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Rehabilitation and Its Concern

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1. Introduction

Researchers have investigated a variety of rehabilitative modes of training in an attempt to ascertain the appropriate mode of exercise, dose, and work load, number of repetitions and order and number of exercises in order to bring about favourable improvements in asthmatic symptomology. However, the research regarding the effects of exercise training on asthmatics is sparse and there has continually been a self-inflicted restriction of physical and sporting activities in asthmatics. This is so despite clinicians having advised that exercise can take place when asthmatics use beta-agonists prior to exercise, avoid conditions that are likely to produce exercise-induced asthma and participate in swimming which is deemed less asthmogenic than other forms of exercise (Cochrane & Clark, 1990). Asthmatics can safely and successfully exercise with the correct interventions (Nagel, 2008) as seen when 41 medals were won (albeit controversially due to the stimulant effects of asthma medication) at the 1984 Olympic Games by American athletes with a history of asthma or exercise-induced asthma (EIA) in high-respiratory events such as cycling and swimming (Haas et al., 1987). The number of patients with chronic obstructive pulmonary diseases and asthma are on the rise over the entire world. Education, environmental control and drug therapy are the corner stone's in the management of asthma. Nowadays pulmonary rehabilitation is a recognised discipline for stabilisation and improvement of asthma and chronic obstructive pulmonary diseases. Pulmonary rehabilitation program (PRP) could improve the quality of life, pulmonary functions, exercise tolerance, reduce the symptoms and anxiety of patients and decrease frequency and duration of hospitalisation (Frownfelter, 1987; Cambach, 1999).

The concept of rehabilitation, involving holistic efforts to restore patients with debilitating and disabling disease to an optimally functioning state, is a relatively recent practice in pulmonary medicine. In 1974, a committee of the American College of Chest Physicians defined pulmonary rehabilitation as "an art of medical practice wherein an individually tailored, multidisciplinary program is formulated which through accurate diagnosis, therapy, emotional support and education stabilizes or reverses both physiopathological and psychopathological manifestations of pulmonary diseases and attempts to return the patients to the highest possible functional capacity allowed by his handicap and overall life situation" (Petty, 1975). More recent definitions were formulated by the NIH and by a task force of the European Respiratory Society (ERS). According to the NIH, pulmonary

rehabilitation has to be defined as a multidimensional continuum of services directed to persons with pulmonary disease and their families, usually by an interdisciplinary team of specialists, with the goal of achieving and maintaining the individual's maximum level of independence and functioning in the community (Fishman, 1994). According to the ERS task force, pulmonary rehabilitation is a process which systematically uses scientifically based diagnostic management and evaluation options, to achieve the optimal daily functioning and health-related quality of life of individual patients suffering from impairment and disability, due to chronic respiratory diseases as measured by clinically and/or physiologically relevant outcome measures (Donner et al., 1997). Although both definitions are primarily applied to patients with COPD, they are clearly also applicable to other patients suffering from chronic respiratory diseases. The new official statement of the ATS on pulmonary rehabilitation, published in 1999, supports this approach by defining pulmonary rehabilitation as a multidisciplinary program of care for patients with chronic respiratory impairment that is individually tailored and designed to optimize physical and social performance and autonomy (American Thoracic Society, 1999). These definitions refer to the philosophical concept of rehabilitation as the restoration of the individual to the fullest medical, mental, emotional, social and vocational potential of which the person is capable. From the beginning it has been clear that the goals of rehabilitation were multifactorial and included the following:

- Decreasing respiratory symptoms and complications
- Encouraging self-management and control over daily functioning
- Improving physical conditioning and exercise performance
- Improving emotional well-being
- Reducing hospitalizations

These goals are nowadays considered as outcome parameters for asthma management in general. Therefore, pulmonary rehabilitation as the application of the whole spectrum of scientifically evaluated non-pharmacological treatment options has to be considered as an integrated part of optimal management of both disease conditions especially for the patients with persistent physiological deficit after optimal pharmacological treatment or persistent impact on psychological functioning or health status. Present insights in determining factors on daily life functioning and health status, related to the systemic effects of the disease process of Bronchial Asthma, strengthen this approach to consider this intervention as part of an integrated management process.

2. Eligibility criterion

Any patient with symptomatic severe asthma, who is disabled either by the underlying disease, or by related therapy or by complications or by the systemic effects of the disease process, should be considered for pulmonary rehabilitation. The ATS statement considers pulmonary rehabilitation indicated for patients with chronic respiratory impairment who despite optimal medical management, are dyspneic, have reduced exercise tolerance, or experience a restriction in activities (American Thoracic Society, 1999). In fact, based on the defined goals of COPD and Asthma management by the ATS as well as by the ERS, pulmonary rehabilitation can no longer be considered as a separate intervention but as part of an integrated medical approach for the disabled COPD and Asthma patient (American Thoracic Society, 1999; Sifakas et al., 1995). Improvement in health status, functional

capacity and reduction of symptoms, which are defined treatment goals for COPD and Asthma should not be restricted to these specific conditions, and instead should be considered as outcome parameters for all chronic respiratory diseases including severe asthma.

Furthermore, it is important as part of the selection procedure that the patient is not distracted or limited by other serious or unstable medical conditions, that he/she is willing and able to learn about his disease and is motivated to devote the time and effort necessary to benefit from a comprehensive care program (Ries, 1995). Most of these rehabilitation programs can be completed in an outpatient setting. An ERS task force also defined specific selection criteria for in-hospital treatment (Donner et al., 1997). In-hospital management allows comprehensive diurnal assessment of the individual patient outside the habitual home environment. In-hospital rehabilitation can also be considered for specific intervention strategies or facilitates training of the most disabled patients, e.g. those with supplemental oxygen or patients receiving noninvasive mechanical ventilation. Post-intensive care patients with either disabling respiratory problems or weaning failure after acute respiratory support are also candidates for a comprehensive management program. Selection criteria for inpatient programs according the ERS are summarized in **Table 1**. Asthma is generally considered as one of the non-COPD indications for pulmonary rehabilitation (Donner et al., 1997). A survey of clinical control of asthma in Europe highlighted that a considerable percentage of children, as well as of adults, is markedly limited in daily life, as well as in social activities (Rabe et al., 2000). However, most asthma management programs largely rely on pharmacological intervention by administration of bronchodilating and anti-inflammatory agents in a stepwise manner (WHO,1995). Nonpharmacological intervention strategies are largely overlooked in asthma management plans.

Selection criteria for inpatient programs according the ERS	
1	Need for an integrated 24-hour supervised monitoring management plan, including training, teaching of coping skills, and other aspects of daily life functioning
2	Behavioral intervention to correct psychosocial problems
3	Need for specific intervention strategies, such as nutritional therapy
4	Participation in pre-operative and post-operative rehabilitation programs
5	Post-intensive care patients with either disabling respiratory problems or weaning failure after acute respiratory support
6	Identification and assessment of patients for long term oxygen therapy or long-term home mechanical Ventilation
7	Logistic aspects when outpatient rehabilitation is not available and the traveling distance does not allow the patient to participate in intensive rehabilitation

Table 1. Selection criteria for inpatient programs according the ERS

3. Components of rehabilitation

Based on the historically defined approach of pulmonary rehabilitation, each patient enrolled in a rehabilitation program has to be considered as a unique individual with

specific physio and psychopathological impairment caused by the underlying disease. Therefore, pulmonary rehabilitation incorporated many different therapeutic modalities applied as a comprehensive, multidisciplinary care program including pharmacological treatment. Specific components in this Physical Therapy approach of patients with asthma are supported by scientific data supporting the efficacy and effectiveness of the applied intervention procedure. In order to improve quality of life or to promote self-management behavior of chronically ill patients with asthma, it is also important to consider the different dimensions of the rehabilitation program. In general, a distinction has to be made between:

- Aim of the intervention;
- Level on which the intervention is focused;
- Directness of the intervention (Maes, 1993).

For pulmonary rehabilitation (PR) in general, these dimensions are described in **Table 2**.

