THE EFFECTS OF ENDURANCE EXERCISE PROGRAMME ON THE RESPIRATORY FUNCTION OF ASTHMATIC CHILDREN

BY

ARINOLA OLASUMBO SANYA (MRS.)
B.Sc. Physiotherapy (Ibadan)
M.Ed. Physical & Health Education (Ibadan)

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University of Ibadan
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DEDICATION

To my ROOTS; with gratitude to God for the inspiration and affection therefrom.

ABSTRACT

Bronchial asthma is an obstructive respiratory disorder characterised by recurrent attacks of breathlessness.

Some studies have suggested that the exacerbation of asthma by exercise is probably due to the fact that asthmatics are poor in physical fitness and that small amounts of exertion may produce disproportionate hyperventilation and onset of exercise-induced asthma (EIA). Several studies have shown that regular physical exercise has no adverse effects on the respiratory function of asthmatic children. Rather, it had beneficial effects on their physical and psychological growth. Several researchers have recommended regular physical activities for asthmatic children but with a pre-exercise administration of a bronchodilator drug to suppress the onset of EIA and enable the asthmatic child to exercise safely. The aim of this study was to find out whether asthmatic children can engage in regular physical exercise without the pre-exercise bronchodilator therapy and with no resultant adverse effects on their respiratory function.

Fourteen asthmatic children participated in a graded endurance exercise programme thrice weekly for 12 weeks. Five asthmatic children who did not participate in the exercise served as controls. Forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC) and peak flow rate (PFR) were used as indices of respiratory function.

The mean number of asthmatic attacks three months before the programme was 1.64 $\pm$ 1.5 in the experimental subjects and 2.4 $\pm$ 1.5 in the control subjects. The baseline respiratory function measurements showed that all the subjects were poor in respiratory function when compared to the predicted normal values (PNV) for normal Nigerian children.

None of the subjects developed frank or full blown asthmatic attacks during exercise sessions.

At the end of the programme, t-tests gave significant increases only in the PFR and FEV_1 in the experimental group. None of these showed significant increases in the control group. ANOVA for both groups gave significant F-ratio for only the PFR and FEV_1 in the experimental group. Significant increases in resting

PFR and FEV_1 were observed after 10 and eight weeks of training respectively.

Only the experimental group had significant decrease ($t = -3.135$; $P < 0.01$) in the number of asthmatic attacks during the programme. Absenteeism from school on account of asthma during the programme came to an aggregate of 10 days and 14 days in the experimental and control groups respectively compared to the 56 days and 28 days which were reported three months before the programme.

It was concluded that regular physical exercise training can be tolerated by asthmatic children without a pre-exercise bronchodilator administration if the programme is carefully designed and monitored. The physical conditioning programme had no adverse effects on their respiratory function. Rather, by the end of the programme, the asthmatic children had improved in their respiratory function measurements and their clinical status.

It was recommended that the complete treatment programme for asthmatic children should include physical exercise programme.

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CERTIFICATION

We certify that this work was carried out by Mrs. Arinola Olasumbo Sanya in the Department of Physical and Health Education, University of Ibadan, Ibadan.

(Supervisor)

L. O. Amusa, B.Sc.(U.N.N.), M.P.E. (Springfield), Ed.M. (Columbia), D.P.E. (Springfield),
Senior Lecturer in the Department of Physical and Health Education, University of Ibadan, Ibadan, Nigeria.

21/8/86

(Co-Supervisor)

W. I. Aderele, M.B.,Ch.B. (Leeds), D.C.H., M.R.C.P. (UK), F.W.A.C.P.
Senior Lecturer and Consultant in Paediatrics, College of Medicine, University College Hospital, Ibadan, Nigeria.

DEPARTMENT OF PAEDIATRICS
UNIVERSITY COLLEGE HOSPITAL
IBADAN, NIGERIA.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Bronchial asthma is a chronic respiratory condition which was thought to be common among caucasians but rare among African children (Warrel et al, 1975; Dobbs, 1979). However, the reports by Aderele 1979 and 1982 seem to refute this impression. Aderele (1979) was of the view that asthma is one of the commonest causes of chest diseases in African children. Asthma is primarily an obstructive respiratory condition in which there is impedance to ventilation. It manifests by paroxysmal episodes of dyspnoea, wheezing, cough, increased mucus production and a sense of constriction in the chest (Itkin, 1964).

It is a common clinical observation that exercise is a specific precipitant of asthma (Aderele, 1979; 1982; and 1985; and McNeil, et al, 1966). This can be explained on the basis of increased ventilatory requirements. Greater transpulmonary pressures are required to increase the rate of airflow through the

airways. This makes wheezing pronounced in asthmatics during and after exercise. Several studies (Jones, et al 1962 and 1963; Buston, 1966 and Fisher, et al 1970) have confirmed that exercise induces bronchoconstriction in asthmatic patients. According to Aderele (1979, 1982 and 1985), exercise is one of the commonest precipitants of asthmatic attacks in childhood. This phenomenon, according to Holgate (1983), is due to the fact that asthmatics are poor in physical fitness and even small amounts of exertion may produce disproportionate hyperventilation and therefore, bronchoconstriction.

In the past, physicians, parents, teachers and other members of the society tended to insist on prolonged period of bed rest and a generally low level of physical activities for the asthmatic child (Itkin, 1964). The asthmatic child is often exempted from household chores at home and from physical education sessions at school. He is considered unfit to play games or participate in any strenuous activities, and generally over-pampered. According to Henriksen and Nielsen (1983), exercise induced bronchoconstriction

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and environmental over-protection are reasons why many children with bronchial asthma avoid physical activities. In the same vein, Scherr and Frankel (1958) believed that the combination of over-protection by parents and physical incapacitation due to asthma, can lead to the asthmatic child being deprived of all physical activities. The asthmatic child grows up to see himself as fragile and special; he often grows up to be lazy and unable to withstand normal stresses of life. Due to the fact that the symptoms of acute asthmatic attacks can be troublesome and frightful, the asthmatic child may be physically and emotionally isolated by his peer group. This may result in great mental suffering and loss of much initiative and confidence which should normally aid his personality adjustment to life (Scherr and Frankel, 1958).

There is a tendency for asthmatic patients, particularly children, to subscribe to low level of physical activity for fear of provoking asthmatic attacks. Some studies (Jones et al, 1962 and 1963; Itkin 1964; and Seaton et al, 1969), on the effect of physical exercise on asthma, tend to imply that it is

unsafe to make asthmatics exercise for more than five minutes at a stretch. This is because the respiratory function indices would fall below the resting level and severe exercise-induced bronchoconstriction would ensue. If, however, the respiratory endurance of the asthmatic child can be built up gradually by exercise, then his respiratory function might improve. Several workers (Jones et al, 1962 and 1963; Itkin, 1964; McNeil et al, 1966; Henriksen and Nielsen, 1983 and Holgate 1983), have shown the beneficial effects of regular physical exercise for asthmatics, but have highlighted the problem posed by exercise-induced bronchoconstriction following exercises of more than three to five minutes duration. These workers have therefore, recommended the administration of a bronchodilator drug prior to exercise in order to overcome bronchoconstriction and enable the asthmatic child to exercise safely for longer periods.

1.2 Statement of the Problem

The main aim of this study was to evaluate the effects of graduated general conditioning or physical

fitness exercise programme of 12-week duration at a frequency of three exercise sessions per week, on the respiratory function of asthmatic children without a pre-exercise administration of a bronchodilator drug.

The specific aims were as follows:

1. To determine the effects of general conditioning exercise programme of 12-week duration at a frequency of three exercise sessions per week on the pre-training values of the ventilatory function variables.
2. To determine the effects of general conditioning exercise programme of 12-week duration at a frequency of three exercise sessions per week on the frequency of asthmatic attacks during the programme.
3. To find out whether asthmatic children could engage in physical exercise on regular basis.
4. To see whether asthmatic children could adjust to and benefit from graduated regular exercise without pre-exercise administration of a bronchodilator drug.

1.3 Hypotheses

1.3.1 General hypothesis

Endurance exercise programme of 12-week duration at a frequency of three exercise sessions per week with no pre-exercise bronchodilator administration would have no significant effect on the respiratory function of asthmatic children.

1.3.2 Specific hypotheses

1. There would be no significant difference between the initial and final pre-bronchodilator values of the forced expiratory volume in the first second (FEV_1) of the asthmatic children following a 12-week endurance exercise programme.
2. There would be no significant difference between the initial and final pre-bronchodilator values of the forced vital capacity (FVC) of asthmatic children following a 12-week endurance exercise programme.
3. There would be no significant difference between the initial and final pre-bronchodilator values of the peak flow rate (PFR) of asthmatic children

following a 12-week endurance exercise programme.

4. There would be no significant difference between the pre- and post-training values of chest expansions of asthmatic children following a 12-week endurance exercise programme.

5. There would be no significant difference between the frequency of asthmatic attacks during the 12 weeks of endurance exercise programme and the 12 weeks pre-programme period.

1.4 Delimitation of Study

The scope of this study was as follows:

1. Selection of subjects was limited to patients who have been diagnosed as having bronchial asthma by a paediatrician, based on the normally used criteria such as a history of at least three attacks of breathlessness, often associated with cough and auscultatory findings of widespread respiratory rhonchi. This was to exclude other respiratory conditions that have some common features with asthma, such as bronchitis, tuberculosis, emphysema and bronchiectasis. To ensure this, subjects were

selected from the Paediatric Asthma and Chest Clinics of the University College Hospital (U.C.H.), Ibadan. Asthmatic children in the mild, moderate and severe groups according to the classification of Aderele (1979) were included in the study as they became available.

2. Only subjects whose asthma was uncomplicated by such respiratory conditions as pulmonary tuberculosis, other childhood diseases of the liver, heart, kidney and blood and any physical, visual or auditory handicap were used.

3. Only subjects between six years and 12 years were included in the study. This is because children below six years might not be able to carry out instructions concerning exercise programme and the assessment of their respiratory functions, while those above 12 years are outside the usual paediatric age group. This age range was also chosen for easy comparison with results of studies on ventilatory functions in normal Nigerian school children by Aderele and Oduwole (1983a) and Oduwole et al (1983).

1.5 Limitations

The limitations encountered in the study were:

1. The number of subjects was few for the following reasons:

   a. The consent to participate in the study was required from both the subjects and their parents. Consent was refused by some parents for fear that the study could make the asthmatic condition of their children worse in spite of assurance and willingness of the asthmatic children to participate. Refusal to give consent was encountered mostly from the fairly well educated parents.

   b. The age range of subjects included in the study greatly limited the number. Aderele (1979) reported that the age at presentation in U.C.H. of children with asthma was from 10 months to 13 years and that 49% of the patients reviewed were less than five years old. Therefore, going by this report (Aderele, 1979), an appreciable number of the asthmatic patients seen at the clinic did not qualify to participate in the

study.

c. Poor and irregular attendance at exercise sessions led to the results of some of the subjects being discarded. This was because they had missed more than half of the exercise sessions and fortnightly reassessment sessions. Their results could not represent the effect of 12 weeks programme. The discarded results further reduced the number of subjects. It was aimed to have about 50 experimental subjects and about 20 controls. However, it was not possible to recruit 70 subjects for eight weeks from two clinics per week. (The Children's Chest Clinics on Mondays and the Children's Asthma Clinics on Thursdays).

2. It was not possible to control what the patients did at home in terms of medication and physical activities which could affect the outcome of this study. The patients were instructed not to carry out the exercises at home but that they should continue with their normal activities of daily living.

3. Since much reliance was placed on parents and patients to give information concerning frequency and severity of asthmatic attacks at home, drugs used and their dosages, types of physical activities at home and other relevant information, it was not possible to fully ascertain whether or not the patients and their parents gave accurate information.

4. Poor and irregular attendance posed a serious problem. This was in spite of all attempts to encourage regular attendance such as offering transport fares and providing refreshments for subjects and parents.

1.6 Significance of Study

Asthmatic children are not often encouraged to participate in physical exercise programme because exercise is believed to make asthma worse. This low level of physical activities has been shown to have adverse effects on the physical and psychological development of the asthmatic child. The outcome of this study will throw more light on the importance of

physical exercises in the management of asthma in children. It will shed light on whether it is necessary in all exercise situations to give a pre-exercise bronchodilator drug to asthmatic children. This is particularly important in view of the economic situation in Nigeria where some essential drugs are scarce and when they are available, they are very expensive. The magnitude of the problem can be appreciated when one considers how many times in a day the asthmatic child finds himself in the mood for exercise. Will he require a pre-exercise bronchodilator each time? Or does he abstain totally from physical exercise? The outcome of this study will also shed light on the minimum duration of training required to attain improved respiratory function measurements in the asthmatic children. The outcome of this study will be particularly useful to the following people:

1. The doctor, especially the paediatrician, who would be able to apply the outcome of the study to take a decision on the safety of exercise therapy for asthmatic patients. He will be able to decide whether general conditioning exercises

prescribed for the asthmatics on continuous basis can improve their respiratory efficiency and make them better prepared for stress and able to lead normal lives.

2. The physical therapist; who will be able to decide with more confidence, the extent to which he can work up the asthmatic child in a rehabilitation exercise programme either as a routine or as part of a programme for an asthmatic child with other presentation on referral. He will be able to decide whether he can use general conditioning exercises to improve the lot of the asthmatics in terms of frequency and severity of attacks and the extent of airway obstruction between and during attacks.

3. The physical educator; especially the classroom teacher, who will have more knowledge about asthma and physical activities and thus make appropriate decisions about the asthmatic child and school physical education activities.

4. The parents and guardians of the asthmatic child who with a better knowledge of the scope of the

asthmatic child from the point of view of physical activities, can help him to grow into a physically and psychologically fit adult.

5. The asthmatic patient himself who would know and understand himself better as far as his condition is concerned, he will be able to know his own limit of physical activities based on his experience and not on his fears.

1.7 Definition of Terms

The following terms are defined as they are used in this study:

Initial Pre-bronchodilator Value

This refers to all the measurements taken as part of the initial assessment of the subject before the administration of the bronchodilator drug.

Initial Post-bronchodilator Value

This refers to all the measurements taken as part of the initial assessment of the subject after the administrationof the bronchodilator drug.

Final Pre-bronchodilator Value

This refers to all the measurements taken at the

end of the 12 weeks of endurance exercise programme as part of the final assessment of the subjects before the administration of the bronchodilator drug.

Final Post-Bronchodilator Value

This refers to all the measurements taken at the end of the 12 weeks of endurance exercise programme as part of the final assessment of the subjects after the administration of the bronchodilator drug.

Ventilatory Variables

These refer to the measurements of the FEV_1, FVC, PFR, respiratory rate and chest expansion at the three levels (apical, lateral costal and diaphragmatic).

Respiratory Function

This refers to the total mechanism of ventilation whereby air is drawn into the lungs and expelled. It includes the function of the thoracic cage, the respiratory muscles, the respiratory tract and the lungs. In this study, respiratory function was assessed by timed vital capacity (FEV_1 and FVC), flow rate of expired air through the respiratory tracts (PFR) and movement of the thoracic cage during respiratory excursions (chest expansions at apical, lateral costal and diaphragmatic levels.

Normal Subjects/Children

This refers to non-asthmatic children who are apparently healthy and who have no personal or family history of acute or chronic cough and breathlessness or clinical evidence of respiratory, cardiac or other major systemic illness.

Predicted Normal Values (PNV)

These are already determined values of the respiratory functions of normal (free from any respiratory diseases) Nigerian children between the ages of four and 18 years. For the purpose of this study, predicted normal values of PFR, FEV_1 and FVC for each subject were estimated using the values obtained by Aderele and Oduwole (1983a) and Oduwole et al (1983). (See Appendices B6 and B7).

CHAPTER 2

REVIEW OF LITERATURE

2.1 Definition and clinical features of asthma

The word "asthma" is a Greek derivation which signifies "panting". The earliest use of the word was traced to Hypocrates (460-370 B.C.) who used it to describe episodic shortness of breath (Scadding, 1976).

