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Pulmonary Function Response to Respiratory Muscle Training by Incentive Spirometer in Children with Down's Syndrome

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ABSTRACT:

Background: Children with Down's syndrome have a significant respiratory disorder with recurrent chest infection that account for a large number hospitalization. Respiratory problems are considered one of the significant alterations in life course of Down's syndrome children. The aim of this study was to determine the effect of respiratory muscle training by incentive Spirometer on the pulmonary function in children with Down's syndrome.

Subjects and methods: Thirty children with Down's syndrome from both genders participated in this study. Their age ranged from 5- 10 years. All Children were complaining from repeated chest infection and decreased ventilatory functions. The children IQ level ranged from 50-60%. Children with Down's syndrome were assigned randomly into two equal groups. The study group received chest physical therapy program including: positioning and vibration for clearance of the lung in addition to deep breathing exercises by using incentive spirometer , where the control group received chest physical therapy program including: positioning and vibration for clearance of the lung. The treatment session was one hour, conducted 3 times per week for successive three months. Measurements of pulmonary function test (included FVC, FEV_j, PEF, RR and SaO₂) were done before the study and repeated at the end of the study after three months.

Results: The training group showed a greater statistical significant improvement in FVC, FEV_j, PEF & SaO₂ and reduction RR than the control group.

Key words: Pulmonary function, incentive spirometry and Down's syndrome.

INTRODUCTION:

Down's syndrome (DS), Trisomy 21 is the term used to refer to the most common chromosomal abnormality which occurs in 1:800 live birth, as the faulty cell division affect the twenty first pair of chromosomes. The extra chromosomal 21 after almost every organ resulting in a multi system disorder, neuromotor, musculoskeletal, cardiopulmonary pathologies and a wide spectrum of life threatening complications^(4,9)

One of the significant alterations of life course is respiratory problems which are primary cause of morbidity problems and / or hospital admission, particularly in young children with Down's syndrome. It has been reported that up to 88 % of children with Down's syndrome would be hospitalized over a 6.5 year period and over half the causes for admission as respiratory problems (6,10).

Young children with Down's syndrome have an excess of respiratory problems due to many contributing factors seen in Down's syndrome such as immune dysfunction, hypotonia, neuromuscular weakness of respiratory muscles (12,14).

The low vital capacity with decreased ventilatory pump in addition to immune dysfunction might account for the high incidence of respiratory problems commonly seen in children with Down's Syndrome(6,10).

Pulmonary therapy helps restoration or maintenance of cardio-respiratory functions of DS children who have respiratory problem due to neurological, musculoskeletal and impaired ventilatory pump that is likely to kill many children with Down's syndrome⁽¹³⁾

Chest physical therapy represents a collection of diverse techniques designed to help clear airway secretions, improve distribution of ventilation and enhance efficiency and conditioning of respiratory muscles. These methods include positioning techniques, chest percussion and vibration, directed coughing and various breathing conditioning exercises⁽³⁾.

Safe and effective physiotherapy management of infants and children with respiratory disorders requires the understanding of treatment aims and appropriate techniques. Techniques of chest physiotherapy employed in adult population can be used; in children and generally the same contraindications apply, those are including: careful positioning to optimize lung functions (ventilation and perfusion), postural drainage, percussion, vibration and breathing exercises⁽²⁾.

Incentive spirometer was used to improve cough mechanism through improving inspiratory capacity and strengthen of the diaphragm⁽¹⁸⁾. Incentive spirometer is targeted to give biofeed back for inspiratory and/or

expiratory effectiveness. It works best with older children⁽¹⁶⁾.

The aim of this study was to determine the effect of respiratory muscle training by incentive spirometer on the pulmonary function in children with Down's syndrome.

SUBJECTS, MATERIALS AND PROCEDURES

Thirty children with Down's syndrome from both genders selected from patients of Physical therapy Department at Abou-Elrish Hospital, Cairo University were participated in this study. Their age ranged from 5- 10 years (8.13 ± 0.354 years). All Children were complaining from repeated chest infection, " decreased ventilatory functions. The children IQ level ranged from 50-60 %. Children with musculoskeletal deformities of the chest & spine, skin diseases, cardiac or vascular disorders were excluded from the study.

