	UCL	55.0 ± 2.35	55.7 ± 1.78	0.7	2.116	< 0.05 (Sig.)
	LCL	59.7 ± 2.68	60.6 ± 2.91	0.9	2.033	< 0.05 (Sig.)
Control	UCL	55.1 ± 2.48	55.6 ± 2.46	0.5	1.273	> 0.05 (N.Sig.)
	LCL	59.7 ± 2.68	60.1 ± 2.11	0.4	1.566	> 0.05 (N.Sig.)

DISCUSSION

The pre-test values of all patients indicated a low percentage of ventilatory parameters, when compared to normal predicted values. This is thought to be due to the spasticity, weakness and in-coordination of the respiratory musculature. This matter might account for the high incidence of respiratory problems due to retention of secretion and airway obstruction, commonly seen in children with cerebral palsy. Children with cerebral palsy were selected because their mortality rate is higher than that of children in the general population[14].

The pre-treatment results revealed that patients included in both groups were analogs with respect to the age and severity of spasticity. Simultaneously, mean percentage of the ventilatory function parameters and chest expansion tests in both groups before starting of treatment were statistically non-significant (P > 0.05). The data collected from children in both groups before starting of treatment revealed limitation in their ventilatory function variables ranging from mild to moderate affection, including VC, PEFR and MVV, while having nearly normal FEF_{25-75}, in relation to the predicted normal values.

The results of this study before starting of treatment came in agreement with those of van den Berg-Emons et al.,[24] who found that normal daily conditions in the children with diplegic cerebral palsy were significantly lower than in their healthy peers. So, special physical activity programs for these children are recommended.

Mean values of chest expansion in both groups at both upper and lower chest levels before treatment revealed significant restriction in chest expansion. The thoracic cage normally provides for adequate function of the respiratory musculature. Thus, abnormalities of the thorax due to disturbance of the neuromotor mechanism may result in a loss of mechanical advantage of the respiratory muscles.

The results of chest expansion before starting the treatment program coincide with those of Hutzler[9], who reported that lung expansion in cerebral palsy patients is restricted by the stiff chest wall. Moreover, the deficits with power of the respiratory muscles consequently affect the ribcage mechanisms. Moreover, Kanda et al[10] stated that spasticity and poor chest expansion are responsible factors for respiratory problems in spastic cerebral palsied children.

Patients in the study group only received a suggested program of breathing exercises, which was carried out three times per week for 12 successive weeks. In addition, all patients in both groups were involved in a traditional treatment program. Mean percentage of VC, PEFR and MVV in the study group at the end of treatment indicated a statistically significant difference. The breathing exercises helps to achieve maximal inspiration and maximal forced expiration and to eliminate those factors that may interfere with the normal mechanics of breathing.

It is well known that the respiratory problems commonly seen in cerebral palsy are caused by impairment of control of the respiratory muscles. The increase in ventilatory functions may be accounted for in two ways. First, breathing exercises probably helped in strengthening the muscles of inspiration; the diaphragm and of forced expiration; the abdominal muscle. Second, the breathing exercises could have allowed the child to learn better control of breathing by attempting to eliminate the abnormal patterns of breathing, exhibited by the child. The spastic muscle tone caused the child to assume un-natural positioning and posture, which in turn could have caused the abnormal breathing pattern. The abnormal breathing pattern, abnormal muscle tone and abnormal posture could also cause a decrease in respiratory volume. These three abnormalities found in the children selected for this study; diplegic CP children, could account for the decrease in ventilatory functions[17].

As indicated from the results of the control group at the end of treatment, there was slight decrease in mean values of the measured parameters, which were statistically non-significant. However, the efficiency of the NDT on reducing of muscle tone and facilitation of normal postural patterns and movement was reported in many studies[7].

The significant changes observed in the percentage of ventilatory parameters after treatment of the study group indicated a valuable improvement in the airways obstruction, which can be attributed to better control of breathing mechanism. This increased control leads to improvement of expiratory phase of respiration as a result of improved action of the respiratory muscles. Increasing of chest expansion at the end of treatment revealed an improvement of the mechanics of respiration. It can be attributed to improved coordinated action of the respiratory muscles, reduction of muscle tightness and facilitation of trunk control. Improvement of chest expansion resulted in increase of the flow rate of the inspired air through these air ways and so decreased the incidence of repeated infection[19].

The results of the present study agreed with those of Bar-Or[2], who reported that performance of the respiratory muscles depending specifically on their strength and on general muscle strength.

The present results also came in agreement with those of Kumar and Kiran[13], who used a diaphragmatic breathing pattern to improve ventilation and demonstrated improved breathing control. During diaphragmatic breathing, the upper chest and shoulders remained relaxed, preventing the unwanted upper chest movement. Also noted was an increase in the depth of respiration and coordination of the respiratory musculature.

Percentage of improvement in the mean values of chest expansion in both UCL and LCL of the study group increased significantly. Improvement in the chest mobility was suggested to be due to facilitation of upper back muscles, elimination of abnormal posture of the scapulae, reduction

of spasticity and increasing of range of shoulder girdle movements.