The American Thoracic Society (1962) defined bronchial asthma as a disease of the respiratory passage characterised by dyspnoea of an obstructive type which is predominantly expiratory, partially reversible and of varying severity and duration. Herxheimer (1975) described bronchial asthma as a tendency to transient attacks of dyspnoea by bronchial obstruction which may occur at any time of the day or night but most usually in the evening, during the night or early in the morning. Also, that the obstruction may be brought about by spasm of the bronchial muscles or by oedema of the mucosa or by mucus secreted into the bronchial lumen or by any combination of these three factors.

Aderele (1985) defined asthma as a respiratory disorder characterised by recurrent attacks of breathlessness due to bronchospasm and obstructive secretion.

According to Itkin (1964), it is preferable to consider asthma as a chronic diffusely obstructive disease of the bronchial tree made manifest by paroxysmal episodes of dyspnoea, wheezing, cough, increase mucus production and a sense of constriction within the chest. The characteristic symptoms of asthma are wheezing, laboured breathing with prolonged expiration, a tight and dry cough with viscid sputum, (Thurlbeck, et al, (1970); Aas, 1972).

The disease may occur in acute attacks with free intervals lasting from a few hours up to several years, or it may occur in chronic form in which the patient is constantly combating bronchial obstruction with severe acute exacerbations. The disease may be so mild that it hardly affects normal function of life or it may develop into an unbearable menace with

continuous respiratory embarrassment and incapacitation (Aas, 1969; Swineford, 1973). The acute attack may be of short duration or it may be extremely prolonged; it may even lead to death due to lack of oxygen ((Aas,1972).

Apart from the airway obstruction which is characteristic of asthma, restrictive dimensions get added to the problem as the condition becomes more chronic. During the acute phase of asthma, due to the severe obstruction (more pronounced during expiration), the chest still remains in an inflated inspiratory position at the end of expiration. With each added inspiration, the magnitude of the change tends to increase (Itkin, 1964). With subsequent attacks particularly in childhood, the result of the above is that pressure changes within the thorax tend to bring about bony and cartilagenous distortions which make up the typical chest deformities of the asthmatic patient. The deformities according to Itkin (1964) include the sternum becoming prominent, the ribs assuming more horizontal position, the anterioposterior diameter becoming equal to or greater than the lateral diameter, giving the typical "barrel" chest deformity in asthma. There is a tendency

for the shoulders to become elevated and for kyphosis of the spine to become greatly exaggerated. These changes do not become fixed until after a number of attacks, particularly those occurring in childhood.

Other clinical features of asthma which are not necessarily peculiar to asthma alone include breathlessness on exercise (McNeil, et al, 1966; Jones, 1976 and Herxheimer, 1975) and reduced lung function (in terms of lung volumes) during an acute attack or in the asymptomatic phase in chronic cases.

The aetiological and precipitating factors in bronchial asthma include allergy (specific foods, animal epidermis, atmospheric and chemical pollutants), heredity, infection, emotion or psychological factors (Cohen, 1971 and 1977; Vavra et al, 1971) and physical exercise (Femi-Pearse, 1974; Arsdel, 1976; Jones, 1976; and Aderele, 1982). Two studies on childhood asthma in Nigeria (Aderele, 1979) and 1982) have shown exercise to be the most prominent precipitant of asthmatic attacks. In the study of the aetiological and precipitating

factors in bronchial asthma in 380 children, Aderele (1982) observed exercise to be the precipitating factor in 171 (45%) of the cases. In an earlier study, Aderele (1979) reported that 60 (30%) out of 200 cases in the study presented with exercise as the precipitant of asthma.

The exact incidence of bronchial asthma in many parts of the tropics is unknown (Aderele, 1985). However, bronchial asthma is reported to be one of the commonest causes of chest disorders in African children (Aderele, 1985). Sofowora (1970) estimated an incidence of 2.4 per cent in Nigerians. According to Femi-Pearse (1974), there were about one million asthmatics in Nigeria out of an estimated 60 million population and about 42,500 of them in Lagos alone. Aderele (1979, 1981 and 1982) studied 200, 280 and 380 asthmatic children respectively at the Paediateic Asthma Clinics of the University College Hospital (UCH), Ibadan.

2.2 Bronchial response to exercise and exercise-induced asthma (EIA)

2.2.1 Bronchial response of normal subjects to physical exercise

According to Itkin (1964), muscular exercise increases the rate and depth of respiration in the normal healthy individual, it also increase the consumption of oxygen and the rate of diffusion of gases. Itkin (1964) reported further that this increase in pulmonary ventilation occurs without changes in the expiratory volumes such as PFR, FEV_1 and FVC.

2.2.2 Bronchial response of asthmatic subjects to physical exercise

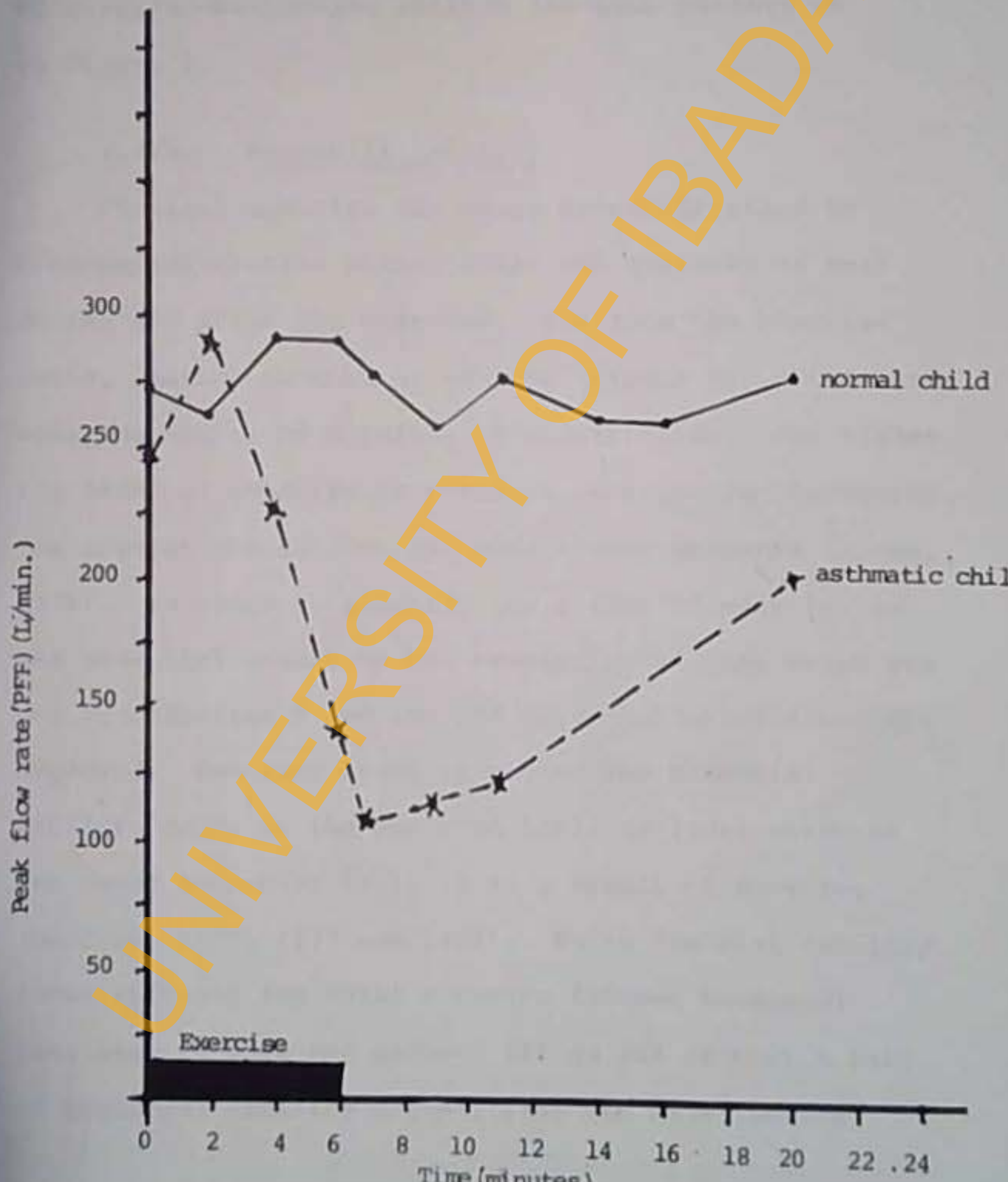
According to McNeil et al (1966), it is a common clinical observation that exercise makes asthma worse. Jones et al (1962 and 1963) and Femi-Pearse (1974) also agreed with this. Cotes (1963), McNeil et al (1966) and Seaton et al (1969) explained this observation on the basis of increased ventilatory requirements. Increase in airways resistance of some degree after exercise can be observed in a high proportion of patients

with asthma of extrinsic or intrinsic types (Scadding, 1976). When the increased airway resistance gets to a level when the symptoms of asthma are induced, the condition is referred to as exercise-induced asthma (EIA) (Scadding, 1976).

According to Godfrey (1977), EIA was first described over 300 years ago by Sir John Floyer who observed that "all violent exercise makes the asthmatic to breath short". From then on, many investigators (Aderele, 1979 and 1982; McNeil et al, 1966; Jones, 1976 and Femi-Pearse, 1974) have noted exercise as a potential cause of wheezing in their asthmatic patients. Based on the outcome of studies, Godfrey (1981) defined EIA as a post-exercise fall in PFR of greater than 10 per cent. In another report by Godfrey (1977), the typical pattern of response to exercise in an asthmatic child as it differed from healthy normal child of similar size is as shown in Figure 1. Both children were well at the time of the study and both had PFR within normal range. They both went through a six-minute running on a treadmill. In the healthy child, there was a little random oscillation of PFR during and after

the exercise but no significant change. By contrast, in the asthmatic child, the PFR rose for the first two minutes of running, then it began to fall sharply and reached its lowest point at one minute after stopping the exercise when it had fallen by 57 per cent. The PFR slowly rose towards the base line over the next 20 minutes.

Godfrey (1981) found a similar pattern of response in another related study. He was able to illustrate the changes in FEV_1 in an asthmatic child in response to a six minute treadmill running. He observed that it was rare for the onset of EIA to curtail the completion of the test; when and if EIA set in at all during the test, it was a mild one. However, the major broncho-constriction and fall in FEV_1 appeared after the exercise had been stopped. The fall in FEV_1 reached its most severe level about two to three minutes post exercise, it then rose back gradually towards the resting level. According to Godfrey (1977), depending on the degree of fall in FEV_1, it is the post-exercise bronchoconstriction that is the EIA itself. The lung function index (FEV_1 or PFR) used to document the change



caused by exercise does not matter. All the indices of airways obstruction reflect the same pattern as in Figure 1.

2.2.3 Bronchial lability

Physical exercise may cause bronchodilation or bronchoconstriction either after the exercise or both during and after the exercise. The form the exercise takes, whether running or walking (Figure 2), can determine the degree of dilation or constriction. The higher the level of exercise in terms of duration and intensity, the greater the dilator and constrictor response (Jones, 1976). In order to quantify the effect of exercise on the bronchial status of the asthmatic, indices which sum the bronchodilator and the EIA (bronchoconstriction) are employed. One such index is called the Bronchial Lability Index or the Exercise Lability Index which is the total bronchial lability as a result of exercise (Godfrey, 1975, 1977 and 1981). While exercise lability index reflects the total exercise induced bronchial lability, it does not reflect EIA as EIA is only a part of bronchial lability (Jones, 1966 and 1976; Godfrey,

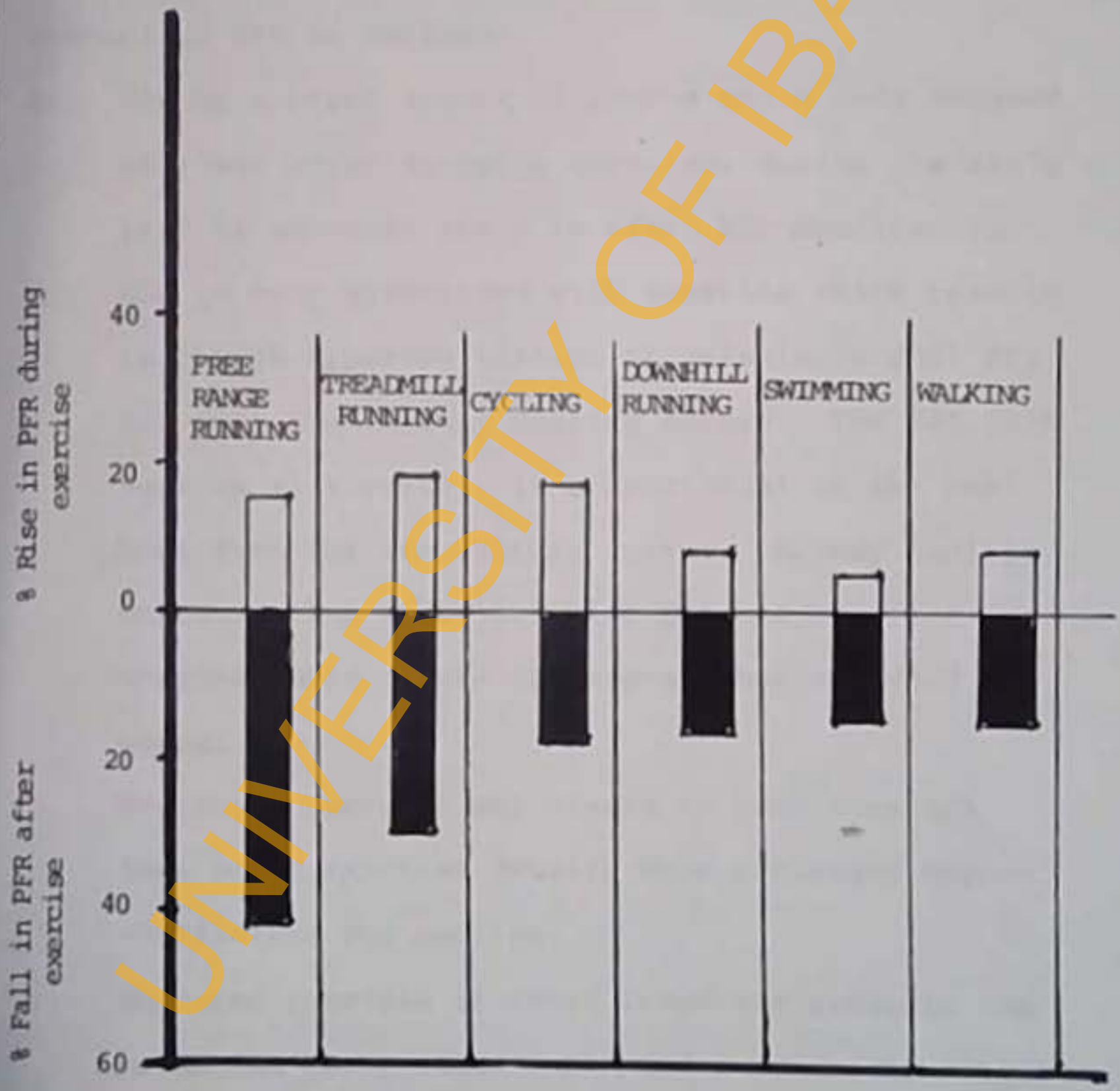


Figure 2: Effect of type of exercise on the response of asthmatic children to exercise (Godfrey, 1977).

1976, 1977 and 1981).

2.2.4 Mechanism of EIA and bronchial lability

In order to make understanding of the mechanism of EIA and bronchial lability simple, Godfrey (1981) summarised EIA as follows:

1. EIA is a brief attack of asthma which only becomes manifest after stopping exercise; during the early part of exercise there is often bronchodilation.
2. EIA is only associated with exercise which results in enough hyperventilation of relatively cool dry air such that airway cooling occurs. The EIA that sets in as a result, is proportional to the heat lost from the respiratory system. Airway cooling occurs during exercise while EIA occurs after exercise when airway temperature has returned to normal.
3. Prolonged exercise may result in much less EIA than brief exercise despite more prolonged hyperventilation and cooling.
4. Repeated exercise at short intervals exhausts the mechanism for producing EIA and renders the subjects

refractory to EIA. The subject is not however, refractory to antigen-induced asthma.