PR dimensions		
1	Aim of the intervention	Reduction and control of respiratory symptoms
		Improvement in physical functioning
		Improvement in quality of life
		Reduction of the number of acute exacerbations
		Promotion of self-management behavior
		Improvement of cognition and behavior
		Reduction of psychological impact of physical impairment and disability
		Improvement of survival
2	Level of focusing of the intervention	Individual
		Group
		Environment
3	Directness of the intervention	Direct
		Indirect
		Supported by educational material

Table 2. PR dimensions

Based on this approach, interventions directed at improvement, for example quality of life, have to be focused on improvement of general psychological, social, practical and physical well-being of the patient. Dependent upon the aim and the phase the patient is in, the interventions can involve physical exercise programs as well as stress-management programs, social skills training or different kinds of counseling and support. The level of focusing of the intervention has to be decided depending on the aim of the intervention and the expected efficiency. Group-directed programs are preferable and programs have to be directed at the environment of the patient (Van den Broek, 2005). Psychological group interventions directed at patients and partners can increase efficiency in order to get management goals (Wouters, 2007). Furthermore, interventions can be directed at changing or adaptation of the environment of the asthma patient. These interventions are often specified by the term “social engineering”, because these interventions are directed at modification of living-, work-, or leisure-time situations and healthy life-styles of the patient

from a social or patient perspective (Van den Broek, 1995). Finally, the directness of intervention has to be considered. As part of a comprehensive intervention, indirect interventions can be considered in order to improve social support for the patient or to train other professionals in intervention skills. This theoretical approach of intervention programs is still largely unattainable in most rehabilitation programs, based on the limited resources still now spent on non pharmacological intervention strategies in asthma. In this approach, components of a rehabilitation program are individualized based on a careful assessment of the patient, not limited to lung function testing, but addressing physical and emotional deficits, knowledge of the disease, cognitive and psychosocial functioning, as well as nutritional assessment. Furthermore, this assessment must be an ongoing process during the whole rehabilitation process. Education, exercise training, vocational therapy, physical therapy, psychosocial support and nutritional intervention are now generally applied modalities in pulmonary rehabilitation.

4. Patient education

Patient education is generally used as an “umbrella term for various forms of goal-directed and systematically applied communication processes, directed at the improvement of cognition, understanding and motivation, and the improvement of action- and decision-making possibilities of a patient to improve the coping with and recovery of the disease” (Damoiseaux, 1984). Ideally, patient education is more than provision of information to the patient, but is a “planned learning experience using a combination of methods such as teaching, counseling and behavior modification techniques which influence patient knowledge and health behavior” (Jones et al., 1990). Promotion of self management behavior in asthma can be directed to improve adherence to medical advice with respect to medication and healthy life-style, directed at the stabilization or retardation of the progression of the clinical picture or at the avoidance of undesirable consequences and complications. Medical advice to chronically ill patients can also be directed at various aspects of cognition and behavior. In asthma, studies concerning patient education are directed on improvement of self-management, are restricted to medical outcome measures and are conducted by a wide variety of health care workers not explicitly trained to provide educational intervention (Green et al., 1977). The outcome variables as measured in different studies are generally restricted to number of attacks, emergency room visits, visits to the physician, knowledge, re-hospitalization rate and use of drugs while in most studies no psychosocial outcome variables are included. Therefore, it is very important that an effective educational program in asthma directed at improvement of self-management and quality of life provides information in a structured way and those both psychological as well as medical parameters are included. To involve several dimensions of the multiple problems of the asthmatic patient, a multidisciplinary program is preferred and follow-up sessions seem to be helpful in the prevention of re-hospitalization or relapse. Group-directed programs are preferable and programs have to be directed at the environment of the patient (Van den Broek, 1995). In asthma, most educational programs are conducted by various professionals, the environment of the patient is generally not involved and most of the studies do not pay attention to the problems of partners. Characteristics like depression, anxiety and optimism, wellbeing, the number and length of hospital admissions and use of health services can be influenced positively by patient education programs. Most of these studies have only short term effects. Van den Broek (1995) reported the effects of a patient education group

intervention program as part of a pulmonary rehabilitation program. Patients were randomly assigned to an experimental group and a control group. Partners participated in the study. Patients in the control group received medical advice and standard clinical care. The experimental group followed a structured educational program consisting of two components: an informative part and an educational part. The total program was directed at teaching self-management skills. Patients were followed for 12 months after the end of the rehabilitation program. The characteristics of an optimal education program for patients with asthma are described in Table 3 (Van den Broek, 1995).

Characteristics of an optimal education program
• The program should be conducted by experts specially trained in techniques to change behavioral or irrational cognitions
• Information should be provided in a structured way
• A group-program is preferable from a health economical perspective, but a combination of an individualized program and a group-program may be most effective
• Both participation of the social environment and attention to the problems of the partners should have a high priority to maintain newly acquired skills and cognitions in the home-situation
• Both medical and psychosocial parameters have to be emphasized
• The responsibility of the patient for his own health must be emphasized
• In order to promote the patient's self-activity and to support the maintenance of behavioral changes in the home-situation, additional materials should be made available to the patient to be used at home
• Follow-up sessions are necessary to support the patient and his or her partner in the home-situation
• Specific patient education interventions should be implemented in a multidisciplinary program, in addition to standard care to improve physical and psychological functioning
• Short- and long-term effects have to be evaluated by valid measurements.

Table 3. Characteristics of an optimal education program

Stabilization or reversal of disease-related psychopathology was one of the initially defined goals of pulmonary rehabilitation. Personality traits and intrapsychic conflicts, as well as acute psychological states as panic, anxiety or depression, are widely recognized problem categories in patients with asthma and COPD. Specific psychosocial intervention strategies are usually required in order to modify these problems. Kaptein and Dekker (2000) recently reviewed the nature of psychosocial support in different rehabilitation programs. They concluded that relaxation techniques as a predominantly passive form of intervention were the most frequently applied type of psychosocial support, aimed at more controlled and efficient breathing. The authors concluded that future research is needed to assess the outcome of more specific psychosocial intervention strategies, as well as to delineate the contribution of psychosocial intervention itself over and above pulmonary rehabilitation programs.

5. Motivation

Motivation is the best predictor of the success of rehabilitation (Brannon et al., 1998). Over 70% of patients with Asthma and COPD do not adhere to treatment (Mellins et al.1992), which may be because of inadequate information or depression. Motivation is essential if participants are to practise at home. A twice-a-week programme of structured exercise is not enough by itself to improve exercise tolerance (Ringbaek, 2000). Participants are unlikely to ignore their own beliefs and goals in order to follow a prescriptive approach, and education is not achieved by simply feeding information into an empty vessel and pressing the right buttons. The hierarchical hospital environment may encourage some patients to take up the sick role and assume that the experts know best. This apparent compliance is counterproductive in the rehabilitation process. Motivation is enhanced by participants taking responsibility for their own management (Hough, 1996).

Factors that increase and decrease motivation are:

Increase motivation	Decrease motivation
<ul style="list-style-type: none"> • Clear advance information in large print • Realistic expectations • Active participation, e.g. self-monitoring, invitations to question, comment, design programmes, contribute ideas • Verbal commitment from participants • Praise, warmth, humour, honesty and responsiveness from the rehabilitation team • Family involvement • Focus on health rather than disease • Short simple regimes (Mellins et al., 1992) • Understanding the rationale of each component • Early success, reinforced by progress charts • Access to notes (McLaren,1991) • Continuity of personnel • Certificate of completion. 	<ul style="list-style-type: none"> • Fatigue • Fear of failure • Anxiety or depression • Advice that is inconvenient or difficult to follow • Embarrassment • Boredom, e.g. repetitive exercise, 12-minute walking test, waiting for transport. • Lack of recognition of the individual as a whole.

6. Exercise training

Impaired exercise tolerance is a prominent feature especially in patients suffering from Asthma and COPD. Exercise limitation especially in patients with Asthma is the result of complex changes including a wide spectrum of variables:

- Reduced expiratory airflow as a consequence of poor elastic recoil
- Increased airways resistance leading to increased work of breathing and increased ventilatory drive
- Reduced pulmonary vascular bed and increased pulmonary vascular resistance contributing to exercise induced hypoxemia
- Impaired cardiac output by impediment of right heart filling and left ventricular systolic function and skeletal muscle dysfunction.