Equipment

1. Pulmonary function test instrument (Schiler-spirovit SP-10) was used to measure forced vital capacity (FVC), peak expiratory flow (PEF), Forced expiratory volume in the first second (FEV₁), respiratory rate (RR) and arterial oxygen saturation (SaO₂) as the machine is connected with a special sensor to measure the arterial oxygen saturation non-invasively.
2. Incentive spirometry (Meddiciser, manufactured by Eastern Medikit Company, India): This device consisted of three plastic tubes with graduated scale and ball and mouth piece. These devices give feedback on inspiratory and/or expiratory effectiveness as a modality of respiratory muscle training.
3. Vibrator: A device (Germany-Thrive 707) was used at frequency 50-60 Hertz (HZ) for lung clearance.

Procedures:

Children with Down's syndrome were assigned randomly into two equal groups: **Group (1): (The Study group)** received chest physical therapy program including: positioning and vibration for clearance of the lung in addition to deep breathing exercises by using incentive spirometer⁽¹⁴⁾

A. Positioning: Each child was instructed to assume a relaxed upright sitting. It was

reported that positioning improves ventilation and oxygenation⁽⁷⁾.

B. Vibration: By using vibrator with frequency 50-60 Hertz (HZ). Vibrator was applied on chest wall for ten minutes for both lungs. Figure 15 showed the therapist while applying vibrator on child with " Down's syndrome lying in inverted head position⁽¹⁴⁾.

C Breathing exercises: By using Incentive Spirometer, which give visual feedback on inspiratory and expiratory effectiveness. Each child was asked to breathe deeply for three times then relax and apply that for six cycles⁽¹⁴⁾.

D. Inspiratory muscle training: The child was asked to inhale through mouthpiece so that the ball moved upward on a graduated scale and maintained up as much as possible. This scale expresses the amount of air inspired through the mouth piece connected with it. The child was encouraged to take more deep breath through the mouth piece to move the ball more up, and to increase number of balls lifted. **E. Expiratory muscle training:** The child was asked to blow through mouthpiece with the incentive Spirometer in inverted position, so that the ball moved could be moved upward and maintained up as much as possible. This scale expresses the amount of air expired through the mouth piece connected with it. The child was encouraged to blow harder through the mouth piece to move the ball more up, and to increase number of balls lifted.

Group (2): (The control group) received chest physical therapy program including: positioning and vibration for clearance of the lung.

The treatment session was one hour, conducted 3 times per week for successive three months.

Measurements of pulmonary function test (included FVC, FEV₁, PEF, RR and SaO₂) were done before the study and repeated at the end of the study after three months.

Statistical analysis

The mean values of FVC, FEV₁, PEF, RR and SaO₂ were measured and calculated before the study and at the end of the study after three months for the both groups, then the results were compared using the paired -t- test to determined the level of significance. Comparison between groups were done using the independent t-test ($P < 0.05$).

RESULTS

The results of this study indicated that there were a greater significant improvement in FVC, FEV₁, PEF and a greater significant reduction in RR and SaO₂ in the study group than the control group (table 1,2 and 3).

Table (1): The difference between the pre and post test values of the FVC, FEV₁, PEF, RR and SaO₂ of the study group.

	Mean + SD		t- value	Significant
	Pre	Post		
FVC	1.57+0.42	2.89+0.46	5.22	<0.05
FEV ₁	1.15+0.36	2.32+0.34	4.64	<0.05
PEF	2.12+0.52	3.10+0.58	6.512	<0.05
RR	25.71+2.57	20.21+2.17	-4.63	<0.05
SaO ₂	90.52±3.23	96.81±3.16	6.17	<0.05

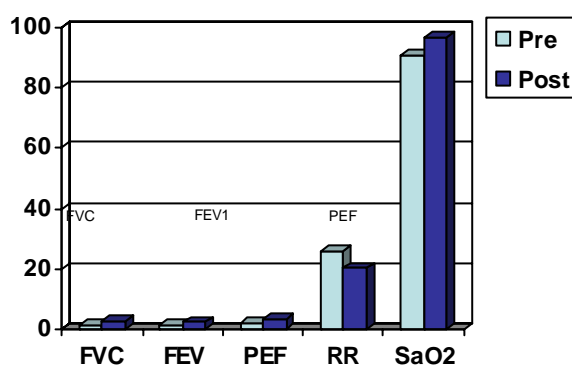


Fig. (1): The difference between (he pre and post test values of the FVC, FEV₁, PEF, RR and SaO₂ of the study group.