5. The drug cromolyn sodium has a protective effect on EIA when given before exercise. It does not inhibit the onset of EIA when given immediately after exercise even if it is before the onset of any significant bronchoconstriction. While corticosteroids do not inhibit EIA whether given before or after exercise.

6. Late reaction or delayed reaction has not been reported for EIA.

According to Jones (1976), the sequence of dilation followed by constriction on exercise in the asthmatic, suggests that two mechanisms are operating with opposing effects. The effect on the bronchiole during exercise depends on which of the two mechanisms is dominant. Though the cause of each of these mechanisms is not known precisely. Jones (1976) suggested that the early bronchodilation could be due to catecholamine release on exercise while hyperventilation (Fisher et al, 1970), metabolic acidosis (Seaton et al, 1969 and Widdicombe et al, 1962) and a release of a constrictor substance

during exercise (Kerr et al, 1970) are possible causes of bronchoconstriction.

According to Holgate (1983), the precipitating event in exercise-induced bronchoconstriction is cooling of the airway mucosa during humidification of inspired air. Weinstein et al (1976), Bar-Or et al (1977) and Chen and Horton (1977) noted from their studies that breathing humid air attenuated EIA. They noticed that exercise in warm humid atmosphere, produces less bronchoconstriction than exercise performed in cold, dry conditions. They used this to explain the low asthmagenicity of swimming; that EIA occurs more frequently in runners than in swimmers doing the same amount of work.

Anderson (1984) contended that the initiating event in EIA might be the loss of water and not the loss of heat from the airway.

From all these different views on the mechanism of EIA, there are some areas of agreement which are of clinical importance. It is generally agreed that physical exercise is a precipitating factor of asthma, even in asthmatic patients who are in clinical remission.

It is also generally agreed that the severity of EIA can be manipulated by the appropriate choice of type, duration and intensity of exercise.

2.2.5 Effects of type, duration and level of exercise on EIA and bronchial lability

According to Sly (1970) and Godfrey (1977), the type, severity and duration of exercise influence the incidence and the degree of EIA. Godfrey (1977) contended that some types of exercise can be tolerated by the asthmatics, particularly swimming, in which Olympic Gold Medals have been won by asthmatics.

Jones (1976), Silverman and Anderson (1972) and Anderson et al (1971 and 1975) have reported that different types or nature of exercise evoke the constrictor response in bronchial lability (EIA) to varying degree. Jones (1976) reported that walking, swimming, stepping, running up and down the stairs, bicycle ergometry, treadmill running and running on a flat surface evoke the constrictor response in ascending order of potency from walking to running on a flat surface. If an unsuitable type of exercise is used, an asthmatic patient

might fail to demonstrate the typical post exercise bronchoconstriction (Jones et al, 1963).

Godfrey (1975 and 1977) and Fitch and Morton (1971) in their studies, carried out series of exercise tests in which they used different types of exercise on asthmatics. Their results were similar to those of other workers (Silverman and Anderson, 1972; Anderson et al, 1971 and Jones, 1976). In each of the exercise tests, the subjects exercised at the same level of oxygen consumption and for a standard six-minute period, such that the exercises were comparable from the metabolic point of view. Fitch and Morton (1971) found that free-range running around the hospital grounds or the corridor was most potent asthmagenic stimulus resulting in 47 per cent fall in PFR post exercise. Treadmill running caused about 33 per cent fall in PFR, cycling caused 25 per cent fall in PFR while swimming and walking caused the least EIA with post exercise fall of between 13 per cent and 15 per cent (Figure 2).

Variations in duration of exercise affect the onset and severity of EIA. Jones et al, (1962)

reported the effect of exercises of long and short durations on the FEV_1 of 34 asthmatic children. Following exercise of short duration (one minute or brief exercise) there was an increase in FEV_1 (broncho-dilation) in all the subjects although the change was small in most of them. The peak increase was reached in 24 subjects during the first minute post exercise and in the remainder, one to five minutes post exercise. Twenty subjects returned to their resting level of FEV_1 within five minutes and the others from six to 39 minutes. There was no EIA or EIB (exercise induced bronchoconstriction) from this duration of exercise. Following exercise of long duration (five to 10 minutes), the FEV_1 increased slightly during the early part of the exercise. Immediately after exercise, FEV_1 was above or near to the resting level in some subjects while in others, there was a pronounced post-exercise fall. The maximum post-exercise fall in FEV_1 occurred between one and five minutes when it was 75 per cent of resting level. After this point, the FEV_1 rose sharply in all the children and stabilised near the resting value between 10 and 15 minutes.

Exercise lasting up to 16 minutes produced less bronchoconstriction than exercise lasting six to eight minutes (Silverman and Anderson, 1972). Godfrey (1977) reported that brief exercise even if it is quite strenuous does not usually give much trouble and that intermittent exercise is usually well tolerated by the asthmatics. He further reported that the worst types of exercise for the asthmatics are those that last for six to eight minutes such as middle distance running. Longer and more strenuous exercise such as cross country running was found to be well tolerated by asthmatic patients. (Figure 3). The result of the study by Mahler et al (1981) were similar to those obtained by Godfrey (1977).

The intensity or level of exercise also affects the onset and severity of EIA. According to Fisher et al (1970), there is an increase in airway resistance and a decrease in maximal expiratory flow after strenuous exertion in some patients with asthma. Silverman and Anderson (1972) found that increasing the work load by changing the gradient of the treadmill, caused an increase in the amount of bronchoconstriction; there was

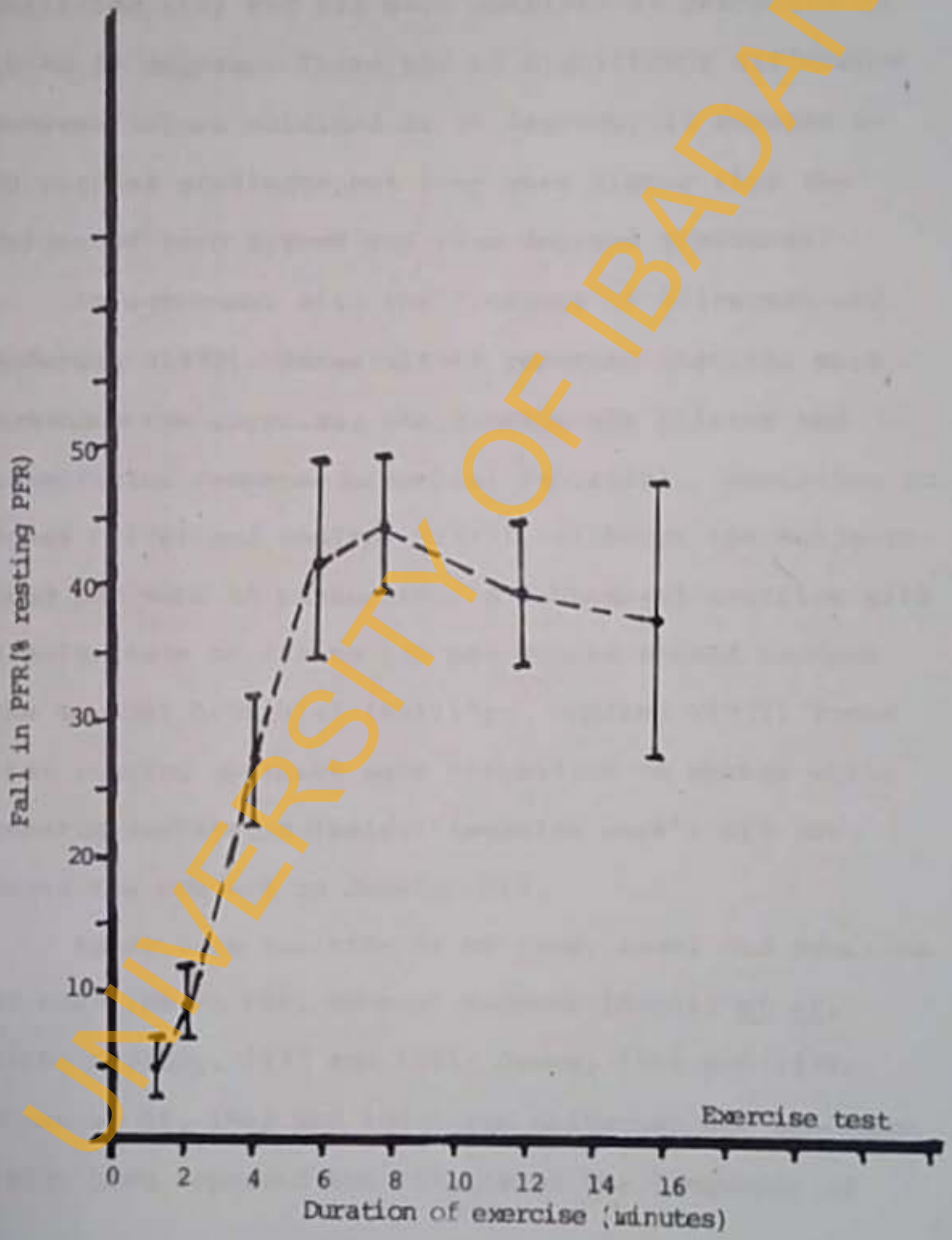


Figure 3: Effect of duration of exercise on exercise-induced asthma (EIA) (Godfrey, 1975)

a higher bronchial lability. Maximum value of bronchial lability and EIA were obtained at gradients of 15 to 20 degrees. There was no significant difference between values obtained at 10 degrees, 15 degrees or 20 degrees gradients, but they were higher than the values of zero degree and five degrees gradients.

In agreement with the findings of Silverman and Anderson (1972), Jones (1976) reported that the more strenuous the exercise, the greater the dilator and constrictor response (bronchial lability). According to Jones (1976) and Godfrey (1977), although the subjects need not work to exhaustion, a submaximal exercise with a pulse rate of 180 to 190 per minute should produce the maximal bronchial lability. Godfrey (1977) found that running upstairs made asthmatics to wheeze while running downstairs (being "negative work") did not cause the subject to develop EIA.

Apart from the effects of type, level and duration of exercise on EIA, several workers (McNeil et al, 1966; Godfrey, 1977 and 1981; Jones, 1966 and 1976; Jones et al, 1962 and 1963; and Silverman and Anderson, 1972) have reported the effects of the frequency of

exercise tests within a short period on EIA and bronchial lability. The workers found that repeated exercise tests within a relatively short period or intermittent exercise tests of constant duration and intensity have a diminishing effect on EIA and bronchial lability. Jones et al (1963) observed that exercise in the form of short bouts, is more suitable for asthmatics than prolonged continuous exercise even when this is at a level that would not make the subject unduly breathless.

2.2.6 Effects of drug on EIA

EIA is a good model of clinical asthma in many respect. For this reason, EIA has been used to study the effects of various pharmacological agents both from the therapeutic point of view and for the light such studies can shed on the pathogenesis of asthma (Godfrey, 1977). Godfrey (1975, 1977 and 1981), and Jones et al (1963) have suggested the use of exercise tests to evaluate the efficacy of drugs used in the management of asthmatic patients. Drugs, according to Jones et al (1962) and Godfrey (1981) have been used to either

suppress, abolish or cause exacerbation of EIA.

Jones et al (1962 and 1963) reported that the effect of exercise on the respiratory function of asthmatic patient can be modified by bronchodilator drugs in two ways: Exercises lasting less than 2 minutes preceded by a bronchodilator drug, produced a greater increase in FEV_1 than exercise alone. Broncho-dilator before exercise lasting from five to 10 minutes reduced or abolished fall in FEV_1. They recommended the pre-exercise use of bronchodilator like isoprenalin sulphate, adrenalin or noradrenaline.

While all sympathomimetic drugs are effective in the protection of the asthmatic subject from EIA, the selective beta stimulants such as salbutamol, orci-prenaline and terbutaline are more appropriate prior to exercise than those drugs which cause tachycardia such as isoprenaline and adrenalin (Godfrey, 1977). On the other hand, Sly (1984) and Godfrey (1977) advocated the use of salbutamol aerosol as prophylactic agent for the patient or asthmatic athlete who is troubled clinically by EIA. This is due to its bronchodilating efficiency, rapid onset of action, prolonged effect,

relative lack of adverse effects and convenience; the aerosol should be inhaled before starting exercise.

In a study of clinical pharmacology of oral and inhaled salbutamol, Walker et al (1972) found that FEV_1 rose within 10 minutes of inhalation while peak rise in FEV_1 was seen between one and three hours after an oral dose in six subjects.

Several studies (Godfrey, 1977 and 1981; Jones et al, 1963; Jones, 1976; Silverman and Anderson, 1972; McNeil et al, 1966; Fisher et al, 1970; Sly, 1984; Orenstein and Reed, 1984) recommended a pre-exercise administration of a bronchodilator to suppress the onset of EIA which might not allow the asthmatic to exercise safely and for a long time.

An international symposium on the special problems and management of allergic athletes held in 1984, was necessitated by the fact that 1984 was an Olympic year and because individuals with allergic diseases often compete at a disadvantage in athletics. Not only do such athletes have disability associated with the disease but they are deprived the use of a large number of drugs particularly if they are competing at

international level such as the Olympics (Godfrey, 1984). For example, theophylline derivatives have been shown to be effective in inhibiting EIA in about 80 per cent of individuals tested. They can therefore be administered to asthmatic athletes prior to their events in order to prevent the onset of EIA during competition. However, it is known that theophylline improves muscle contractility, it may also prevent development of fatigue not only of the respiratory muscles but also of other skeletal muscles (Ellis, 1984). If theophylline is administered to an asthmatic athlete prior to his event, the effect of the drug, while inhibiting EIA, will put him at a performance advantage. This constitutes ergogenic aid as defined by Fox and Matthews (1981). In view of this, Ellis (1984) recommended inclusion of theophylline derivatives in the list of drugs banned for use in international sports.

2.2.7 Effects of physical training on EIA

The effect of physical training or physical conditioning on EIA depends on the factors discussed

earlier. The onset and severity of EIA as a result of general conditioning exercise programme would depend on the duration of the exercises in the programme, the level or intensity of exercise, the type of exercise, whether the exercise is intermittent or continuous and whether or not there is pre-exercise administration of a bronchodilator. (Jones, 1976; Jones et al, 1962 and 1963; Godfrey, 1977 and 1981).

Physical training will not provoke severe EIA if the duration of exercises in the training programme is brief or lasts more than 12 minutes (Jones et al, 1962 and 1963; Silverman and Anderson, 1972; and Godfrey, 1977 and 1981); if the level is submaximal (Jones, 1976; Godfrey, 1977 and 1981); if the nature or type of exercise is non-asthmagenic such as swimming or walking on flat surface (Jones, 1976; and Godfrey 1981 and 1977); if there is a pre-exercise administration of a bronchodilator (Sly 1984; McNeil et al, 1966; and Godfrey, 1977 and 1981); and if the exercise is intermittent (Jones, 1976; and Godfrey, 1977 and 1981).

According to Holgate (1983), exercise itself serves only to increase tidal volume and respiratory rate. It

is not essential to bronchoconstriction. He was of the view that when the effect of exercise on EIA is being considered, it should be noted that asthmatics are in poor physical condition and even small amounts of exercise may produce disproportionate hyperventilation and therefore bronchoconstriction.

2.2.8 Clinical implications of EIA

According to Godfrey (1977), EIA sometimes presents a clinical problem especially in children as it prevents them from taking their desired amount of exercise. Although it is rare that EIA is the only obvious manifestation, asthmatics who develop EIA should be encouraged to carry on with most exercises since the type of exercise encountered in everyday life and even in sports, may not be asthmagenic. McNeil et al (1966) and Godfrey (1977) have recommended that asthmatics who develop EIA can participate in intermittent exercises as obtained in football and some types of gymnastics but will not be able to cope with continuous running for up to eight minutes. He also recommended a pre-exercise administration of an

appropriate bronchodilator such as salbutamol, to protect the child from EIA and enable him to exercise safely and with confidence. This is also the stand of the American Academy of Pediatrics (1970).