Leg fatigue attributable to peripheral muscle weakness has now been generally recognized as a common limiting symptom during exercise in Asthma and COPD (Killian et al., 1992). Several factors have been suggested to explain the occurrence of skeletal muscle dysfunction in Asthma and COPD: chronic inactivity and deconditioning, systemic inflammation, systemic corticosteroid administration, hypoxemia, electrolyte disturbances and muscle depletion as a consequence of a chronic process of tissue wasting. Asthma and COPD-related changes in structure and metabolism of the skeletal muscles are furthermore reported:

- Decreased oxidative capacity (Maltais et al., 1996),
- Greater proportion of fatigue-susceptible fibers as a consequence of shifts from type 1 fibers to type 2 fibers (Satta et al., 1997),
- Changes in energy rich phosphagen metabolism (Pouw et al., 1998).

Lower capacity for muscle aerobic metabolism is related to an increased lactic acidosis for a given exercise work rate and enhances ventilator needs by increasing non aerobic carbon dioxide production. This requirement imposes an additional burden on the respiratory muscles already facing increased impedance to breathing. Exercise in Asthma and COPD is also related to an early onset of muscle intracellular acidosis (Wuyam et al., 1992). Remarkably, opposite changes in diaphragmatic fiber composition are now reported especially in more severe Asthma and COPD patients towards a higher proportion of fatigue-resistant fibers (Levine et al., 1997). Besides these changes in intrinsic diaphragmatic muscle structure, mechanical disadvantages and altered muscle fiber length mainly as a consequence of static and dynamic hyperinflation, as well as an altered muscle environment contribute to a dysfunction of inspiratory muscles and especially of the diaphragm in Asthma and COPD. A possible imbalance between inspiratory muscle function and increased muscle load related to the increased resistive and elastic load is an important determinant of dyspnea, susceptibility to inspiratory muscle fatigue, drive on the respiratory muscles and hypercapnia (O'Donnell DE & Webb KA, 1993). Towards this complexity in pathophysiological and metabolic changes especially in Asthma patients, the outcome of exercise training as part of a rehabilitation program has to be interpreted.

Indeed, pulmonary rehabilitation programs almost include a measure of exercise training, generally based on transfer of standard recommendations for exercise training from healthy subjects to these disabled pulmonary patients frequently ignoring the complexity of bodily changes related to or a consequence of the disease state. Therefore, exercise testing before a training program is generally advised in order to determine the nature of exercise limitation, e.g. cardio circulatory, ventilatory, diffusion limitation, limitation in the pulmonary circulation, or peripheral muscle limitation. Subsequent exercise training can be prescribed based on the individual limitations of the patient.

Pulmonary rehabilitation could improve the quality of life and pulmonary functions. Cambach et al had reported that quality of life and exercise capacity improved after the rehabilitation program. Field et al also had demonstrated that children with asthma had improved pulmonary function after the daily relaxation and massage therapy. They found best improvement in FEF25-75 values (in common with our findings) which reflects small airway obstruction. These results mean PRP could lead improvement in airway obstruction and control of asthma. In another study carried out by Cox et al it was shown that pulmonary rehabilitation had beneficial effects on endurance, psychological variables, quality of life, skills, coordination, smoking habits, airway obstruction and dyspnea . However bronchial hyperresponsiveness, need of pulmonary drugs and complaint of cough did not change. They followed patients for two years and long term effects of PRP were evaluated. Kathiresan G et al shown that there is a beneficial effect on quality of life (Table 4) and pulmonary functions (Table 5) pulmonary rehabilitation should be placed as a component of management in childhood asthma.

	First visit	Second visit	p
Rehabilitation group			
Symptom score	0.63 ± 0.71	0.19 ± 0.40	0.01
	(median: 0.5)	(median: 0)	
Medication score	4.40 ± 1.70	3.50 ± 0.80	0.007
Quality of life Index	6.02 ± 0.5	6.40 ± 0.40	0.009
Control Group			
Symptom score	0.67 ± 0.57	0.49 ± 1.40	0.16
		(median: 0)	
Medication score	4.09 ± 0.79	4.06 ± 0.93	0.32
Quality of life Index	6.15 ± 0.29	6.27 ± 0.49	0.16

Table 4. Symptom and medication score and quality of life index of rehabilitation group and control group

	First visit	Second visit	p
Rehabilitation group			
VC	76.62 ± 8.64	83.12 ± 12.38	0.05
FVC	78.00 ± 8.83	84.75 ± 10.76	0.02
FEV ₁	74.23 ± 11.67	80.62 ± 12.27	0.009
PEF	65.62 ± 8.50	73.43 ± 7.32	0.001
FEF ₂₅₋₇₅	75.73 ± 11.12	85.31 ± 14.45	0.006
Control group			
VC	78.66 ± 10.39	80.25 ± 6.25	0.75
FVC	79.67 ± 8.64	81.41 ± 7.07	0.36
FEV ₁	73.75 ± 7.12	75.91 ± 5.43	0.15
PEF	6.33 ± 7.22	68.91 ± 9.16	0.21
FEF ₂₅₋₇₅	74.54 ± 11.96	76.66 ± 10.37	0.37

Table 5. Pulmonary functions (% predicted values for age and height) of rehabilitation group and control group

7. Exercise prescription

In general, exercise training can be divided into two types: aerobic or endurance training and strength training. The majority of the studies of exercise training in Asthma and COPD have focused on endurance training. However, no clear recommendations for Asthma and COPD are yet available. However, in normal subjects, clear recommendations are available about duration, intensity and frequency for aerobic training (Casaburi, 1993). According to these recommendations, aerobic training calls for rhythmical, dynamic activity of large muscles, performed three to four times a week for 20–30 min per session at an intensity of at least 50% of maximal oxygen consumption. Such a program of aerobic training is capable of inducing structural and physiological adaptations that provide the trained individual with improved endurance for performance of high-intensity activity. Most of the rehabilitation programs include exercise sessions of at least 30 min, three to five times a week. Although no ideal duration has been established, duration in many programs is around 8 weeks. Limited information is also available regarding physiological outcome of different types of exercise testing. Continuous training especially seems to be related to physiological improvement while interval training (Coppoolse et al., 1999).

	Mode	Intensity	Protocol	Duration	Frequency
Lower limb 1) endurance training Ground walking Treadmill walking Stationary Cycle or a combination of the above with a total duration of 30 minutes	Walking training Ground-based	80% average speed on 6MWT 75% peak speed on ISWT Dyspnoea rating of 3 (moderate)	Continuous or interval	30 minutes	4 or 5 times a week that includes 2 or 3 supervised sessions and home exercise training
	Walking training Treadmill	As for ground-based walking training but reduce speed by 0.5 to 1 kph until familiar with treadmill	Continuous or interval	30 minutes	4 or 5 days a week that includes 2 or 3 supervised sessions and home exercise training
	Stationary cycle training (if possible)	Dyspnoea rating of 3 (moderate)	Continuous or interval	30 minutes	4 or 5 days a week that includes 2 or 3 supervised sessions and home exercise training
2) strength training	Strength training with weights (Leg press, Quadiceps extension). Strength training without weights (Squats, Straight leg raise, Step-ups or stair climbing, Sit-to-stand from progressively lower chairs)	10 RM (repetition maximum)		10 repetitions (1 set)	2 or 3 times a week with at least 1 day rest between sessions
Upper limb 1) endurance training	supported arm training and Unsupported arm Training	Determine the weight that the patient can only lift 15 times Dyspnoea rating of 2 or 3 (slight or moderate)		15 repetitions (1 set)	4 or 5 times a week that includes 2 or 3 supervised sessions and home exercise training
2) strength training	Strength training for the upper limbs should focused on the accessory muscles of inspiration and muscle groups used in everyday functional tasks	10 RM (repetition maximum)		10 repetitions (1 set)	2 or 3 times a week with at least 1 day rest between sessions

Table 6. Individual exercise prescription

In healthy subjects training is normally targeted by means of percentage of maximal heart rate (60–90% of predicted) or the percentage of maximal oxygen uptake (50–80% predicted) achieved (American College of Sports Medicine (ACSM), 1990). However, principles of exercise training intensity derived from normals are often not applicable to pulmonary patients who are limited by breathing capacity and dyspnea. Indeed, Casaburi et al. compared high work rate training versus low work rate training and concluded that physiologic training effects were much less marked in patients who trained at low work rate, even though the total amount of work involved in the training regimen was the same irrespective of the training group to which the patient was assigned.