Table (2): The difference between the pre and post test values of the FVC, FEV₁, PEF, RR and SaO₂ of the control group.

	Mean±SD		t-value	Significant
	Pre	Post		
FVC	1.45+0.47	2.26+0.46	2.48	<0.05
FEV ₁	1.12-0.36	1.78+0.34	2.76	<0.05
PEF	2.08-1.04	2.51+0.52	2.47	<0.05
RR	25.91+2.87	22.85+2.68	-2.81	<0.05
SaO ₂	90.31 ±3.42	93.91 ±3.67	3.25	<0.05

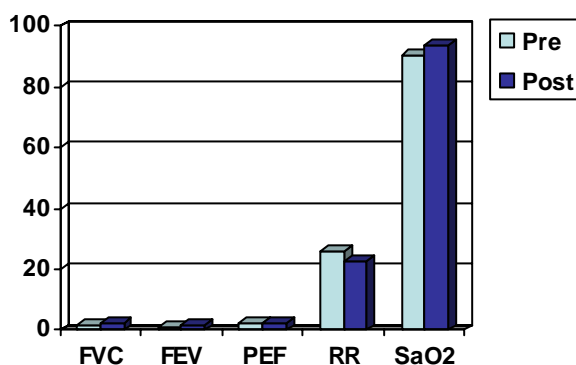


Fig. (2): The difference between the pre and post test values of the FVC, FEV₁, PEF, RR and SaO₂ of the control group

Table (3): The difference between (lie values of the FVC, FEV, PEF, RR and SaO₂ in the study and the control group.

	Mean + SD		t- value	Significant
	Study group	Control group		
FVC	2.89+0.46	2.26+0.46	2.59	<0.05
FEV ₁	2.32+0.34	1.78+0.34	2.52	<0.05
PEF	3.10+ 0.58	2.51+0.52	2.66	<0.05
RR	20.21+2.17	22.85+2.68	2.87	<0.05
SaO ₂	96.81 ±3.16	93.9U3.67	3.24	<0.05

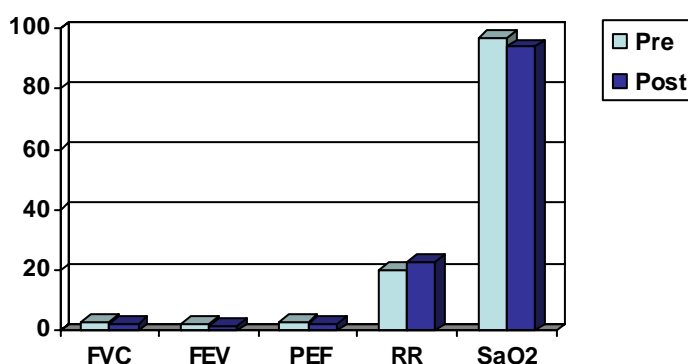


Fig. (3): The difference between the values of the FVC. FEV. RR and Sao2 in the study and the control group.

DISCUSSION

The present study was conducted to investigate the effect of hydrotherapy on ventilatory functions in Down's syndrome children. Thirty children with Down's syndrome of both genders with recurrent chest infection without congenital heart disease were included in this study. The children were assigned randomly into two groups of equal number. The study group received chest physical therapy program including: positioning and vibration for clearance of the lung in addition to deep breathing exercises by using incentive spirometer, where the control group received chesc physical therapy program including: positioning and vibration for clearance of the lung. The treatment session was one hour, conducted 3 times per week for successive three months. Measurements of pulmonary function test (included FVC, FEV_j, PEF, RR and SaO₂) were done before the study and repeated at the end of the study after three months.