Another clinical implication of EIA is the use of exercise testing in clinical investigation of an asthmatic (Godfrey, 1975 and 1977). Exercise test can be used to confirm the diagnosis of asthma in a patient who is clinically fit at the time of initial examination; it will thus serve to differentiate asthma from other respiratory problems (Godfrey, 1975, 1977 and 1981; Jones et al, 1962 and 1963 and Jones, 1976).

With the growing knowledge of the mechanism of EIA and the factors precipitating it, exercise prescription for asthmatics is made easier, bearing in mind the safety of the patients. There is conclusive evidence from the reports of several studies (Peterson and McElhenny, 1965; Graff-Lonnevig et al, 1980; Henriksen and Nielsen, 1983; Strick, 1969; and Scherr and Frankel, 1958) that asthmatic children can derive a lot of physical and psychological benefits from taking regular physical exercise. Asthmatics should exercise regularly

in spite of EIA, provided the precipitating factors are avoided in the course of exercise prescription. Godfrey (1984), while reviewing the contributions to the symposium on the special problems and the management of allergic athletes, noted with delight that eight and 10 per cent of the Australian Olympic Team were asthmatic in the 1976 and 1980 Olympics respectively, and that slightly more than half of them were swimmers. The asthmatic athletes must have been encouraged to swim as it is known that swimming has about the lowest asthmagenicity of the various sports and exercises.

2.3 Effects of asthma on the physical and psychological growth of a child

According to Graff-Lonnevig et al (1980), children with bronchial asthma are afraid of developing EIA while their parents and teachers compound their fears by being overprotective. As a result, there is lowering of the working capacity of asthmatic children. They find it difficult to keep up with healthy children in their physical and psychological growth. The effect

is that this may lead to social isolation of the asthmatics. They lose self-confidence and develop the feeling of being the "loser".

All the 28 children in the study of Henriksen and Nielsen (1983) were found to be poor in physical fitness. These workers implied that asthma disturbs the physical and psychological development of the asthmatic child. Sly (1976) reported a psychological consequence of inactivity on asthmatic subjects.

Aderele (1981) on the other hand, concluded from a study of the physical growth of Nigerian children with bronchial asthma that, asthma on its own, is not a usual cause of severe growth retardation in childhood. He was of the view that the observed differences in the growth indices of the subjects could be primarily genetic and socio-economic rather than being due solely to the severity and the duration of asthma.

Gershwin (1981) reported that during a United States National Survey, asthma was found to be the most frequent cause of absence from school and work. Peterson and McElhenny (1965) had earlier reported that the 20 boys studied by them missed an aggregate of 185

school days in the school year before the study. Peterson and McElhenny (1965) were of the view that the presence of asthma which is a chronic and disabling ailment, creates in a child psychological, physical and emotional disturbance.

During the psychological assessment of the subjects in their study, Peterson and McElhenny (1965) found most of the children to be emotionally immature and sub-standard as far as their capacity for physical activity was concerned.

According to Scherr and Frankel (1958), the combination of over protection by parents and physical incapacitation due to asthma can frequently lead to the asthmatic child being deprived of all physical activities. This, they contended, may lead to great mental suffering and loss of initiative and confidence which the asthmatic needs, to aid his personality adjustment to life. The deficient personality adjustment to life may cause the asthmatic child to suffer behavioural and personality disorders. He may become unmanageable, irritable and dependent on others. At the other extreme, he may become aggressive, hostile, demanding,

bullying his parents and other children around. He feels that he must compete with non-asthmatic children and where he is unable to do this successfully, he becomes more of a problem in his management. Strick (1969) suggested that asthmatics are deprived of the physical and psychological benefits of general conditioning exercises as a result of their ailment, while Holgate (1983) was of the view that asthmatics are poor in physical condition and due to the frightening and troublesome nature of asthmatic symptoms, they may be isolated by their peer groups.

2.4 Respiratory function tests

According to Jones (1976), asthma has an unusual property of impaired ventilatory function. At the same time, asthma causes fluctuations in the level of respiratory function over the period of time the attack lasts.

The most important and most easily performed pulmonary function test is to assess the respiratory organs and their ability to ventilate (Garbe, 1978). According to Garbe (1978), the main function of respiration

is the supply of oxygen to all tissues of the body and the subsequent removal of carbon dioxide (CO_2) which is a waste product of metabolism. Any impairment of this function as is found in bronchial asthma, is significant and may have serious consequences.

According to Aderele and Oduwole (1983b), most respiratory problems in childhood can be diagnosed and managed without pulmonary function tests; the tests however, add objective parameters to observable clinical phenomena. The tests reveal defects in some aspects of lung function which are not accessible to routine clinical methods of examination.

2.4.1 Spirometric indices of ventilation (Dynamic lung volumes and airflow)

Spirometry is the most usual screening test of ventilation. It is the procedure commonly referred to as "pulmonary function test" (Francis, 1978). According to McFadden et al (1973), the spirometric assessment is either the absolute volume expired in a given time such as FEV_1 and FVC or rate of change of volume with time or flow rate such as PFR and maximum expiratory flow

rate (MEFR). Jones (1976) described FVC as VC measured during forced expiratory effort. The FVC is the maximum volume of air that can be expelled as rapidly and completely as possible after maximum inspiratory effort (Garbe, 1978). According to Itkin (1964), that portion of FVC which is expired by the end of the first second is called forced expiratory volume in the first second (FEV_1). FEV_1 is a measure of timed VC and it is the most commonly used measure of timed VC. FEV_1 is a measure of FVC in a given time just as FEV_2 and $FEV_{0.75}$.

FVC and FEV_1 can be obtained from a single spirometric tracing or spirogram (Figure 4). They are both expressed in litres (Francis, 1978; Garbe, 1978; and Jones, 1976), and they both vary with the anthropometric characteristics of the subject such as age, height, body weight, surface area and sex. (Francis, 1978; Garbe, 1978; Jones, 1976 and Herxheimer, 1975).

Another measure of absolute volume of expired air in a given time is the forced expiratory volume in the first 0.75 seconds ($FEV_{0.75}$). Jones (1976) was of the view that $FEV_{0.75}$ is a better index for children because

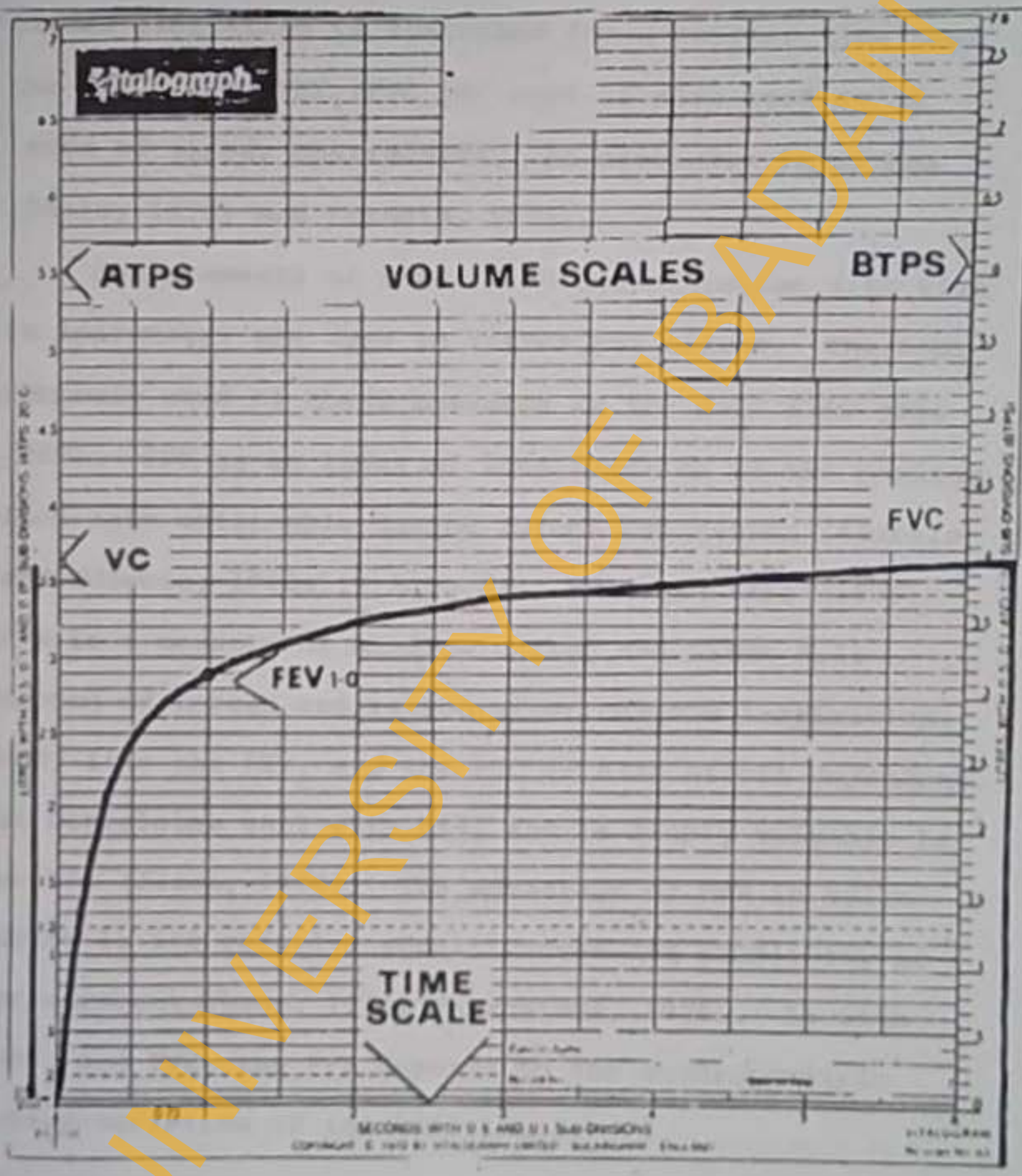


Figure 4: Forced expiratory spirogram (Garbe, 1978).

forced expiration is sustained for a shorter time than the FEV_1. The FEV_1/FVC per cent is also used as an index of airway obstruction. It decreases in asthma (Jones, 1976; and Francis, 1978).

Measurements of rate of change of volume with time in spirometry are done in litres per minute. The most commonly used of these measures is the peak flow rate (PFR). PFR as an index of lung function is the maximum flow rate attainable during forced expiration (Aderele and Oduwole, 1983a). According to Herxheimer (1975) PFR is a measure of airflow during the first 0.01 second of forced expiration after maximum inspiration. PFR, like the FEV_1 and the FVC is also effort dependent. It correlates well with FEV_1 and is highly valuable in asthma (Jones, 1976). The advantage of PFR in spirometry is its relative sensitiveness and simplicity of measurement (Jones, 1976; Herxheimer, 1975). As with FEV_1 and FVC, the PFR depends on the anthropometric characteristics of the individual.

2.4.2 Clinical implications of spirometry in lung function test for asthmatic children

The measurements of spirometric indices can be useful in the diagnosis of bronchial asthma and for the differential diagnosis of asthma from other obstructive airway disease such as chronic and wheezy bronchitis and emphysema (Herxheimer, 1975). For example, the FEV_1/FVC per cent which is between 95 and 70 per cent in normal subjects is below 70 per cent in asthma and other obstructive diseases.

In a clinical setting, spirometry is used to detect airway obstruction by the degree of response of the airway to bronchodilator administration (Francis, 1978). Also, spirometry can be used to test the efficiency of drugs used to treat asthma. (Godfrey, 1977, 1981 and 1984; Sly, 1984 and Herxheimer, 1975). Spirometry is useful in the assessment of prognosis in asthma. According to Herxheimer (1975), it is well known from spirometry that lung function is below normal during an acute attack of asthma, it would not however be possible to prove this unless the lung function values before the attack are known.

Aderele and Oduwole (1983b) recommended that pulmonary function tests be performed routinely in all asthmatics during clinical follow-up even when they are in clinical remission. This will make it possible to detect those who have residual bronchial obstruction. The recommendation was based on their findings that a lot of asthmatics during remission have poor pulmonary function.

2.4.3 Measurement and instrumentation in spirometry

(a) Forced expiratory volume in the first second (FEV_1) and forced vital capacity (FVC)

FEV_1 and FVC are usually measured during the same expiration. Their values are determined from forced expiratory spirogram as shown in Figure 4. FEV_1 and FVC are measured using a dry or wet spirometer or gas meter (Herxheimer, 1975). A recording spirometer such as the Vitalograph spirometer is preferable as the values of FEV_1 and FVC can easily be read off from the tracing.

(b) Peak Flow Rate (PFR)

Although PFR can be measured by sophisticated techniques (Jones, 1976), the Wright Peak Flow Meter (Wright and McKerrow, 1959) provides a simple technique of measurement. The Wright Peak Flow Meter is a small and very handy instrument which serves as a welcome supplement to the absolute spirometric examination (Herxheimer, 1975). According to Chiang and Han (1965), the Wright Peak Flow Meter can be used for children below the age of 2½ years. The suitability of the instrument in children was confirmed by the studies of Aderele and Oduwole (1983a) who measured PFR in normal children between ages four years and 16 years. They did not report any difficulty of measurement in children below the age of six years which Oduwole et al (1983) encountered in a similar population during the measurement of FEV_1 and FVC. The studies of Onadeko et al (1984), Murray and Cook (1963), and Aderele and Oduwole (1983b) have reported successful measurement of PFR in children using the Wright Peak Flow Meter.

2.4.4 Merits and demerits of the respiratory function indices

(a) Forced Vital Capacity (FVC) and Forced Expiratory Volume in the first second (FEV_1)

According to Herxheimer (1975), the FVC spirogram can be easily recorded if the patient is cooperative. The major advantage of FEV_1 according to Herxheimer (1975) is its relative simplicity and ease of measurement compared with FVC. This is because forced expiration is sustained for only one second in FEV_1. This accounts for the frequent use of FEV_1 relative to FVC (Jones, 1976; and Herxheimer, 1975).

According to various studies, it would seem that the demerits of FEV_1 and FVC outweigh their merits in clinical use on asthmatics. For example, Jones (1976) has reported that many patients get tired easily during forced expiration for FVC measurement which is not time-dependent.

Herxheimer (1975) noticed that forced expiration from maximum inspiration caused bronchial spasm in the sensitive bronchi of an asthmatic. He concluded that the FVC is an unsatisfactory procedure which is likely to

produce low values in a number of patients. The FEV_1 has a similar disadvantage of being tiring to some subjects, resulting in low values especially with repeated attempts. The harsh expiration pressure as a result of the fast and forcible expiration has been known to cause bronchial obstruction in some subjects. (Herxheimer, 1975).

Nowak et al (1979) observed a difficulty in obtaining a spirogram in some patients in acute asthmatic attacks. They expressed the view that this difficulty of obtaining spirogram in illness, greatly limits the usefulness of spirogram.

The small instrumental dead space of the Vitalograph spirometer makes it possible to obtain a spirogram in children provided the instruction is well understood. The studies of Oduwole et al (1983) and Onadeko et al (1979) showed that it is possible to obtain spirogram in children. Chiang and Han (1965) however, reported that it is impossible to obtain a satisfactory spirometric tracing in children below the age of five years. The difficulty encountered by Oduwole et al (1983) in their study seemed to confirm

produce low values in a number of patients. The FEV_1 has a similar disadvantage of being tiring to some subjects, resulting in low values especially with repeated attempts. The harsh expiration pressure as a result of the fast and forcible expiration has been known to cause bronchial obstruction in some subjects. (Herxheimer, 1975).