An exercise training program requires an individual prescription (Table 6) in terms of:

- Intensity.
- Duration.
- Frequency.
- Type (interval or continuous).
- Mode (e.g. walking, cycling, arm exercise).
- Progression.

8. Callisthenic training

Perez et al. (2003) found that callisthenics before exercise training resulted in maximal expiratory flow rate diminishment. This diminishment is significant in that it can act as a preventative method in the development of exercise induced asthma and as such allows the asthmatic to optimally benefit from training. Similarly, Fitch et al. (1986) and Bungaard et al. (1982) used callisthenics as part of their exercise prescription and found improvements in asthma symptomology.

9. Postural retraining

Postural exercises have been recommended since the posture of an asthmatic is typically pronounced by thoracic kyphosis and the flattening of the sacrolumbar portion. These postural misalignments can lead to a decrease respiratory capacity and can severely affect visceral functioning. However, these postural abnormalities have been found to be improved following postural retraining that includes postural, breathing and abdominal strengthening exercises (Goyeche et al., 1980). Possible reasons why postural retraining is implicated is since an asthmatic's posture is affected by changes in the contractile (i.e. muscles) and non-contractile units (i.e. bone, ligaments, tendons, cartilage and connective tissue), and since asthmatics' have a decreased general mobility which can lead to degenerative changes and as such possibly altering afferent impulses and decreasing the lung's reflexogenic efficiency. Further, since asthmatics have a loss of midcervical lordosis more weight and tension is exerted at the cervical-thoracic junction which can lead to an increase in thoracic kyphosis that abducts the scapulae which shortens the pectoralis major and pectoralis minor, lengthens the rhomboids and lowers the trapezius I and II and shortens the serratus anterior, latissimus dorsi, subscapularis and teres major, all of which affect normal breathing (Ayub, 1987). Strunk et al. (1991) also pointed out that postural retraining can correct thoracic kyphosis and improve breathing in asthmatics

especially in severe asthmatics that are more likely to suffer from such postural abnormalities when the pectoral and intercostal muscles are stretched. Ayub (1987) stated that postural retraining in asthmatics should focus on the facilitation of correcting righting, equilibrium and protective reactions with normal tactile, proprioceptive and kinesthetic input.

10. Breathing training

Diaphragmatic breathing exercises could benefit an asthmatic's condition since they compress the abdominal contents which increase intra-abdominal pressure that causes lateral transmission of pressure to the lower ribs laterally, upward and outward motion of the lower ribs and anterior/posterior motion of the upper ribs. This then results in an increase in thoracic volume that decreases intrathoracic pressure which facilitates inspiration (Cahalin et al., 2002). Breathing retraining is essential to an asthmatic since, breathing in an asthmatic is of the thoracic type and since dyspnea can cause the asthmatic to increase inspiration further leading to further overextension of the already over-inflated lungs. This is then worsened by the increased dead-space ventilation, metabolic requirements and a tendency to maintain a low arterial partial pressure of oxygen.

Asthmatics can have a decreased chest expansion and chest deformity as a result of a shortened diaphragm, intercostals and accessory muscles from prolonged spasm. With asthma, the accessory respiratory muscles are fully contracted and the diaphragm is maximally depressed. The accessory muscles are overactive during inspiration which causes stenosis of the major airways leading to an abnormal respiratory pattern. During an asthma attack, the diaphragm is maximally extended and either contracts spasmodically or not at all. This poor excursion of the diaphragm can negatively affect airway reserve, vital capacity (VC) and alveolar gas exchange (Goyeche et al., 1980).

The physiological effects of diaphragmatic breathing are varied and it is claimed that diaphragmatic breathing can correct abdominal chest wall motion, decrease the work of breathing and dyspnea and improve ventilation distribution (Vitacca et al., 1998). The purpose of breathing exercises is to empty the lungs by prolonging the expiratory phase, retrain normal breathing patterns, increase expansile forces in hypoventilated areas, increase lung volume, dilate airways, force mucus into larger airways, re-educate the autonomic diaphragmatic movements, reduce the thoracic type breathing, relax spasmodic muscle contractions, mobilise the ribs and chest wall and correct kyphosis (Goyeche et al., 1980). These benefits are achieved by shortening inspiration and lengthening expiration (Bouchard et al., 1993), by performing expiration via the pulling in of the abdominal muscles dorsally towards the spine while relaxing the abdominal, intercostals and neck musculature (Cahalin et al., 2002). This is achieved by using special weights or belts to increase intra-abdominal pressure, by applying compression to the lower ribs to facilitate expiratory ascent of the diaphragm during expiration which can increase the movement of secretions from the small bronchi into the respiratory passages, by exhaling through a resistive breathing device or by breathing while creating a hissing noise in order to reduce bronchial constriction. These techniques have led to symptom-free and medication-free asthma, an improved ability to halt an imminent attack,

improved loosening and expulsion of mucus, enlargement of the diaphragm excursion, improved chest expansion at the epigastrium, improved maximum breathing capacity and VC (Cahalin et al., 2002). Patients with elevated respiratory rates, low tidal volumes and abnormal arterial blood gases have been identified as those who will benefit the most from diaphragmatic breathing exercises (Cahalin et al., 2002).

Diaphragmatic breathing exercises have also been proven to reduce patients' anxiety levels and to alter their attitude towards work (Lustig et al., 1972) while breathing retraining has been shown to decrease bronchodilator use and acute exacerbations and to improve quality of life (Holloway & Ram, 2004). Ambrosino et al (1981) in turn, have found that deep diaphragmatic breathing and pursed lip breathing can increase a lung patient's maximal exercise tolerance. Diaphragmatic breathing can also lead to an increase in alveolar ventilation due to the changes in breathing pattern via decreases in breathing frequency and increases in tidal volume resulting in increases minute ventilation (Vitacca et al., 1998). Additional benefits of breathing exercises are to correct deviant posture, strengthen abdominal muscles, teach diaphragmatic and lower costal breathing and increase chest expansion (Lustig et al., 1972). Fluge et al. (2004) demonstrated that breathing exercises have been found to increase FEV1, VC and to reduce RV significantly while Strunk et al. (1991) also indicated that breathing exercises can decrease the work of breathing, improve ventilation, decrease oxygen consumption and decrease psychological anxiety.

Yoga is a preferred method of training in older adults and the active or fitness-based yoga that emphasises cardiovascular fitness, resistance training, flexibility and relaxation is an effective treatment for asthmatics (Tummers & Hendrick, 2004). Nagarathna and Nagendra (1985) pointed out that yoga techniques can benefit asthmatics by reducing psychological over activity and emotional instability and thereby reducing efferent vagal discharge while decreasing vagal outflow to the lung which can cause bronchodilation and a small decrease in bronchial reactivity. Yoga can also increase endogenous corticosteroid release, possibly decreasing bronchial reactivity (Udupa & Singh, 1972). Breathing exercises have been found to decrease anxiety during an asthma attack and also prevent the onset of an attack (Sly et al., 1972). Breathing exercises have resulted in clinical improvements which translated into improved school attendance, exercise tolerance, asthma control and self-confidence. Improvements have also been observed in breathing capacity, VC, but not FEV1 (Millman et al., 1965). However, Sly et al. (1972), found that a combination of physical conditioning and breathing exercises can improve VC, reduce the severity of asthma attacks and the need for symptomatic medication, but no change in psychological adjustment and subjectively there was a change in independence, outgoingness, getting along with others, feelings of acceptance, enthusiasm and capability to be a follower (McElhenny & Peterson, 1963). Up to eight months of breathing exercises have resulted in improved pulmonary function, decreased absenteeism and improved sociability, self-assertion and peer relationships. Subjectively, the subjects reported an improvement in their control of asthma, exercise tolerance and emotional stability (McElhenny & Peterson, 1963). Girodo et al. (1992) also found reductions in medication usage and in the intensity of asthmatic symptoms of 32 asthmatic patients utilising breathing training making use of a physical corset. One of the problems with prescribing breathing exercises is that although eagerly accepted by asthma patients, they are just as easily found boring and soon forgotten (Strunk et al.,

1991). Therefore, the structure and setting of the exercises are important since it has been established that breathing exercises have resulted in thousands of asthma sufferers reducing their medication intake and experiencing a sense of control even though this breathing technique does not alter the disease process (Cooper et al., 2003). This is notable in that improvements in subjective attributes and perceptions in asthmatic patients may have major effects on their quality of life and the ability to cope with their disease.