Children with Down's syndrome were selected because the mortality rate is higher than that of children in the general population⁽⁴⁾. Such children are at risk for restrictive and/or obstructive⁽⁶⁾ lung disease. It was stated that respiratory problems are a common causes of hospitalization in children with Down's syndrome because those children had low resistance to infection, hypotonia, relative obesity, a degree of pulmonary hypoplasia with small upper and lower airways. Additionally those children used to have shallow breathing as they use accessory

muscles of upper chest instead of diaphragm that result in collapsed areas of the lungs, reduced lung volumes, respiratory muscle weakness, weakness of cough⁽⁶⁾.

Little information was available in literature to clarify the importance and effectiveness of chest physical therapy for pulmonary functions in Down's syndrome children⁽⁶⁾. The maintenance of respiratory function is obviously necessary for children because respiratory insufficiency is the most frequent cause of critical illness in children with Down's syndrome⁽⁴⁾.

Alveolar ventilation depends on the magnitude of tidal volume and dead space. Decrease in alveolar ventilation is the result of decreased tidal ventilation or increased dead space ventilation. Therefore physical therapy strategies administered to increase alveolar ventilation and decrease dead space ventilation orboth⁽²⁾.

Results of this study showed a significant improvement in pulmonary function (included FVC, FEV_j, PEF& SaO₂) and reduction in. RR in the study and the control group, where there was a significant difference between both groups at the end of the study.

The therapeutic objectives of diaphragmatic breathing exercises are to reduce work of breathing, to alleviate dyspnea, to reduce incidence of post operative pulmonary complication with the physiological objective of improving ventilation, oxygenation, the potential outcomes eliminate accessory muscle activities, decrease respiratory rate, increase tidal ventilation, -improve distribution

Using incentive spirometer in training twice daily for 15 minutes, 5 sessions per week for 8 weeks as a respiratory muscle endurance training showed feasible and beneficial effects in respiratory muscle training for patients with chronic obstructive pulmonary disease and ventilator/ limitation¹. Different studies concluded that incentive spirometer are also a beneficial for encouraging deep breathing, expanding collapsed areas and improving clearance of secretions, so it may be served as a useful tool for preventing complications of pulmonary impairments^{15,18}.

Incentive spirometry is widely used clinically as an adjunct to chest physiotherapy that provides

the patient with visual feedback of the volume of air inspired during a deep breath. It provides low-level resistive training while minimizing the potential of fatigue to the diaphragm. It has been used to enhance lung expansion and inspirator¹ muscle strength¹⁷.

The effects of incentive spirometry on pulmonary functions and arterial blood gases were studied in normal adults of advanced age and patients with chronic pulmonary emphysema. Both groups showed significant increase in forced vital capacity (F.V.C.) forced expiratory volume in the first second (FEV₁), peak expiratory flow (PEF) and partial arterial pressure of oxygen (PaO₂)⁸.¹⁸. Application of biofeedback assisted breathing exercises for patients with cystic fibrosis resulted in a significant improvement in forced vital capacity (F.V.C.), forced expiratory volume in the first second (FEV₁) and arterial oxygen saturation. These data suggest that respiratory muscle feedback assisted breathing exercise training may improve lung function in patients with cystic fibrosis⁵.

The increase in forced vital capacity (F.V.C) observed in subjects received breathing exercises might be related to the enhanced strength of the respiratory muscles and reduction of air trapping. While, the possible mechanisms to explain improvement in forced expiratory volume in the first second (FEV₁) might include increased respiratory muscle strength, increased use of the diaphragm in the expiratory maneuver and better coordinated use of musculature in expelling air⁵.

Respiratory muscle training by incentive spirometer increases production of surfactant which leads to reducing surface tension, increasing lung compliance, decreasing the work of breathing and opening of collapsed alveoli to prevent atelectasis. The improvement of total lung and thoracic compliance may be contributed to increase

arterial oxygen saturation (SaO₂)⁽¹⁸⁾

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