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the report of Chiang and Han (1965). The number of subjects below the age of six years in the study of Oduwole et al (1983) was very few because of the difficulty in getting this age group to perform the test satisfactorily. The children either did not expire forcefully or they were unable to sustain the forceful expiration beyond the one second point. As a result, Oduwole et al (1983) were only able to record FVC and FEV_1 in 14 per cent of the subjects below six years. From this report, the suitability of FEV_1 and FVC as respiratory function tests in normal children was doubtful below age six years. One would conclude that with ill or asthmatic children, the difficulty will be aggravated.

Another demerit of FVC and FEV_1 as measures of respiratory function is the dependence of the measuring instrument such as the Vitalograph Spirometer on electricity supply. This greatly limits the use of the spirometer in a situation where electricity supply is not available or where it is inconsistent.

(b) Peak Flow Rate (PFR)

The main merit of PFR which makes it the method of

choice in clinical monitoring in the hospital and at home, is its simplicity of measurement (Herxheimer, 1975; Jones, 1976; Chiang and Han, 1965; Aderele and Oduwole, 1983a and 1983b; Onadeko et al, 1984; Murray and Cook, 1963; and Wright and McKerrow, 1959).

According to Onadeko et al (1984), measurement of PFR is used to assess respiratory function in clinical practice particularly in young children who might not cooperate adequately when a spirometer is used to study their lung function. PFR measurement can be tolerated by the younger children because the forced expiration is sustained for only 10 milliseconds. Unlike the FEV_1 and FVC measurements, Chiang and Han (1965), concluded from their study that the peak flow meter is a very useful instrument for paediatric practice. According to Rosenblatt et al (1963), the peak flow meter has the advantage of being portable, small in size and relatively easy to use even by extremely ill patients. This is why the Wright Peak Flow Meter is useful for the screening of obstructive pulmonary diseases.

The special clinical advantage of the peak flow

meter is its independence of electricity supply (Wright and McKerrow, 1959). This makes it particularly useful in field testing and for home monitoring of patients. The subject himself or the parents can be easily taught to use the peak flow meter at home.

2.4.5 Predicted Normal Values (PNV)

The values obtained from pulmonary function tests can only be accurately interpreted if they are compared to the values obtained from normal subjects.

According to Francis (1978), predicted normal values (PNV) are based on values from normograms in which the mean values obtained from large groups of healthy or normal people are varied with their height, weight, age, body surface and sex.

As much as possible, the normogram for prediction should be obtained from a population which is similar to that of the study. The most important similarity is racial similarity between the study group and the prediction (normal) group (Onadeko et al, 1979 and 1984; Aderele and Oduwole, 1983a and 1983b; and Oduwole et al, 1983). According to Onadeko et al

(1984), it is unsatisfactory to use the PNV of caucasian children for studies on African ((negroid) children as the values are known to differ in the racial groups. There are ventilatory function studies on normal subjects in a number of racial groups which can now be used to obtain PNV in studies on asthma and other obstructive disease conditions. Such studies in children include the reports of Oduwole et al (1983); Aderele and Oduwole (1983a); Onadeko et al (1979 and 1984); Murray and Cook (1963); and Chiang and Han (1965). The studies of Aderele and Oduwole (1983a) and Oduwole et al (1983) were on normal Nigerian children of Yoruba origin who lived at Ibadan (See Appendices B6 and B7). The boys and girls in the studies were aged between 4½ years and 16 years. The studies by Onadeko et al (1979 and 1984) involved normal Nigerian school children of Yoruba origin who lived in Ibadan and were between the ages of seven years and 18 years.

The importance of PNV in studies on asthma is that it gives basis for the comparison of value obtained from the subject to what it should be; this gives some

indication of the degree of obstruction.

2.5 Physical treatment of asthma

According to Haas et al (1976) physical conditioning is paramount in a well balanced rehabilitation programme for asthmatics. It ensures proper continuation of physical and mental health developmental processes. They were of the view that physical conditioning and breathing exercises are particularly important in children who are kept away from exercise by their parents for fear of EIA. Several other studies (Fein and Cox, 1955; Scherr and Frankel, 1958; Buston, 1966; Peterson and McElhenny, 1965; Hyde and Swarts, 1968; Strick, 1969; Holgate, 1983; Fitch et al, 1976; Graff-Lonnevig et al, 1980; and Henriksen and Nielsen,1983) have reported the beneficial effects of physical exercises on the asthmatic children.

From the principle of treatment outlined by Swineford (1973), physical exercise would feature in both the specific and symptomatic treatments oi asthma. Avoidance of physical exercise constitutes specific treatment of asthma in patients with the tendency for

severe EIA on slight provocation. Several studies (Godfrey, 1975, 1977, 1981 and 1984; Jones, 1966 and 1976; Jones et al, 1962 and 1963; McNeil et al, 1966; Anderson 1984; and Silverman and Anderson, 1972) have reported that the occurrence and severity of EIA depend on the duration, level, type and frequency of exercise. Therefore, the specific treatment of EIA is not the total avoidance of physical exercise but the avoidance of specific asthmagenic exercise situations. The benefit derivable from the use of physical exercise as part of the symptomatic treatment of asthma include the balanced development of the physical and mental health of the child with asthma. If the exercise is carefully prescribed, the fear of EIA can be removed.

2.6 Principles of exercise prescription for asthmatic children

According to Nickerson et al (1983), the optimal safe exercise prescription for asthmatic children is controversial. Several studies (Itkin, 1964; Fein and Cox, 1955; Aderele, 1982; Peterson and McElhenny, 1965; Sly, 1976; Holgate, 1983; Henriksen and Nielsen, 1983;

Godfrey, 1984; American Academy of Pediatrics, 1970; and Graff-Lonnevig et al, 1980) have recommended that asthmatic patients should engage in regular physical exercise.

From the studies of Fitch and Morton (1971), Jones (1966 and 1976), Sly (1976), Silverman and Anderson (1972), Anderson et al (1971), Anderson (1972 and 1984), Godfrey (1975, 1977 and 1981), it is known that some forms of exercise situations (type, duration, level) are more asthmagenic than others. While some authors (Fitch and Morton, 1971; Anderson et al, 1971; Silverman and Anderson, 1972; Anderson 1984; and Godfrey, 1984) recommend only forms of exercise that are unlikely to provoke EIA, others (Nickerson et al, 1983; Peterson and McElhenny, 1965 and Itkin, 1964), encouraged any form of exercise.

From all the above cited studies, it can be concluded that asthma could get worse on exercise, that severe EIA is not evoked in all exercise situations and that regular exercise is beneficial to the asthmatic child. Silverman and Anderson (1972) reported that exercise has become an accepted practice in the management

of wheezy children. Therefore, exercise prescription for the asthmatic children should be such that the exercise programme is of appropriate duration that would not provoke severe EIA. It should contain appropriate types of exercise such that the overall effect of exercise will be non-asthmagenic. The intensity of exercise should be submaximal such that peak heart rate during exercise, does not exceed 180 per minute in children. The exercise programme should be in form of intermittent exercises; the frequency should be at least twice weekly for a minimum of six weeks for maximum benefit.

2.7 Exercise protocol

2.7.1 Duration of exercise

Jones (1966), Fitch and Morton (1971), Silverman and Anderson (1972), and Godfrey (1977 and 1981) reported that peak post exercise bronchoconstriction occurred in exercise of between six to eight minutes duration. The degree of EIA (bronchoconstriction) decreased on either side of this peak. Exercises of longer duration such as the Marathon have been reported

to be well tolerated by asthmatics (Nickerson et al, 1983; and Mahlar et al, 1981). However, post exercise bronchodilation has in fact, been known to occur following brief exercises of between one and two minutes duration (Jones et al, 1962 and 1983). Fitch et al (1976) in their swimming training for asthmatic children, gradually increased the daily duration of swimming until it reached one hour.

2.7.2 Type of exercise

Exercises such as free range running and treadmill running are known to be highly asthmagenic while exercises such as swimming and walking have low asthmagenicity. (Jones, 1976; Anderson, 1972; Silverman and Anderson, 1972; and Godfrey, 1977 and 1981). (Figure 2).

Haas et al (1976) recommended the use of light calisthenics while Jones et al (1962 and 1963), Itkin (1964), Jones (1976) and Godfrey (1977 and 1981) recommended ball games, especially football. Aderele (1982) recommended swimming as a suitable form of exercise for asthmatic children.

The asthmatic subjects in the study reported by Itkin (1964) had calisthenics followed by period of games. Measurements of their performance were done in sit-ups, pull-ups, shuttle run, 50 yard dash and treadmill running. No adverse effects were observed.

Scherr and Frankel (1958) recommended the use of breathing exercises, postural exercises and non-respiratory gymnastics. They reported a study in which the exercises included rope climbing, swimming, tumbling and apparatus workouts with Roman rings, horizontal bars and medicine ball. The children were also taught skills of boxing, judo and self-defence. Graff-Lonnevig et al (1980) designed their exercise programme such that during the warm-up period, they did not allow any running, the warm up was followed by circuit training. Peterson and McElhenny (1965) included in their physical fitness tests, exercises such as 50 yards dash, standing broad jump, sit-ups, soft ball throw, agility run, pull-ups and rope climbing. It was envisaged that these exercises would improve the skills of running, throwing and catching. Hyde and Swarts (1968) gave a group of perennially asthmatic children

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such exercises as strengthening of the abdominal muscles, flexibility techniques to stretch the muscles of the upper limbs, rope climbing, tumbling and relays.

Henriksen and Nielsen (1983) made their asthmatic subjects perform five to six minutes running on the treadmill with gradually increased work loads as the exercise test, while the actual six weeks training included various ball games, running, gymnastics , circuit training and team games such as relay race. Fitch et al (1976) designed a five-month swimming training for 46 asthmatic children.

The American College of Sports Medicine (ACSM) (1978) recommended that the mode of endurance activity should be such that would use large muscle groups as occurs in swimming, rope skipping, run/jog, bicycling, skiing and other forms of endurance activities.

2.7.3 Intensity or level of exercise

The ACSM (1978) recommended that the endurance exercise for healthy adults should be submaximal to achieve between 60 per cent and 90 per cent of maximum heart rate reserve or 50 per cent to 85 per cent of

maximum oxygen uptake (VO_2 max.). However, several studies (Godfrey, 1977 and 1981; Holgate, 1983 and Jones, 1966) on asthmatic children recommended sub-maximal work load falling short of provoking EIA such that will not exceed heart rate of 120 to 180 beats per minute. All the studies prescribed a level that will not exhaust the child and a level that can be individualised.

Graff-Lonnevig (1980) was of the view that each child should be encouraged to try to improve on his own record of cross country skiing rather than compare himself with other children. Peterson and McElhenny (1976) and Scherr and Frankel (1958) recommended that exercise should be individualised and no attempt should be made to exceed the tolerance limit of the individuals. Aderele (1982) recommended that asthmatic children should not be discouraged from physical exercise as long as they exercise within their limits of tolerance. Strick (1969) however, reported that asthmatics can tolerate graded vigorous exercise programme. Similarly, Nickerson et al (1983) recommended that asthmatic children who are receiving adequate drug therapy be

allowed to participate in vigorous exercise programmes, including the forms of exercise that can provoke EIA.

2.7.4 Intermittent exercise programme

Several studies have shown that interrupted exercise is less likely to cause EIA than continuous exercise (Jones, 1966 and 1976; Godfrey, 1975, 1977 and 1981; Haynes et al, 1976; Jones et al, 1962 and 1963; Silverman and Anderson, 1972).

Many endurance exercise programmes for asthmatics have been designed with this in mind (Henriksen and Nielsen 1983; Hyde and Swarts, 1968; Graff-Lonnevig et al, 1980).

2.7.5 Supervision of exercise

Fein and Cox (1955), Scherr and Frankel (1958), Henriksen and Nielsen (1983), Haas et al (1976), and Graff-Lonnevig et al (1980) specifically recommended that physical exercise programme for asthmatic children should be supervised. Close supervision of asthmatic children during training could be implied from the studies of Peterson and McElhenny (1965), Hyde and Swarts (1968) and Fitch et al (1976). Graff-Lonnevig

et al (1980) made the asthmatic boys exercise under the supervision of a physical education teacher while Fitch et al (1976) assigned each subject to a professional swimming coach.

2.7.6 Frequency of exercise per week and total duration of programme

The ACSM (1978) recommended three to five exercise sessions per week for at least 12 weeks with each exercise session lasting between 15 to 60 minutes of continuous aerobic activity for the development and maintenance of fitness in healthy adults.

The 36 asthmatic subjects in the study reported by Itkin (1964) exercised daily for three months. The asthmatic subjects who participated in the five months swimming programme by Fitch et al (1976) started with three exercise sessions per week and the frequency increased gradually until they exercised daily. In the study reported by Scherr and Frankel (1958), the programme was run twice a week with two sessions daily; the subjects were instructed to practise at home daily. The 15 asthmatic children who participated

in the distance running reported by Nickerson et al (1983) ran for four days in a week, for six weeks. The eight months programme for asthmatic boys reported by Peterson and McElhenny (1965) had three sessions per week. The subjects in the study by Henriksen and Nielsen (1983) participated in 90 minutes of supervised physical training twice a week for a period of six weeks. Orenstein and Reed (1984) studied the response of asthmatic children to four months running programme. Winder et al (1979) demonstrated that three weeks of endurance training was enough to demonstrate increase in work capacity in healthy adults, while Henriksen and Nielsen (1983) felt that six weeks were enough in asthmatic children. Peterson and McElhenny (1965) found the greatest amount of improvement in the first four months of the programme.

2.7.7 Mode of exercise

In the studies of Scherr and Frankel (1958), Peterson and McElhenny (1965), Graff-Lonnevig et al (1980), Fitch et al (1976), Haas et al (1976) and Henriksen and Nielsen (1983), the physical conditioning

programme in asthmatic children were essentially aerobics which made use of large muscle groups all over the body. Circuit training, with exercises in stations was used in the studies of Graff-Lonnevig et al (1980) and Henriksen and Nielsen (1983).

2.7.8 Progression of exercise

Haas et al (1976) recommended that exercise programme for asthmatic children be gently graduated. Henriksen and Nielsen (1983) increased the distance gradually to 3.2 km. Fitch et al (1976) progressed the swimming exercise by increasing the frequency from three times weekly to once daily and by increasing the duration to one hour of swimming. The exercise in the study by Graff-Lonnevig (1980) was progressed by changing to strenuous cross-country skiing for one week at five monthly intervals.

2.8 Effects of endurance exercise training on the respiratory function of asthmatic children

When the exercise protocol is carefully worked out such that the exercise is submaximal and the type,

duration and frequency are appropriate such that severe EIA is not evoked, many studies (Nickerson et al, 1983; Fitch et al, 1972; and Haas et al, 1976) have reported no adverse effects of general conditioning exercise on the respiratory function of asthmatic children.

At the end of the six weeks of distance running, Nickerson et al (1983) found no change in the clinical status and the need for treatment of the children. They reported reversed episodes of EIA during the programme. There was also no change in the resting pulmonary function. In the study reported by Itkin (1964) on 36 asthmatic children who went through three months exercise conditioning programme, the result revealed no worsening of the asthmatic condition. There was no significant change in FEV_1. This signified no change in the degree of bronchial obstruction. Itkin (1964) reported no significant difference in the amount of medication required. Following a six-week period of physical training for 28 asthmatic children, Henriksen and Nielsen (1983) found no change in the resting pulmonary function; they however, found a significant reduction in the degree of EIA. In the study reported

by Scherr and Frankel (1958), there were some improvements,in the clinical state and pulmonary function of the 25 asthmatic children who participated in the study. The frequency and severity of asthmatic attacks decreased in the subjects as a group. None of them required hospitalization, while in the previous year, almost half of them were hospitalised for asthma.

After five months of swimming training for 46 asthmatic children, Fitch et al (1972) found significant decrease in the medication received and in the continuous monitoring of the asthmatic state of the children. They found that the frequency and severity of EIA after running, was unchanged by swimming training. On the whole, they observed no significant adverse effects either in the form of increased asthma or change in pulmonary function during the study.