11. Inspiratory resistive breathing training

The purpose of inspiratory resistive breathing training is to enhance respiratory muscle function and in doing so possibly reduce the severity of breathlessness and improve exercise tolerance. This may benefit the asthmatic patients, especially those with severe asthma, since asthmatics could suffer from respiratory muscle dysfunction due to the loss in respiratory muscle bulk and resultant respiratory muscle strength. The use of inspiratory resistive breathing training in asthmatic patients could possibly result in improvements in inspiratory muscle coordination, improvements in inspiratory muscle strength and endurance and the correction of inappropriate respiratory muscle effort (Kim et al., 1993). These improvements and corrections then possibly result in improvements in spirometry variables, a desensitisation to dyspnea, lessening of asthma symptoms, reduced hospitalisations, less emergency room contacts, absences from school and work and/or the decreased use of medication (Ram et al., 2004). According to Ram et al. (2004), despite the possible benefits of inspiratory resistive breathing training, this mode of exercise's current use in asthmatics is presently insufficient and its clinical benefits not yet justified.

12. Aerobic training programme

Kathiresan et al. (2010) evaluated the effect of a supervised aerobic training programme on the cardio respiratory fitness and clinical indicators of control in a group of children with moderate to severe but stable asthma. The degree of response to training and the positive effect on the clinical management were strongly influenced by the level of fitness in the initial evaluation; beneficial effects were shown only in the less fit patients. The results suggest that exercise therapy for the most untrained children can have a role, at least in the short term, in reducing the minimal medication needed for control of moderate to severe asthma. Previous studies in normal and asthmatic patients have shown that the initial grade of fitness and motivation is an important predictor of aerobic improvement after training (Brodal et al., 1977). Cochrane and Clark,(1990) for example, found that the relative gain in $\dot{V}O_{2max}$ after training in asthmatic subjects was negatively related to symptom score on the training day and the baseline level of fitness, and positively to motivation. Thus, the improvement after training in muscular capillarisation, oxidative capacity, muscular strength, and cardio circulatory adjustments is likely to occur in motivated subjects with worse baseline aerobic conditions. However, it should be recognised that the so called "regression to the mean" effect cannot be ruled out by this finding; the random longitudinal variation tends to increase the lower values of a given distribution or, alternatively, the higher values tend to randomly decrease with time. Children's with moderate to severe asthma showed significant degree of improvement after aerobic fitness training (**Figure 1**). Nevertheless, as previously noted,

this higher potential for improvement in the most unfit individuals is a well known phenomenon and it seems highly improbable that such a statistical artifact would be consistently related to another measurable biological effect such as the reduction in inhaled steroids (**Figures 2 and 3**). In this context, there is now growing evidence to show that the systemic effects of inhaled beclomethasone in children are dose dependent (Hanania et al., 1995; Yiallourds et al., 1997) and medication usage seems to be a particularly useful index of overall asthma control. Although the respiratory system is usually considered to be largely insensitive to training effects per se (with the possible exception of muscle ventilator strength and endurance), a cause-effect relationship could explain this association. Thus, one can speculate that a possibly lower occurrence of EIB after training would induce a lower chronic release of inflammatory mediators and therefore reduce the need for inhaled steroids. However, we did not find a significant reduction in the prevalence of a positive EIB test with training, regardless of whether or not there was a positive response (**Figure 2**). Another more plausible hypothesis is that the improvement was related to a higher degree of acceptance and level of self-care in the least fit patients who usually have negative attitudes toward their disease and exertion (Strunk et al., 1989). Thus, Strunk et al. (1989) showed that the wide variability in aerobic performance in a group of 90 children with moderate and severe asthma was mainly related to the degree of social and disease adjustment Engström et al. (1991) in a group of 10 severely asthmatic children submitted to physical training showed that only psychological modifications correlated significantly with aerobic improvement. Thus, individual variations in acceptance and knowledge of the disease seem to influence the usual level of physical activity in asthmatic children, and therefore their degree of fitness. In this context, exercise training may induce a more decided posture in relation to the disease, with consequences in the minimum medication required for clinical control. Results are consistent with those of Thio et al. (1996) who were not able to find a lower prevalence of EIB after dynamic exercise training, although in a previous cross sectional study we found an association between a reduction in $\dot{V}O_{2AT}$ and a higher prevalence of EIB in asthmatic children (Nery et al., 1994). While one can predict a reduction in EIB with aerobic improvement (secondary to training induced lower submaximal ventilation) (Bungaard et al., 1981), in our study this enhancement alone was probably not sufficient to reduce the EIB, at least when assessed in a formal challenge test. A particularly notable finding was the relative inefficacy of the training programme in improving the maximal aerobic parameters in almost 60% of the children. However, one should recognise that maximal incremental testing is not representative of the daily pattern of exercise activities in the paediatric group (which is better characterised by short bursts of activity); new submaximal protocols have been suggested to be more suitable for evaluating training responses in children (Cooper, 1995). In addition, the degree of fitness in the initial evaluation was above that expected for asthmatic children and the low pre-intervention prevalence of unfit children could have induced a type II error. This finding is consistent, however, with the suggestion that secular trends do not reduce the average aerobic fitness of westernized children (Santuz et al., 1997). Kathiresan et al. (2010) shown that the less fit asthmatic children were able to normalize their aerobic fitness with a supervised training programme without clinical complications. Their ability to improve aerobic capacity was not related to clinical and spirometric severity before training. Interestingly, we found a significant association between aerobic improvement and reduction in use of both inhaled and oral steroids.

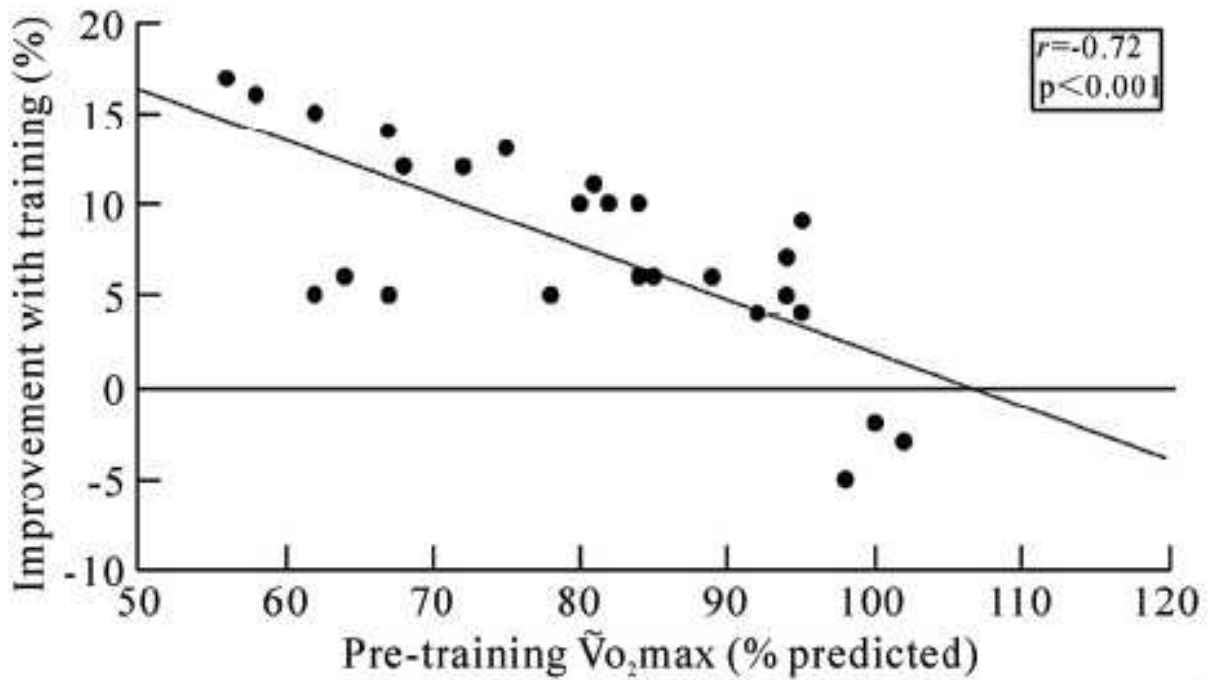


Fig. 1. Relationship between baseline maximal aerobic fitness and degree of improvement after training in 26 children with moderate to severe asthma.