While CP conditions themselves do not directly cause airway or lung dysfunction, consequences of neuromuscular dysfunction, especially ineffective cough, may lead to lung damage. Poor nutritional status, impairment of airway clearance by muscular weakness or in-coordination and poor pulmonary reserve (due to chest wall or spine deformity), increase the risk of significant morbidity and mortality from respiratory infections. They may also have residual chronic lung disease, contributing to their pulmonary problems. In order to prevent or ameliorate these respiratory difficulties, preventive care and use of exercise may be beneficial[23].

The results also agreed with those of Hebestreit and Bar-Or[8], who stated that in children with cerebral palsy, exercise capacity may be limited, especially in tasks requiring good neuromotor coordination. Deficiencies in aerobic and anaerobic performance, strength and coordination may even occur in children without overt manifestations of a neuromuscular or pulmonary disease.

These results confirmed the findings of Dodd et al.,[5] who reported that the increase in VC of the spastic cerebral palsied children can be attributed to the better control of breathing through elimination of the abnormal breathing patterns and strengthening of the respiratory muscles. The findings are also consistent with Schalow and Paasuke[18], who mentioned that improved VC in the spastic cerebral palsied children is due to improving of postural control mechanism.

Children with severe physical disabilities frequently have respiratory problems which affect their quality of life. They commonly stem from central nervous system dysfunctions and/or severe motor disabilities, and consist of various impairments deriving primarily from central and motor dysfunctions, such as dystonia, deformation and dysphagia, which often influence each other and result in respiratory insufficiency, without adequate interventions. Postural control, relaxation and respiratory physiotherapy are the most important and common therapeutic procedures. Counseling should be performed before and throughout the treatment process about how patient's and family's everyday life will be influenced positively and negatively by the treatment, and a multidisciplinary team should support all aspects of their needs[20].

Redstone[16] investigated the respiratory patterns in 10 preschoolers with cerebral palsy (CP) and 10 typical children. A difference between the groups in the use of the regions of the chest wall was also evident with the CP group, having longer abdominal cycles than the control group.

The obtained results confirmed those of Barks[1], who recommended teaching of breathing exercises, designed to help increase breathing capacity and decrease the likelihood of lung infections, during treating children suffering from cerebral palsy. A survey of the literature revealed no study attempting to ascertain whether the vital capacity is affected by breathing exercises in children with cerebral palsy. Researches proved that patients, suffering from cerebral palsy, died more than other persons of comparable age. This may be attributed to greater susceptibility of those children with cerebral palsy to respiratory diseases because of their shallow irregular respirations and diminished tussive effort[21].

Conclusion

The results of the present study, supported by many previous research works, suggest that using the traditional treatment program alone may need a longer period of

treatment for valuable improvement of ventilatory functions. The breathing exercise program received by the study group was designed to strengthen the muscles of respiration and to teach the child better breathing control and get rid of secretion, leading to relief of airway obstruction and ventilatory parameter mesure. So, breathing exercises may be an integral part of the physiotherapeutic program for children with diplegic cerebral palsy.

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الملخص العربي

أثر تدريبات التنفس علي الوظائف التنفسية
للأطفال المصابين بالشلل المخي الرباعي

يهدف هذا البحث إلى دراسة أثر تدريبات التنفس علي الوظائف التنفسية في الأطفال المصابين بالشلل المخي الرباعي ، اشتملت العينة علي أربعين طفلا من الجنسين من المصابين بالشلل المخي الرباعي ، ممن تراوحت أعمارهم من ستة إلى عشرة سنوات تم اختيارهم من العيادة الخارجية بمستشفي أبو الريش الجامعي للأطفال جامعة القاهرة، تم تقسيمهم عشوائيا إلى مجموعتين متساويتين ، محل البحث وضابطة ضمت كل واحدة عشرين طفلا .

خضعت المجموعتين لبرنامج العلاج التقليدي لحالات الشلل المخي الرباعي لمدة ثلاثين دقيقة، بينما تعرضت المجموعة محل البحث فقط إلى برنامج تدريبات تنفس لمدة ثلاثين دقيقة أخري، تم قياس وظائف التنفس ومحيط الصدر قبل وبعد العلاج الذي استمر لمدة اثنا عشر أسبوعا متصلة، بواقع ثلاثة مرات أسبوعيا .

عند مقارنة النتائج قبل وبعد العلاج في كل مجموعة علي حدة أسفرت نتائج البحث إلى حدوث تحسن ذا دلالة إحصائية في المجموعة محل البحث فقط، في السعة الهوائية وفي أقصي سرعة لخروج هواء الزفير وفي أقصي قدرة تنفسية ارادية، بينما كان التحسن في سرعة خروج هواء الزفير في النصف الأوسط من السعة الحيوية غير ذا دلالة إحصائية، وعند مقارنة نتائج المجموعتين بعد انتهاء مدة البحث وجد تحسن ذا دلالة إحصائية لصالح المجموعة محل البحث في كل الوظائف التنفسية المقاسة .

وقد أظهر هذا التحسن أهمية إضافة برنامج لتدريبات التنفس في علاج حالات الشلل المخي الرباعي من أجل تحسين الوظائف التنفسية التي غاليا ما تكون منخفضة نتيجة تشوه القوام وضعف العضلات الذي يصاحب مثل هذه الحالات .