Graff-Lonnevig et al (1980) at the end of the two-year follow up of asthmatic boys to whom they did not give any pre-exercise bronchodilator, found an increase in the respiratory and circulatory dimensions. They noted that when EIA occurred during the programme, it always subsided within 10 to 15 minutes without medical

treatment (indication of mild EIA); inhalation of beta-receptor stimulant was needed only occasionally. They concluded that long-term physical training had no apparent adverse effect on the respiratory or circulatory coefficients and functions in the asthmatic boys.

2.9 Effects of endurance exercise training on the physical and psychological development of the asthmatic children

Reports of many studies while recording no change (adverse or positive), in the pulmonary function of asthmatic children following endurance exercise programme, were almost unanimous in reporting probably some psychological benefits as well as improvement in physical conditioning of the children (Fitch et al, 1976; Vavra et al, 1971; Scherr and Frankel, 1958; and Graff-Lonnevig et al, 1980).

Hyde and Swarts (1968) contended that although exercises could not eliminate the disease of asthma, however, as a result of participation in the physical conditioning programme, the children were able to participate in more school gymnastics and were able

to cope with extra physical demands. They then suggested that a complete programme for perennial asthma should include the conventional medical therapy as well as special exercises to improve the patients' physical capabilities. Based on their results, they suggested that the exercise programme should be continued for as long as obstruction persists.

The study by Graff-Lonnevig et al (1980) have shown that all the boys who participated in the 2-year follow up training programme showed very good ability to participate in the physical activity programme at about the same level as the physical education given at school without pre-exercise medication. This was because the exercise prescription was appropriate.

Nickerson et al (1983) reported improvement in the fitness levels of their distance runners as measured by the specific test for the training which was the 12 minute run.

Scherr and Frankel (1958) found that all the 25 children in their study had demonstrated improvement as a result of participation in the programme by way of improvement and increase in school, home and church

activities as well as loss of fear of asthmatic attacks. They observed definite emotional improvement in each child. This was demonstrated by better adjustment to others in daily activities. Many of the children were able to participate in activities such as summer camping and school sports activities. Some of the children took up jobs as delivery boys and news boys. All these, according to Scherr and Frankel (1958) were activities which the asthmatic children would not previously have attempted because of lack of confidence in themselves. Scherr and Frankel (1958) claimed that some of the asthmatic children gained the respect of their friends and classmates by no longer being the coward or weakling of the peer group.

Henriksen and Nielsen (1983) reported a beneficial effect of endurance training programme on EIB, physical fitness and physical working capacity. The subjects with the most severe EIB were the least fit and they were the ones who gained most from the training.

Holgate (1983) recommended that regular physical activities are needed by asthmatic children to maintain their fitness and help them through difficult periods.

From reports of studies carried out in Australia and the North of England investigating the effects of progressive exercise training on asthma, Holgate (1985) was of the view that there seemed to be little change in objective measurements but quite a marked change in the patients' approach to their disease and to sports.

Peterson and McElhenny (1965) at the end of their eight months of endurance programme for 20 boys concluded that asthmatic children can benefit physically, socially, emotionally and mentally from participation in specially designed, physical fitness programme. They drew the conclusions based on the following findings:

a. 80 per cent of the classroom teachers were of the opinion that the children had improved in the degree of acceptance by other children in the classroom, that the asthmatic boys participated more fully in play ground activities and improved in emotional stability.

b. There was an increase in the intelligence score as well as improvement in the subjects sociability, self-assertion and group activities. There was

enhanced peer group acceptance as a result of the exercise programme.

Itkin (1964) in his study on 36 asthmatic children reported that after the three months of physical training, subjectively, many of the children believed they had improved. Objectively, there was a statistically significant increase in the measurements of their ability to perform the tests.

The American Academy of Pediatrics (1970) recommended that asthmatic children should participate in carefully prescribed physical exercise and sports for their psychological well being.

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

The materials used for this study are listed below:

Materials used for exercise:

1. Wooden bench (33 cm high).
2. Cassette player.
3. Recorded cassette of the Long Play record, "Be My Friend" by Dizzy K. Falola. Track - "Baby kilode".
4. Skipping rope (2.4 metre long).
5. Two batons made from rolled up newspaper (14 cm circumference).
6. Stop watch.
7. Two plastic balls (0.675 metre circumference)

Materials for measurements

1. Plastic tape measure calibrated from zero to 150 cm.
2. Lange Skinfold calliper calibrated from zero to

60 mm (Cambridge Scientific Industries Incorporated, Maryland).

3. Mini-Wright Peak Flow Meter (Figure 5) calibrated from 60 L/min to 800 L/min (Airmed, England).

4. Single Breath Wedge Bellows Vitalograph Spirometer (Figure 6). (Vitalograph Ltd., Buckingham, England).

5. Paediatric Mouth Piece adaptor. (Vitalograph Ltd., Buckingham, England).

6. Paediatric disposable mouth pieces. (Vitalograph Ltd., Buckingham, England).

7. Stadiometer (Weight and Height scales) calibrated from zero to 140 kg (weight)and 75 to 200 cm (height). (Wagebereich, Germany).

8. Stethoscopes. (3M Company, England).

Drug used to assist recovery from exercise-induced wheezing:

1. Salbutamol aerosol called Ventolin Inhaler (Allen and Hamburys (Glaxo) Ltd., London). Each canister contains about 200 inhalations. Each inhalation or puff delivers 100 micrograms of salbutamol.

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Figure 5: The Mini-Wright Peak Flow Meter

Figure 6: The Single Breath Wedge Bellows Vitalograph Spirometer

3.2 Subjects

3.2.1 Selection of subjects

To ensure that for this study only patients who have been properly diagnosed as being asthmatic were selected, all subjects were those attending the Paediatric Asthma and Chest Clinics of the University College Hospital (UCH), Ibadan. The following attributes or factors were considered in the selection of patients:

1. Severity of asthma: It was originally intended that subjects would be chosen from the mild and moderate groups using Aderele's (1979) classification. However, due to the inadequate number of subjects available, the severity of asthma could no longer be used as a criterion for subject selection. Subjects for the experimental and the control groups were therefore selected from the mild, moderate and severe groups as they became available.
2. Age: The subjects were between the ages of six years to 12 years. Children below six years were excluded because it was thought that they might not

cooperate with the exercise training and the tests of respiratory function. While those above 12 years are outside the usual age of paediatrics. This age range was also chosen because normal values were available for the assessment of respiratory function in Nigerian children within this age range (Onadeko et al, 1979 and 1984; Aderele and Oduwole, 1983a;Oduwole et al, 1983).

3. Sex: Boys and girls were included as they became available.

3.2.2 Response rate

A total of 35 asthmatic subjects were recruited over a period of eight weeks from the Monday Chest Clinic and the Thursday Asthma Clinic of the Children's Out-Patient Department of U.C.H. They were to participate in the study either as control or as experimental subjects. Some parents refused to give their consent probably out of fear that exercise would worsen the asthmatic condition of their children. This attitude to exercise was also reported by Aderele (1985). These children were excluded. Out of the 35 children, 23 were allocated to the experimental group on the basis of the

willingness of their parents to allow them to participate in the programme. Twelve subjects were allocated to the control group on the basis that their parents said they would not be able to find time to bring them three times a week for the programme. This was either due to the children being in the afternoon shift in school or the parents having irregular hours of work.

Fourteen of the 23 experimental subjects completed the programme. The results of other subjects were cancelled because they missed at least 25 exercise sessions and at least, five of the six fortnightly reassessments. Five of the 12 subjects in the control group completed the programme. Three subjects had their results cancelled because they did not come for up to five of the six assessments and the final assessment. Four subjects did not even keep their first appointment.

On the whole, 19 subjects completed the study, 14 as experimental subjects and five as controls. The subjects in the experimental group were identified by numbers from E1 to E14 in order of their recruitment while the controls were identified by numbers from C1 to C5 as they were recruited.

3.2.3 Education of subjects and parents

The subjects and their parents were enlightened on the effects of physical exercise on asthma. This was considered to be very important due to the serious nature of asthma in children. McCombs (1976) advocated that parents should be educated on the nature of asthma and the various therapeutic measures available. In this study, it was envisaged that improved parents' education would make the parents to give more effective cooperation to the entire treatment plan. The parents were taught to observe their asthmatic children more closely and regularly.

After selecting the subjects, the purpose of the training and the tests were explained to them and their parents. Informed consent was then obtained from the parents to enable their children participate in the study in compliance with the Declaration of Helsinki of 1975 (World Medical Assembly, 1975) and the American College of Sports Medicine (ACSM), (1979). All the subjects were instructed to report any asthematic attacks which

occurred at home between exercise sessions and the treatment they received. One orientation meeting was held with parents and children prior to entry into the programme to acquaint them with the purpose of the study. It was stressed to the parents that the success of the programme and the maximum benefit to their children depended largely on their cooperation in ensuring the transportation of their children to the programme venue regularly and promptly.

The children were motivated to work hard during every exercise session and to attend regularly and promptly so that they could derive maximum benefit from the programme. Some bit of self and group competitions were encouraged even though each subject was to exercise at his own pace since there was no fixed cadence for performance. The children were given small gifts for regular and prompt attendance and for working hard at the sessions. At the end of each exercise session, the parents and children were given some material inducements as part of maximum encouragement to attend all the sessions.

3.3 Methods

3.3.1 Study design

This study was an experimental clinical trial in which asthmatic children between ages six and 12 years participated in an endurance exercise programme for 12 weeks at a frequency of three exercise sessions per week. The endurance training and the tests were conducted at the Physiotherapy Department, College of Medicine, U.C.H., Ibadan. Some of the required instruments which were not available in the Physiotherapy Department were borrowed from the Departments of Paediatrics, Medicine and Anaesthesia of the U.C.H.

All patients entering the programme either into the control or the experimental group had detailed history of their illness and treatment taken. The information obtained from the informant was compared with that of the patient's hospital case notes. Where there was conflicting information from both sources, especially on issues pertaining to the occurrence and severity of asthmatic attacks and the treatment given, the information in the hospital case note was upheld.

Severity of asthma was computed from the number of asthmatic attacks as recorded in the hospital case notes, using the classification by Aderele (1979).

The following variables were measured pre-training: Forced expiratory volume in the first second (FEV_1), forced vital capacity (FVC), and peak flow rate (PFR), respiratory rate, pulse rate, height, weight, chest diameters, chest expansions and skinfold measurements. These were referred to as the initial pre-bronchodilator variables.

Still pre-training, a bronchodilator aerosol (salbutamol inhaler) was administered to the subjects. The steps outlined for the correct use of inhaler by Kelling et al (1983) and Lee (1983) were followed. Fifteen minutes later, the following variables were measured: FEV_1, FVC, PFR, respiratory and pulse rates. These were referred to as the initial post-bronchodilator variables.

The initial pre- and post-bronchodilator variables served as baseline values to each subject to which subsequent values were compared. In addition, there

was a control group to the entire experimental group. The control group was selected from the available population as described in section 3.2.2.

The experimental subjects went through an endurance exercise programme for 12 weeks at a frequency of three exercise sessions per week. The exercises were arranged in stations in a circuit. They were all aerobic in nature.

Before each exercise session, pre-exercise observations of the subjects were done. These included pulse and respiratory rates, presence of cyanosis, dyspnoea, audible wheezing, wheezing on auscultation and cough. History was taken of any asthmatic attack after the last exercise session and the details of treatment given. Any residual illness was also noted. From all the above observations, the suitability of the patient to participate in the day's exercise session was determined.

The subjects in the experimental group went through all the exercise stations which constituted the circuit at any given exercise session. At each exercise station, subjects were closely observed for signs of exercise-induced asthma (EIA). They were

specifically observed for the presence of cyanosis, dyspnoea, audible wheezing, wheezing on auscultation and cough. From these observations, the suitability of the subject to continue with the exercise was determined. The subject was stopped from proceeding with the exercise if he was found to be excessively breathless accompanied by audible wheezing. Apart from stopping the exercise, salbutamol inhalation was administered and the patient's pulse, respiration and all the earlier stated observations were assessed at one minute, five munites and 10 minutes later. If after 10 minutes, the patient hadn't recovered or had gone into full blown asthmatic attack, it was arranged that a doctor would be contacted for the appropriate management of acute asthmatic attack. Even though this provision was made, it was never utilized as the subjects recovered within 10 minutes.

At the end of each exercise session, a post-exercise observation was done. This included respiratory and pulse rates monitoring, presence of cyanosis, dyspnoea, audible wheezing, wheezing on auscultation, cough and onset of severe exercise induced asthma.

These observations were done at the one minute, five minutes and 10 minutes post-exercise. The post exercise observations were used to assess recovery from exercise.

In order to cope with emergency treatment of severe exercise-induced asthma during the entire programme, a tray was set up containing ampoules of Adrenalin injections ampoules of Aminophylline injections, 3 cc ard 10 cc disposable syringes, disposable needles, cotton swabs, 80 per cent ethanol and salbutamol inhaler canisters. There was an arrangement with two paediatric Medical Registrars who could be called in case of emergency to give prompt treatment for acute asthmatic attack (as a result of exercise) depending on their assessment of the need of the patient. This provision was however, never utilized.

After the programme had commenced, repeated tests were administered fortnightly. On each test day, the following measurements were taken pre-exercise: PFR, FEV_1, and FVC. At one minute and 10 minutes post-exercise, these measurements were repeated. On test days (reassessments), the usual pre- and post-exercise observations were done as for the other exercise sessions. Absence of a subject on any of the fortnightly test days

and the exercise session immediately following the test day, meant that the subject had missed the particular test and would be assessed during the next forthnightly test day. If however, he was present on the exercise session immediately after the test day, his fortnightly assessment was done. The exception to this was the 12th week assessment (6th reassessment) which was done only on the scheduled day because the final assessment was only one week away.

One week after the last exercise session of the 12 weeks training programme, all the initial pre-bronchodilator measurements were done. They were referred to as the final pre-bronchodilator measurements. Salbutamol inhalations were then administered. Fifteen minutes later all the initial post bronchodilator measurements were taken, they were referred to as the final post-bronchodilator measurements.

For the control group, apart from obtaining the detailed history of illness, the initial and final pre- and post-bronchodilator measurements were done just as for the experimental group. Pre-test measurements were taken fortnightly as for the experimental group. However, no

exercise training was given to this group. The number of asthmatic attacks as well as the treatment given were closely monitored for the control group throughout the 12-week period of the study.

At the end of the 12-week exercise programme for the experimental subjects and 12 weeks of only fortnightly measurements for the control subjects, they were all closely monitored mainly via their hospital case notes and also through personal contact for six weeks after the programme.

3.4 Exercise protocol

3.4.1 General design of exercise programme

The exercises in this programme were chosen based on the various reports on exercise and EIA and considering the local needs, ability and interest of the subjects as well as the facilities available. While it was the objective of the exercise design to avoid highly asthmagenic exercises, it was also desired to constantly

stimulate the interest of the children, hence the inclusion of such activities as shuttle run, dancing and ball bouncing in the programme. Few people have access to swimming pool in Ibadan, even if a swimming pool was available, the children in the present study could not swim. One could therefore not include swimming in the exercise programme in spite of the known low asthmagenicity of swimming. In order to encourage the asthmatic child to exercise regularly, the highly asthmagenic types of exercise were included in the programme hoping that with gentle graduation and close observation, severe EIA would not be evoked.

The training programme which was made up of general conditioning exercises lasted for 12 weeks with three exercise sessions per week. Each session was held between 4.00 and 6.00 p.m.

The programme contained exercises which worked up the muscles in the whole body especially the large muscle groups sufficiently enough to have effect on the

cardio-respiratory systems. While it was desirable for the exercises to be vigorous enough to cause mild breathlessness, severe breathlessness was considered dangerous and was avoided as severe exercise-induced asthma could be precipitated. Therefore, any time excessive breathlessness or wheezing was observed during the exercise, the subject was stopped from further exercising for the particular session and he was given salbutamol inhalation to aid recovery from exercise.