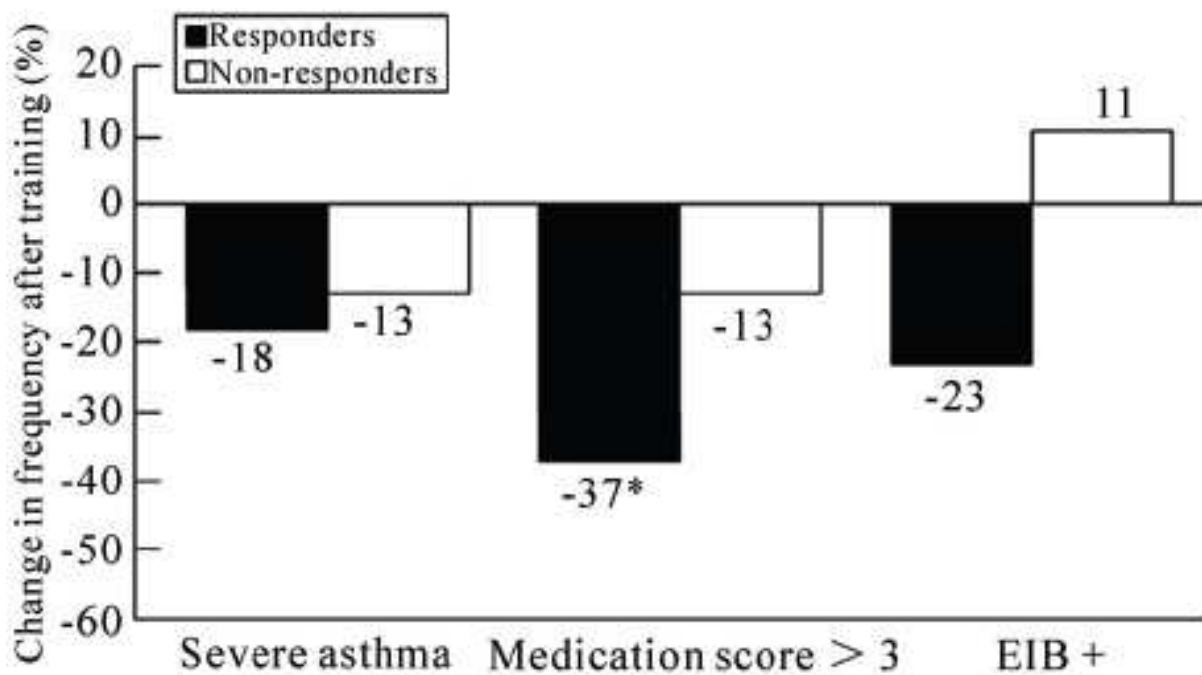


Fig. 2. Association between changes in clinical indicators of asthma severity and positive (responders) or negative (nonresponders) response to aerobic training. * $p < 0.05$ (Fisher's exact test).

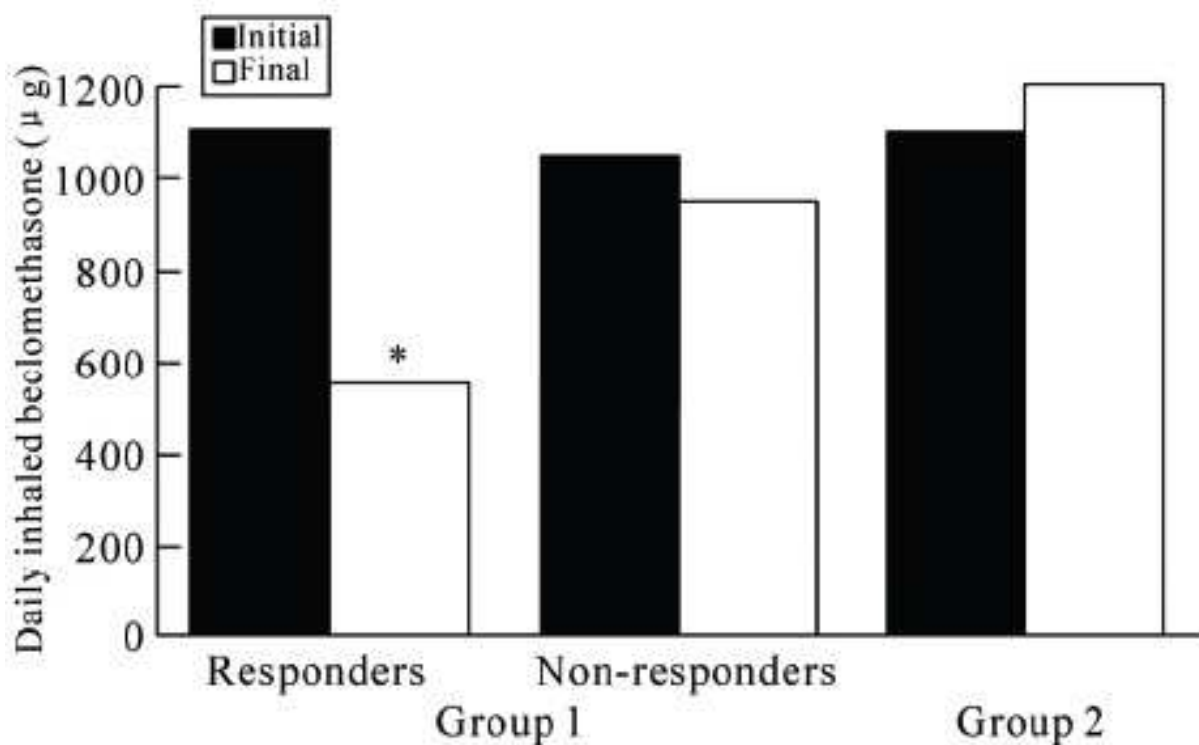


Fig. 3. Mean values of daily inhaled beclomethasone in the initial and final evaluations. Group 1 = trained children with (responders) and without (non-responders) aerobic improvement after training; group 2 = untrained children.* $p < 0.05$ (paired t test).

13. Anaerobic or lactate threshold training

The anaerobic component of physical conditioning may be important in the overall physiologic profile of the individual with asthma (Council et al., 2003). Council et al. (2003) propose that asthmatics should participate in brief, intense bouts of muscle work alternating with rest periods since this mode of training is less likely to induce EIA and reduces the risk of asthma exacerbations while allowing the asthmatic patient to train optimally for longer periods. The importance of improving lactic acid metabolism and tolerance in EIA patients and exercising at or above lactate threshold is of critical importance since, this intensity is not only less likely to induce EIA, it is sufficient to increase aerobic capacity while minimising the amount of water loss from hyperventilation during exercise thus suppressing the onset of EIA. A benefit of lactate threshold training is that this training can increase the anaerobic threshold, reduce the onset of EIA and reduce hyperpnoea which often occurs when lactate threshold is passed (Matsumoto et al., 1999). Council et al. (2003) found that a work: rest ratio of 1: 4 for a total of 45 minutes at lactate threshold can significantly improve VO_{2max} , decrease ventilatory reserve and increase exercise VE in asthmatics. Neder et al. (1999) also found that 30 minutes of exercise at lactate threshold significantly improved pulmonary function, decreased EIA symptoms and reduced medication intake. In light of the above, the present author supports the view of (Council et al., 2003) who indicated that the training effect of a combination of aerobic and lactate threshold training is unfounded in asthmatics and should be used with caution until further research has been conducted. This is so since few studies have been completed to determine

the effect of lactate threshold training programme on the pulmonary and gas exchange parameters of asthmatics. Also, this mode of exercise training may prove dangerous in the untrained and elderly and in an unsupervised environment due to the intensity and effort required. It is essential that further research be undertaken to determine the effectiveness of lactate threshold training on asthmatics especially those with EIA since as stated previously, exercising at or above lactate threshold is less likely to induce EIA but is sufficient to increase aerobic capacity and minimise the amount of water loss from hyperventilation during exercise.

14. Aerobic and combined anaerobic or lactate threshold training

When aerobic and resistance training is combined in the form of circuit training, the effects on the majority of asthma severity measures seem unaffected (Robinson et al., 1992). Also circuit training resulted in no improvements in bronchial responsiveness to histamine, medication usage and symptom scores which included wheezing, coughing, breathlessness, medication use and peak expiratory flow (PEF) (Robinson et al., 1992). However, this exercise training programme did result in significant increases in VO_{2peak} and reduced VE at high workloads. Robinson et al. [49] also found that this mode of training had other benefits on asthmatics other than those on disease severity. These included an increase in self-confidence in undertaking physical activity and an increase in daily physical activity. Additionally, Fitch et al. (1986) found no significant relationship between anaerobic circuit training and PEF, VO_{2max} , VE and VT . However, when aerobic training was combined with anaerobic training, Council et al. (2003) found an increased usage of ventilatory reserves, increased anaerobic threshold and an increased VO_{2max} . Since few studies have been completed on the various forms of combination training, this type of exercise treatment should be used with caution until further research has been conducted.

15. Peripheral muscle training

Patients with Asthma and COPD frequently report disabling dyspnea for daily activities involving the upper extremities such as combing hair, brushing teeth or shaving. It is known that even in healthy persons, arm exercise is relatively more demanding than leg exercise. Some studies have demonstrated that arm elevation is related to a disproportionate increase in the diaphragmatic contribution to the generation of ventilatory pressures (Couser et al., 1992) and that arm elevation is a fatiguing task for the muscles involved as assessed by electromyographic data. Therefore, exercise training of the upper extremities may be beneficial for these patients also from the point of view that exercise training is specific to the muscles and tasks involved in the training. However, relatively few data exist assessing outcomes of upper extremity (UE) training compared with those available for lower extremity training. Studies have demonstrated that UE training leads to improved arm muscle endurance during isotonic arm ergometry (Ries et al., 1988) and that arm training conducted during a pulmonary rehabilitation program led to a reduced metabolic demand associated with arm exercise (Couser et al., 1992). Based on present findings, it can be concluded that strength and endurance training of the UE improves arm function and that these exercises are safe and should be included in rehabilitation programs for patients with pulmonary diseases. Further studies are needed

to explore the effects of arm training on functional outcomes, to evaluate different forms of arm exercise training programs and to determine the effect of arm exercise training on respiratory muscle function.

Randomized, controlled trials have at present demonstrated that lower extremity training of several types and undertaken in several settings is a critical component of a pulmonary rehabilitation program. Pulmonary rehabilitation consisted of 12 4-hour sessions which included education, physical and respiratory care instruction, and psychosocial support and supervised exercise training, followed by monthly reinforcement sessions for 1 year. The education group received 2-hour sessions which included videotapes, lectures and discussions. This comprehensive rehabilitation program produced a significantly greater increase in maximal exercise tolerance, maximal oxygen uptake, exercise endurance, self efficacy of walking and these effects were associated with a marked reduction of the symptoms of perceived breathlessness, muscle fatigue and shortness of breath. These positive effects of rehabilitation on dyspnea were confirmed by the results of O'Donnell et al. (1993) who demonstrated that after rehabilitation there was a significant shift of the relationship between dyspnea and workload downwards, indicating that at any given workload, dyspnea was less. Similar results were reported by Goldstein et al. (1994) They performed a prospective randomized controlled trial of respiratory rehabilitation in 89 subjects.

Exercise activities included interval training, treadmill, upper-extremity training and leisure walking as part of an 8-week inpatient rehabilitation program. Significant improvements in exercise tolerance, measured by submaximal cycle time and walking distance were demonstrated and sustained for 6 months in the rehabilitation group. There were also significant differences in questionnaire assessment of dyspnea and dyspnea index. These and other results provide convincing evidence that lower extremity training is beneficial in patients with chronic airflow limitation and exercise limitation. Lower extremity training can be recommended on evidence-based scientific criteria to be included in the rehabilitation of patients with asthma and COPD.

16. Health-related quality of life (HRQoL)

Pulmonary rehabilitation plays a key role in the management of Asthma and COPD. Although the American Thoracic Society recently provided a grade of 1A for evidence of health-related quality of life (HRQoL) benefits related to pulmonary rehabilitation, knowledge about the psychological and behavioral processes explaining the impact of pulmonary rehabilitation on HRQoL in Asthma and COPD patients remains limited.

HRQoL outcomes related to pulmonary rehabilitation explores five themes:

- Optimizing pulmonary rehabilitation components to improve HRQoL;
- Characterization of a responder phenotype;
- Suitability of pulmonary rehabilitation following acute exacerbations;
- Exploration of psychological and behavioral mechanisms explaining pulmonary rehabilitation benefits;
- Long-term maintenance of HRQoL benefits after pulmonary rehabilitation.

Evidence supports the use of pulmonary rehabilitation to improve HRQoL in patients with Asthma and COPD. However, it is unclear how pulmonary rehabilitation improves HRQoL and which characteristics confer the greatest HRQoL benefits. Moreover, most studies failed to provide a compelling theoretical rationale for the intervention employed. Some studies have analyzed the long-term outcome of rehabilitation on quality of life. Ketelaars et al. (1997) evaluated the long-term effect of rehabilitation on HRQL. She reported that patients with moderate HRQL scores upon admission had the greatest decline after 9 months of followup, despite having made substantial gains in HRQL by the end of the initial rehabilitation program. Otherwise, patients with poorer baseline HRQL scores showed very little improvement during the rehabilitation program and remained severely impaired in HRQL long term. These authors suggested that differentiated aftercare programs may be indicated in order to maintain initial gains in HRQL. Wijkstra et al. (1996) reported that rehabilitation at home for 3 months followed by once-monthly physiotherapy sessions improves HRQL. Future research should focus on improving the understanding of the psychological mechanisms implicated in the adoption and maintenance of healthy behavior.

17. Case study

History/Chart note

A 20-year-old female was transported on a stretcher to the medical and physiotherapy facility at a national track meet. Her teammates report that she collapsed at the end of the 4 x 800 M. They stated that she does this all the time and has done so after other 800-M heats and practices. She becomes grey and extremely short of breath and usually is not able to speak during the first 5 minutes after the race. It usually takes approximately 25 minutes before she recovers. To their knowledge, she has never received medication or treatment for this but it has been described as "panic attacks." You are the only physiotherapist in the facility. The physician has gone across the track to deal with another injury. The woman is still very out of breath but her teammates state that she is doing better.