It was a group training with the exercises in stations and arranged in a circuit. Each station was supervised by an assistant who ensured that the exercises were performed properly and who counted the number of times (repetitions) each exercise was performed. Group training was preferred for the subjects because they were children. The spirit of competition generated by the group training made each child to put in his best. Even though the children exercised together, there was only one subject at a time in each station. Group training was preferred for the children because it would make each child to feel that he was not

alone with his problem. There was one minute rest between exercise stations during which each subject carried out breathing exercises. The timing was uniform for the rest periods and the exercise periods for a group. This exercise protocol was chosen because it was envisaged that the effect of circuit exercise would mimic exercises of short duration performed one after the other. (Jones et al, 1963). The following were the exercises included in the circuit.

Station 1 - 17 metre shuttle run.
Station 2 - Rope skipping.
Station 3 - Ball bouncing on the wall.
Station 4 - 38 metre walk/run.
Station 5 - Bench step.
Station 6 - Dancing.
Station 7 - Zig zag broad jump.
Station 8 - Running on the spot.
Station 9 - Ball bouncing on the floor.
Station 10 - Jump to wall point.

The subjects could enter the circuit at any station but they all moved in clock-wise direction until they completed the circuit.

3.4.2 Specific description of exercise stations

Station 1: 17 metre shuttle run

For this exercise, the shuttle run test designed by Matthews (1978) was used. Two parallel lines were marked on the floor 17 metres apart. Two batons made of rolled up old newspapers were placed behind one of the parallel lines. The subject stood behind the other line which was then designated the "start line". On the signal "Go", the subject ran to the opposite line, picked up one of the batons and ran back to the "start line" behind which he placed the baton. The subject then ran back to pick up the second baton and placed it behind the "start line". A cycle was completed when the two batons were behind the "start line". The next cycle began immediately with a reversal of the "start line" so that there would be no need to return the batons to the initial position at the end of each cycle. The score was the number of completed cycles in the specified period of exercise depending on the stage or progression as scheduled in the exercise programme as shown in Table 1.

Station 2: Rope skipping

A 2.4 metre long rope with a wooden handle at either end of the rope was used for this exercise. Each subject skipped using a suitable length of rope for his height. Since the heights of the subjects varied, the length of rope was adjusted to the individual height. The rope was knotted in several places to shorten it while the knots were loosened to lengthen it for taller subjects. The score was determined by counting the number of times the rope hit the floor in front of the subject for the duration of exercise.

Station 3: Throwing and catching a ball

A plastic ball with a circumference of 0.675 metre was bounced against the wall and caught by the subject on its rebound. The subject stood two metres from the wall, he was instructed to throw the ball to a point about 20 centimetres (cm) above his height on the wall and to catch the ball on its rebound. The score was determined by the number of times the plastic ball hit the wall for the duration of exercise.

Station 4: 38 metre walk/run

At this exercise station, the subject could either walk or run (Figure 7) for the whole or part of a marked out rectangular area with a perimeter of 38 metres. The score was the number of times the subject went round the marked out area for the duration of exercise.

Station 5: Bench step

A 33 cm high bench was used for this exercise which was done at the subject's own cadence. The height of the bench was in conformity with the adaptation of the Ohio State University Step Test by Callan (1968) for elementary school boys. The subject was instructed to step up the bench and step down one leg after the other continuously for the duration of the exercise. The score was the number of times the subject stepped up and down (one cycle) for the duration of exercise.

Station 6: Dancing

At this station, the subjects danced to some popular local music which stimulated their interest. Each subject was free to dance in his own style. Only

Figure 7: Subject Performing 38 metre walk/run.

the duration of dancing was recorded.

Station 7: Zig zag broad jump

The subject jumped two rows of five "squares" each from one "square" to another in a zig zag fashion (Figures 8 and 9) following the adaptation of a test advanced by Matthews (1978). Each square had dimensions of 98 cm by 90 cm and had markings in the centre indicating where the feet of the subject should be placed on jumping. A cycle was completed when a subject jumped from the "start" to the "finish". Since the exercise was continuous for the duration alloted, at the end of each cycle, there was a reversal of the "start" and the "finish". The number of cycles completed in the duration of exercise constituted the score.

Station 8: Running on the spot

The subject ran on the spot for the duration of exercise. No repetition of exercise was recorded for this station.

Station 9: Ball Bouncing on the floor

A plastic ball with a circumference of 0.675 metre was continuously bounced about on the floor (Figure 10)

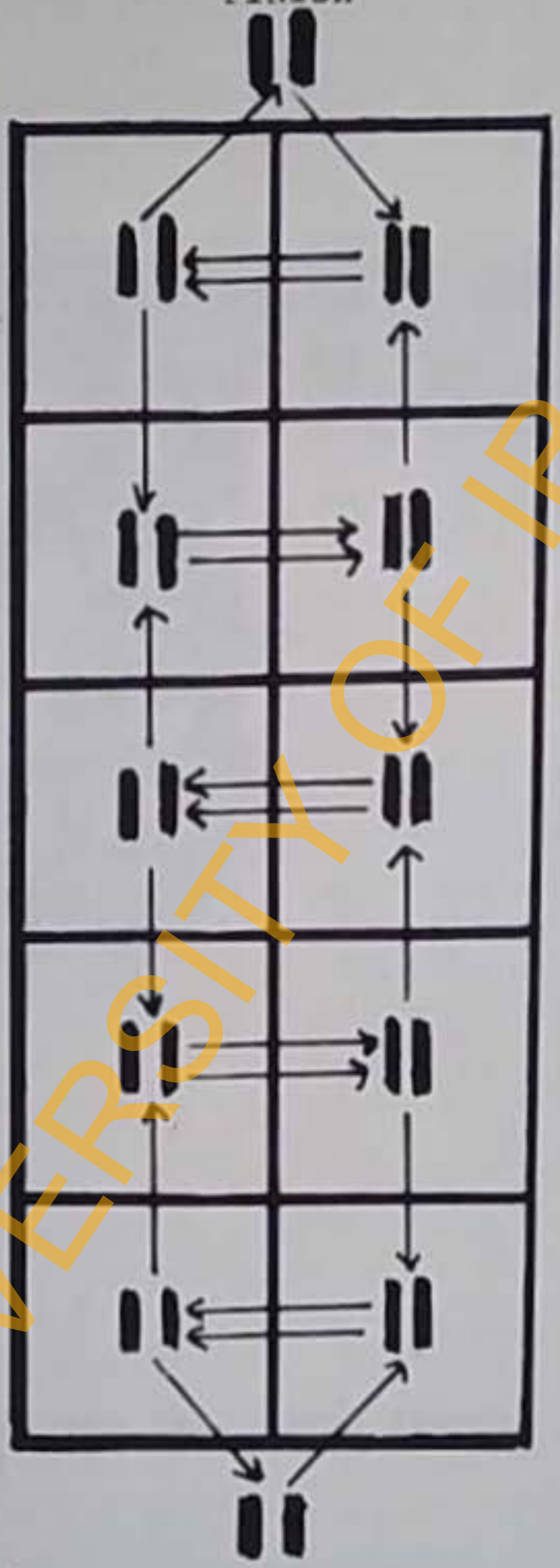

Figure 8: Zig-zag broad jump (Adapted from Matthews, 1978).

Figure 9: Subject Performing Zig-Zag Broad Jump.

Figure 10: Subject Performing Ball Bouncing on the Floor.

by the subject for the entire duration of exercise. Only the duration of exercise was recorded for this station as it was difficult to count the number of repetitions.

Station 10: Jump to wall point

The subject was required to jump to reach a mark on the wall. The mark was made on the wall at about 15 cm from above the tip of the middle finger of the subject's outstretched right arm (Figure 11). This was to make room for the individual variation in height. The number of jumps made in the duration of exercise was the score.

3.4.3 Progression of exercise

The duration of the exercise sessions was made to progress by increasing the time spent at each station and therefore the total time spent to complete the exercises in the circuit. Alternatively, the exercise was progressed by adding on more stations to the circuit. There was a minimum of five stations and a maximum of 10 stations. The periods of rest were not considered as part of the duration of exercise. The

Figure 11: Subject Performing "jump to wall point".

time spent at each exercise station was from a minimum of one minute to a maximum of four minutes. The exercise programme was progressed weekly as shown in Table 1.

Irrespective of the time allocated to be spent at each station, exercises were performed entirely at subjects own pace although the number of times the patient performed the exercise in each station was recorded. Since it is not desirable for the training to produce undue distress, the subject should exercise to a level below the maximum of which he is capable in order to exercise safely. Therefore, no attempt was made to make the level of exercise uniform for the group as a whole. Each subject was allowed to adjust to his individual tolerance. There was no pre-exercise administration of a bronchodilator.

Although the American Colleges of Sports Medicine (1978) recommended a minimum of 15 minutes per exercise session for an endurance programme for healthy adults, for the purpose of this study, the total duration of exercise was started at five minutes and gradually increased to 40 minutes. Starting at 15 minutes

TABLE 1

Weekly progression of exercise programme

Week	Number of exercise stations	Time spent at each station (minutes)	Total duration of exercise (minutes)
1	5	1.0	5.0
2	5	1.5	7.5
3	6	1.5	9.0
4	6	2.0	12.0
5	7	2.0	14.0
6	7	2.5	17.5
7	8	2.5	20.0
8	8	3.0	24.0
9	9	3.0	27.0
10	9	3.5	31.5
11	10	3.5	35.0
12	10	4.0	40.0

duration might produce such a drastic fall in lung function measurements that the subjects and their parents might lose confidence in the programme as a result of excessive breathlessness. The exercise programme was designed such that the respiratory endurance of the subjects would be gradually built up from spending one minute per exercise station with total duration of exercise of five minutes to spending four minutes per exercise station with total duration of exercise of 40 minutes.

3.4.4 Exercise sessions

Each exercise session was described such that the week and the day of the exercise was depicted. Each of the weeks one to 12 was described by the corresponding number. The days of the week were designated 1, 2 and 3 for Monday, Wednesday and Friday respectively. For example, the Wednesday exercise session in the 10th week was described as 10:2, while 6:1 referred to the Monday session during the 6th week.

There were supposed to be 36 exercise sessions in the entire programme, but only 34 were held as two of

the days fell on National Public Holidays.

3.5 Measurements (Tests)

Before measurements were commenced, there was a pre-test run of procedures. Each child was asked to repeat each test until he was familiar with the technique, then the initial pre- and post-bronchodilator assessments were done. Measurements for the initial assessments were not done during or immediately after an acute attack of asthma. They were taken in between attacks. The initial assessments included the following measurements.

3.5.1 Peak Flow Rate (PFR)

This was measured using a Peak Flow Meter. In order to overcome the problem of excessively large dead space which would not record PFR below 150 litres per minute as obtains in the Pulmonary Monitor (by Vitalograph Ltd., England), a Mini-Wright Peak Flow Meter specifically designed for paediatric measurement was used. Measurements as low as 60 litres per minute could therefore be recorded (See Figure 5).

PFR was measured with the subject in sitting position (Figure 12). The technique of performing the test was demonstrated until the child had become familiar with the procedure. Each subject was instructed to take a deep breath and apply his lips tightly round the edge of the disposable mouthpiece, and to breathe out as hard and as fast as possible. The test was repeated three times. The best recording was taken as the value of PFR. The measurements were recorded in litres per minute. Predicted normal value of PFR for each child was estimated from age and sex using the values obtained by Aderele and Oduwole (1983a). See Appendix B6.

3.5.2 Forced Vital Capacity (FVC) and Forced Expiratory Volume in the First Second (FEV_1)

FVC and FEV_1 were measured using a spirometer. For this study, a single breadth wedge bellows Vitalograph spirometer was used. Prior to spirometry, each child was made to practise full exhalation with the use of brightly coloured baloons. A little

PFR was measured with the subject in sitting position (Figure 12). The technique of performing the test was demonstrated until the child had become familiar with the procedure. Each subject was instructed to take a deep breath and apply his lips tightly round the edge of the disposable mouthpiece, and to breathe out as hard and as fast as possible. The test was repeated three times. The best recording was taken as the value of PFR. The measurements were recorded in litres per minute. Predicted normal value of PFR for each child was estimated from age and sex using the values obtained by Aderele and Oduwole (1983a). See Appendix B6.

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Figure 12: Measurement of PFR using a Mini-Wright Peak Flow Meter.

competition was introduced into the baloon blowing. Each child was allowed to take away as many baloons as he could inflate fully. The technique required maximum inspiration followed by a forced, rapid, maximum expiratory effort. The following were the procedures prior to testing.

a. The spirometer was connected to electricity supply.

b. The vitalogram chart was inserted into the carrier which was moved to the starting position such that the stylus point was on the "stylus start" line of the chart just off the grid (Figure 6).

c. The paediatric adaptor was cleaned and fitted into the breathing tube, the disposable mouthpiece was fitted tightly into the adaptor.

d. The test procedure was explained and demonstrated several times to the subject. All forms of restrictions in the subject's clothing were removed.

e. The measurements were taken with the subject seated on a chair with a back rest.

After these preliminaries, the test commenced. Each subject was instructed to take in a deep breath, apply his lips tightly round the edge of the mouthpiece

and breathe out as fast and as hard as possible into the mouthpiece while the operator pressed the "Recording" knob (Figure 13). At the preliminary stage, the subject's nostrils were clipped between the operator's thumb and middle finger to prevent air leakage via the nose and get him used to exhaling completely through the mouth. The actual tests were done without nose clipping when the patient had got used to breathing out via the mouth only. The subject was encouraged to continue to breathe out until the stylus point no longer showed any movement.

The measurements were recorded using the BTPS volume scale on the right hand side of the chart. Similar to the reports by Nowak *et al* ((1979), Onadeko *et al* (1979), Oduwole *et al* (1983) and Henriksen and Nielsen (1983), the test was performed three times on each subject and the best recording was used. From each test, the FEV_1 and FVC were determined from the vitalograph tracing. (Figure 4).. Both the FEV_1 and FVC were measured in litres. Predicted normal values of FVC and FEV_1 were estimated for each child from age and sex using the values obtained from Oduwole *et al*

Figure 13: Measurement of FEV_1 and FVC using a Vitalograph Spirometer.

(1983). See Appendix B7.

3.5.3 Chest diameters

Chest diameter measurements included anterio-posterior diameter to the right and left, and lateral diameter, using non elastic tape measure and recorded in centimetres. Measurement of lateral diameter was taken at the level of the tip of the sternum (by locating the tip of the xiphoid cartilage) from the midaxillary line on the left side to the midaxillary line on the right side. Measurement of the anterio-posterior diameter was taken at the level of the tip of the sternum from the anterior midline of the body to the posterior midline of the body, on the left and right sides.

3.5.4 Chest expansions

Measurements of chest expansion were taken at maximum inspiration and then at maximum expiration. The difference between the measurements represented chest expansion. Measurements were taken at three levels namely: apical, lateral costal and diaphragmatic. Apical expansion was measured at the level of the sterno-manubrium junction (angle of Louis). Measurement

of lateral costal expansion was taken at the level of the tip of the sternum (tip of xiphoid cartilage), diaphragmatic expansion was measured at the level of the tip of the tenth rib. All measurements were taken using a non-elastic tape measure, and recorded in centimetres.

Measurement of chest expansion at various levels served as some pointer to restrictive chest condition in addition to the obstructive airway condition of asthma.

3.5.5 Respiratory and pulse rates

Respiratory rate per minute was taken by listening to respiratory movements using a stethoscope. The number of excursions per minute was counted using a stop watch. Pulse rate was estimated by counting the radial pulse per minute using a stop watch. Radial pulse was obtained by lightly pressing the middle finger against the raidal artery above the wrist.

3.5.6 Weight and height

Each subject was weighed with only his under-clothes on. Weight was recorded in kilograms. Height

of each subject was measured and recorded in centimetres; it was taken without shoes on. Weight and height were measured using the stadiometer.

3.5.7 Body composition

The effect of training programme on body composition was assessed by estimating lean body weight (LBW), per cent body fat (% fat) and body density (D_B). In order to estimate the above, a Lange Skinfold calliper was used to measure subscapular and triceps skinfolds.

The following Parizkova Equations (Parizkova, 1961) were used to compute body density for the age group stated by the equation as well as for children between ages six to eight years as there was no other appropriate equation for them.