Questions

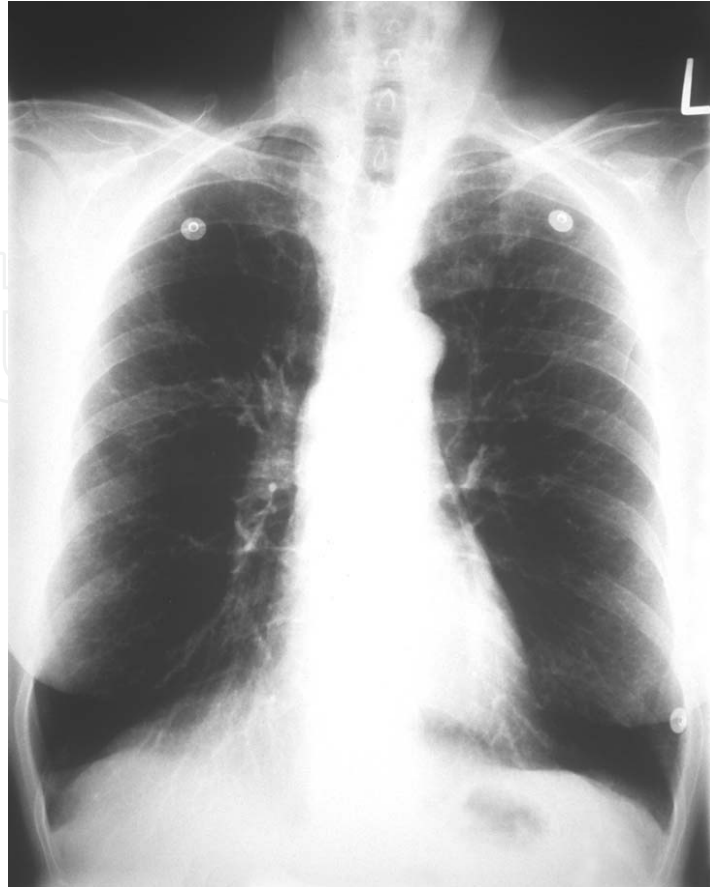
1. What assessment parameters should you monitor?
2. What factors would be indicative of worsening or improvement of her respiratory and cardiovascular status? Her PEFr is 3.81 L/sec. The age predicted PEFr for a person the same age and height is 8.87 L/sec. Do you think this person is having a panic attack?

Auscultation

What are the breath sounds and adventitious sounds that you would expect to hear on auscultation?

Chest X-ray

After a similar event, she went to Emergency Room and had a chest x-ray (Figure 8). Identify the characteristic features of this x-ray. What do you think it will look like when the patient is feeling well and her pulmonary function is near normal?



Arterial blood gases

Her arterial blood gases at the Emergency Room were

pH: 7.25 PaCO₂: 59 HCO₃⁻: 26 PaO₂: 60

What is the primary acid-base disturbance? Is compensation present? Is the patient hypoxemic? If so, is the hypoxemia due to hypoventilation or other causes?

Spirometry and expiratory flow rates

Her spirometry and PEFr before and after the use of bronchodilators are shown in Table 7. Her height is 180 cm. Interpret the spirometric values. What pattern of lung pathology is shown? Complete the table and calculate the % predicted values and the % improvement after bronchodilator administration.

	Pre BD	Pred	% Predicted	Post BD	% Improvement
FEV1	1.8	3.8L		3.0	
FVC	3.2	4.7		4.2	
FEV1/FVC	56%	80%		71%	
PEFR	3.81	8.87			

Table 7. Spirometry and Peak Expiratory Flow Rates

Physical therapy management

What health professionals would you advise this woman to see?

17.1 Answer guide**History/Chart NOTES**

1. What assessment parameters would you monitor?
 - Vitals: HR, RR, BP, SpO₂ if oximeter available but this device is not usually available in this situation
 - Cyanosis
 - Dyspnea; difficulty with speaking because of shortness of breath; indrawing (supra clavicular, intercostal, diaphragmatic)
 - Posture
 - Is the patient barrel chested?
 - Accessory muscle use
 - Abnormal auscultatory findings
 - PEFV but unlikely to have peak flow meter
2. What factors would be indicative of worsening or improvement of her respiratory and cardiovascular status?
 - Worsening of condition would include vitals moving further away from normal range, increased cyanosis, increased dyspnea, increased indrawing, worsening of auscultatory findings
 - Improvement would include vitals moving toward the normal range, and the patient attaining some level of composure, decreased dyspnea, and improved auscultatory findings

Auscultation

In a patient with acute asthma, one would expect to hear:

- Most commonly, high- or medium-pitched wheezes in both inspiratory and expiratory phases. The wheezes may also be polyphonic.

Chest X-ray

- Chest x-ray findings consistent with acute asthma are:
- Large lung fields
- Horizontal ribs
- Elongated mediastinum and small cardiothoracic index
- Flattening of hemidiaphragms

Other features of interest are:

- EKG electrodes
- Breast shadows bilaterally

Often, the chest x-ray of people with asthma can appear normal when they are not having an acute exacerbation.

Arterial blood gases

pH :7.25 PaCO₂ :59 HCO₃⁻ : 25 PaO₂ : 60

PaCO₂ and pH indicate a respiratory acidosis.

The PaCO₂ has increased 19 and no large change in HCO₃⁻ has occurred. The HCO₃⁻ may have increased 2 mEq/L if the patient's HCO₃⁻ was usually 23 mEq/L. Regardless, the HCO₃⁻ is well within the normal range and is consistent with an acute respiratory acidosis.

The PaCO₂ has an increased 19 for a decrease in PaO₂ of 20 to 40 mmHg consistent with hypoventilation and other causes contributing to hypoxemia.

Spirometry and peak expiratory flow rates

Interpret the spirometric values.

This person's FEV₁, FVC, and the PEF_R are reduced compared to the predicted values provided for a sample of healthy people of similar age, gender, and height. A more precise estimate of how abnormal these results are can be determined by calculating the percent-predicted values (see below).

What pattern of lung pathology is shown?

The pattern is consistent with an obstructive pattern because both the FEV₁ and FVC are reduced.

Complete the table and calculate the % Predicted values and the % improvement after bronchodilator administration.

The % predicted values are calculated from: patient's result ÷ predicted value X 100 = % predicted

There is a significant bronchodilator response as shown by large improvement in the FEV₁. The percent change post bronchodilator for the FEV₁ can be calculated from:

$$= (\text{Post} - \text{Pre}) \div \text{Pre} \times 100$$

$$= (3.0 - 1.8) \div 1.8 \times 100 = 67\% \text{ change}$$

A change in the FEV₁ after a bronchodilator of 14% to 15% or more is considered to be clinically significant.

Calculated values for spirometry and peak expiratory flow rate:

	Pre BD(L)	Pred	% Predicted	Post BD(L)	% Improvement
FEV ₁	1.8	3.8L	47	3.0	67
FVC	3.2	4.7	68	4.2	
FEV ₁ /FVC	56%	80%	70	71%	
PEFR	3.81	8.87	43		

Abbreviations: Pre BD: before bronchodilator; Pred: predicted; Post BD: after bronchodilator.

Physical therapy management

What health professionals would you advise this woman to see?

The women should see a physician so that her asthma can be specifically diagnosed and managed optimally from a medical perspective. This could be a general practitioner, pulmonologist, and/or sports medicine physician. The patient may need specific advice on the medications that she is able to take to manage her asthma while she is competing. Some prescription drugs register positively when the athletes are drug tested.

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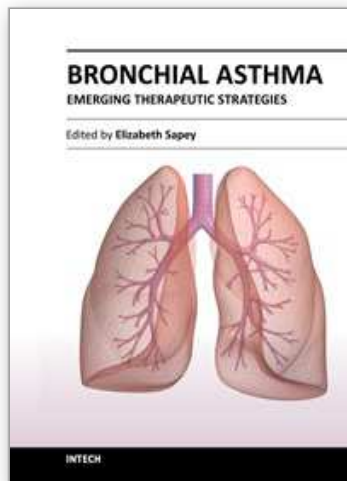
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Bronchial Asthma - Emerging Therapeutic Strategies

Edited by Dr. Elizabeth Sapey

ISBN 978-953-51-0140-6

Hard cover, 260 pages

Publisher InTech

Published online 29, February, 2012

Published in print edition February, 2012

Asthma remains a serious health concern for millions of people globally. Despite continuing research interest, there have been few advancements that impact clinically on patient care, potentially because asthma has been treated as a homogeneous entity, rather than the heterogeneous condition it is. This book introduces cutting-edge research, which targets specific phenotypes of asthma, highlighting the differences that are present within this disease, and the varying approaches that are utilized to understand it.

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