Males

9 to 12 years: $D_B = 1.108 - 0.027 \log \text{triceps} - 0.039 \log \text{subscapular}$

Females

9 to 12 years: $D_B = 1.088 - 0.014 \log \text{triceps} - 0.036 \log. \text{subscapular}$

Siri's Equation (Siri, 1961) was used to compute % fat for all the subjects from the known body density (D_B).

Siri's Equation: % fat = $\frac{495}{D_B}$ - 450.

3.5.8 Final subjective assessment

At the end of the 12-week training period, the parents of the experimental subjects were requested to subjectively evaluate the programme and its effects on their children. The questionnaire (See Appendix F) was administered on the parent or guardian who usually brought the subject for the exercise sessions.

3.6 Treatment of data

1. The percentages of FEV_1, FVC and PFR values from the tests to the predicted normal values were determined for all the subjects for the entire study.
2. The summary values showing mean and standard deviation were computed for all the measured variables.
3. Paired t-tests and the chi square (X^2) tests were used to determine the significance of differences or changes during the programme.
4. The analysis of variance (ANOVA) procedure was used

to determine the overall changes that accompanied the 12 weeks of the endurance programme. The changes were considered to have taken place over eight stages of the programme. The eight stages were: Initial pre-bronchodilator, Reassessment 1, Reassessment 2, Reassessment 3, Reassessment 4, Reassessment 5, Reassessment 6 and Final pre-bronchodilator.

5. Each hypothesis was tested at 0.05 level of significance. All the tests (χ^2, t-tests and F-ratio) were significant at the 0.05 probability level.

6. The data analyses were done both manually and using a computer.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Results

4.1.1. Physical Characteristics of Subjects (Appendix C)

The baseline (pre-programme) physical characteristics of the subjects in both the experimental and control groups are shown in Table 2. There were six girls and 13 boys in the entire group.

The experimental group was made up of three girls and 11 boys while the control group was made up of three girls and two boys. There was no significant difference in the mean age of the two groups ($t = 0.263$; $P > 0.05$).

4.1.2. Clinical History of Subjects (Appendix A)

This refers to the clinical history of the asthmatic condition in all the subjects with special emphasis on the clinical history during the period of three months before the commencement of this programme.

TABLE 2

Physical Characteristics of Subjects (Pre-exercise)

Physical Characteristics	Mean and Standard Deviation		t-Value
	Expt Group	Control Group	
Age (Years)	9.18 ± 1.74	9 ± 2.12	0.263 (N.S.)
Height (cm)	129.34 ± 12.47	126.1 ± 10.96	0.55 (N.S.)
Weight (kg)	23.97 ± 5.85	20.68 ± 5.68	1.10 (N.S.)
Body density (kg/litre)	1.050 ± 0.004	1.054 ± 0.005	1.62 (N.S.)
Percent fat	18.0 ± 1.9	19.6 ± 2.6	1.26 (N.S.)
Fat Weight (kg)	4.4 ± 1.4	4.1 ± 1.4	0.41 (N.S.)
Lean Body Weight (kg)	19.6 ± 4.6	16.6 ± 4.3	1.31 (N.S.)
Lateral Chest Diameter (cm)	31.9 ± 2.6	29.8 ± 2.4	1.64 (N.S.)
Right anterio-posterior chest Diameter (cm)	30.7 ± 2.7	28.9 ± 2.0	1.56 (N.S.)
Left anterior-posterior chest Diameter (cm)	30.7 ± 2.7	28.9 ± 2.0	1.56 (N.S.)

N.S. = Not significant

The mean and standard deviation of age at onset of asthma in the experimental and control groups were 3.5 ± 3.1 years and 4.5 ± 2.4 years respectively (Table 3).

The mean and S.D. of duration of illness (asthma) were 5.6 ± 2.47 years and 4.4 ± 1.8 years respectively in the experimental and control groups (Table 3). There was no significant difference in the mean duration of illness of the experimental and control groups ($t = 1.153$; $P > 0.05$).

The entire group was made up of four mild asthmatics, 13 moderate asthmatics and two severe asthmatics. The experimental group was made up of three mild asthmatics, ten moderate asthmatics and one severe asthmatic. There was no significant difference in the distribution of severity of asthma in both the experimental and control groups ($X_2^2 = 0.64$; $P > 0.05$).

The factor precipitating asthma was unknown in 11 of the entire subjects. Five of the 19 subjects gave cattarrh as the known precipitating factor. In one subject, exercise was the precipitating factor.

TABLE 3
Clinical History

Study Number	Age at onset (years)	Duration of illness (years)	Severity of asthma	Precipitant of asthma	Number of asthmatic attacks 3 months before programme	Absenteeism from school on account of asthma 3 months before programme (days)
Experimental Group						
E1	0.92	7.08	Moderate	Unknown	2	5
E2	1.5	6.25	Moderate	Cattarrh	1	3
E3	2	5	Moderate	Unknown	2	3
E4	Unknown	Unknown	Severe	Exercise	6	10
E5	4	7	Moderate	Unknown	None	None
E6	0.33	5.67	Moderate	Cattarrh	1	Not applicable
E7	3	5	Mild	Unknown	1	1
E8	9	1	Mild	Unknown	1	None
E9	6	4	Moderate	Eating bread	1	3
E10	1	10	Moderate	Cattarrh	2	Temporary withdr
E11	3	5	Moderate	Unknown	1	1
E12	4	6	Mild	Unknown	None	None
E13	10	2	Moderate	Cattarrh	3	10
E14	0.75	9	Moderate	Cattarrh	2	6
Mean	3.25	5.21	-	-	1.64	3.5
S.D.	3.14	2.81	-	-	1.5	3.6
Control Group						
C1	4	5	Moderate	Unknown	2	5
C2	5	2	Moderate	Unknown	4	10
C3	7	3	Moderate	Unknown	2	5
C4	6	6	Severe	Dust	4	8
C5	0.67	6.33	Mild	Unknown	None	None
Mean	4.53	4.47	-	-	2.4	5.6
S.D.	2.43	1.89	-	-	1.5	3.8
Overall Mean	3.59	5.02	-	-	1.8	4.1
S.D.	2.96	2.57	-	-	1.5	3.7

He was a severe asthmatic and was in the experimental group. The other severe asthmatic, who was in the control group had asthma precipitated by exposure to dusty environment (Table 3).

There was a positive history of asthma in the family of five subjects; two of these (C2 and C3) were siblings (See Appendix A). The number of asthmatic attacks three months before the start of the study in the entire group ranged from zero to six with a mean and S.D. of 1.8 + 1.5 attacks. Three of the subjects had no attack at all. Two (14.3%) of the subjects in the experimental group were symptom-free in the three months preceding the programme while 12 (85.7%) had asthmatic attacks. Four of the controls had asthma three months before the programme while the fifth subject was symptom-free (Table 3).

One subject was admitted into hospital on account of asthma during the three months pre programme period. The subject was severely asthmatic and in the experimental group; he was admitted into hospital three times. The number of attendances at the Asthma Clinic during three months

before the programme, ranged from one to 11 in the entire subjects.

All the subjects were routinely placed on intermittent bronchodilator therapy by their doctors. The drugs were used only when required. The bronchodilator drug used by all the subjects was salbutamol (Ventolin). Salbutamol was administered as syrup in three subjects while it was used in the tablet form in the remaining 16 subjects (Appendix A). Each tablet or 5mls syrup contains 2 milligramms (mg) of salbutamol B.P. There was no significant difference in the mean daily dosage of salbutamol between the experimental and control groups.

(X_2^2 = 0.434; $P > 0.05$).

Absenteeism from school on account of asthma three months before the programme ranged from no absenteeism to temporary withdrawal from school (Table 3). One of the subjects had not started school. One subject who was in the experimental group had withdrawn temporarily from school for the rest of the

school year due to too frequent absenteeism from school which had resulted in an extremely poor academic performance. The 17 subjects who were attending school missed an aggregate of 73 school days because of asthma, as reported by the parents. Twelve of these subjects were in the experimental group; they missed an aggregate of 56 school days while the five subjects in the control group missed an aggregate of 28 school days because of asthma.

4.1.3. Baseline pulmonary function tests

(See Appendices B2, B3, B4, B5, B6 and B7)

4.1.3.1 Peak flow rate (PFR)

The baseline values (initial pre-bronchodilator values) of PFR of the entire subjects ranged from 100 to 260 litres/minute with a mean and standard deviation (S.D.) of 192 ± 45.9 litres/min.

The initial pre-bronchodilator (IPRB) value of PFR in the experimental group ranged from 100 to 260 litres/min with a mean and S.D. of 197.5 ± 44.49 litres/min. The IPRB value of PFR in the control group ranged

from 120 to 260 litres/min. with a mean and S.D. of 178 ± 56.75 litres/min.

Table 4 shows the relationship between the base-line values of PFR and the predicted normal value (PNV). It also shows the relationship between the IPRB value and the initial post bronchodilator (IPOB) value of PFR. All the subjects had IPRB value less than the PNV of PFR. No subject had IPRB value less than 50% of PNV, while none of them had IPRB value above 90% of PNV of PFR. There was no significant difference in the % PNV of initial pre-bronchodilator PFR in the experimental and control groups ($X^2_3 = 4.389$; $P > 0.05$).

Fifteen minutes after the administration of ventolin inhalation, all the subjects had increased PFR values (Initial Post Bronchodilator value). This increase ranged from 9.5% of the initial pre-broncho-dilator value of PFR to 45% with a mean and S.D. of 20.83 ± 11.54%. There was no significant difference ($X^2_4 = 1.933$; $P > 0.05$) in the percent increase of the initial pre-bronchodilator PFR between the two groups after bronchodilator administration.

TABLE 4

BASELINE VALUES OF PFR AS RELATED TO PNV AND IPOB VALUES

Study Number	Age (years)	PNV of PFR	IPRB value of PFR (L/MIN)	% PNV of IPRB value	IPOB value of PFR (L/MIN)	% IPOB value of IPRB value	% Increase in IPRB value
Experimental Group							
E1	8	260	230	88.5	260	113.0	13.0
E2	8	260	185	71.1	210	113.5	13.5
E3	7	217	180	82.9	200	111.1	11.1
E4	10	294	180	61.2	215	119.4	19.4
E5	11	310	250	80.6	280	112	12.0
E6	6	181	100	55.2	145	145	45.0
E7	8	260	150	57.7	200	133.3	33.3
E8	10	294	240	81.6	270	112.5	12.5
E9	10	294	160	54.4	190	118.8	18.8
E10	11	310	200	64.5	260	130	30.0
E11	8	260	210	80.8	230	109.5	9.5
E12	10	294	180	61.2	230	127.8	27.8
E13	12	332	260	78.3	290	111.5	11.5
E14	10	281	240	76.2	270	112.5	12.5
Mean	9.21	274.74	197.5	71	232.14	119.28	19.28
S.D.	1.72	39.5	44.49	11.65	41.4	10.69	10.69
Control Group							
C1	9	270	180	66.7	220	122.2	22.2
C2	7	216	130	60.2	180	138.5	38.5
C3	10	294	200	68.0	240	120	20.0
C4	12	332	260	78.3	295	113.5	13.5
C5	7	216	120	55.6	170	141.7	41.7
Mean	9	265.6	178.0	65.76	221.0	129.18	29.18
S.D.	2.12	50.39	56.75	8.6	50.29	12.27	12.27
Overall Mean	9.15	272.37	192.4	69.6	229.21	120.83	20.83
S.D.	1.77	41.33	45.9	10.96	42.73	11.54	11.54

PFR - Peak flow rate
PNV - Predicted normal value
IPRB - Initial pre-bronchodilator
IPOB - Initial post-bronchodilator.

4.1.3.2 Forced Expiratory Volume in the first Second (FEV_1)

The baseline values (IPRB value) of FEV_1 in the entire subjects ranged from 0.3 litre to 1.35 litres with a mean and S.D. of 0.958 ± 0.294 litre (Table 5). The IPRB values of FEV_1 in the control group ranged from 0.3 litre to 1.3 litres with a mean and S.D. of 0.85 ± 0.424 litre. The IPRB values of FEV_1 in the experimental group ranged from 0.6 litre to 1.35 litres with a mean and S.D. of 0.996 ± 0.255 litre (Table 5).

Table 5 shows the relationship between the base-line values of FEV_1 and the PNV of FEV_1. It also shows the relationship between the IPRB value of FEV_1 and the IPOB values. All the subjects had IPRB values less than PNV of FEV_1. No subject had IPRB value of FEV_1 less than 20% of PNV while none had value above 90% of PNV. There was no significant difference in the % PNV of the initial FEV_1 in the two groups ($X_3^2 = 3.45$; $P > 0.05$).

TABLE 5

Baseline values of FEV_1 as related to PNV and IPOB values

Study Number	Age (Years)	PNV of FEV_1	IPRB value of FEV_1	% PNV of IPRB value	IPOB value of FEV_1	% IPOB value of IPRB value	% Increase in IPRB value
Experimental Group							
E1	8	1.34	0.8	59.7	1.05	131.25	31.25
E2	8	1.34	0.6	44.78	0.85	141.67	41.67
E3	7	1.32	0.95	71.97	1.15	121.05	21.05
E4	10	1.68	0.85	50.6	1.2	141.18	41.18
E5	11	1.79	1.2	67.04	1.5	125.0	25.0
E6	6	1.12	0.6	53.57	0.9	150.0	50.0
E7	8	1.34	0.75	55.97	1.0	133.33	33.33
E8	10	1.68	1.35	80.36	1.7	125.93	25.93
E9	10	1.68	0.9	53.57	1.75	194.44	94.44
E10	11	1.79	1.3	72.63	1.7	130.77	30.77
E11	8	1.34	1.1	80.09	1.5	136.36	36.36
E12	10	1.68	1.25	74.41	1.5	120.0	20.0
E13	12	1.87	1.25	66.85	1.6	128.0	28.0
E14	10	1.47	1.05	71.43	1.3	123.81	23.81
Mean	9.21	1.53	0.996	64.5	1.33	135.9	35.9
S.D.	1.71	0.23	0.255	11.4	0.31	18.9	18.9
Control Group							
C1	9	1.5	1.3	86.67	1.6	123.08	23.08
C2	7	1.15	0.55	47.83	0.8	145.46	45.46
C3	10	1.68	0.9	53.57	1.05	116.67	16.67
C4	12	1.87	1.2	64.87	1.35	112.5	12.5
C5	7	1.15	0.3	26.09	0.55	183.33	83.33
Mean	9	1.47	0.85	55.81	1.07	136.2	36.2
S.D.	2.12	0.32	0.424	22.3	0.49	29.3	29.3
Overall Mean	9.15	1.52	0.958	62.2	1.27	136.0	36.0
S.D.	1.77	0.25	0.302	14.8	0.35	21.0	21.0

FEV_1 - Forced Expiratory Volume in the first second
PNV - Predicted Normal Value
IPRB - Initial pre-bronchodilator
IPOB - Initial post-bronchodilator.

Fifteen minutes after the administration of ventolin inhalation, all the subjects had increased FEV_1 values. The increase ranged from 12.5% of IPRB value of FEV_1 to 94.4% with mean and S.D. of 36 ± 21.2%. The mean and S.D. percent increase in the experimental group were 35.9 ± 18.9% while they were 36.2 ± 29.3% in the control group. The difference in the two groups was not significant (X^2_3 = 4.457; P > 0.05).

4.1.3.3. Forced Vital Capacity (FVC)

The baseline (initial pre-bronchodilator) values of FVC in the entire subjects ranged from 0.51 litre to 1.7 litres with a mean and S.D. of 1.118 ± 0.311 litres (Table 6). The baseline values of FVC in the experimental group ranged from 0.7 litre to 1.7 litres with a mean and S.D. of 1.154 ± 0.2086 litres (Table 6). The baseline value of FVC in the control group ranged from 0.5 litre to 1.451 litres with a mean and S.D. of 1.02 ± 0.419 litres.

Table 6 shows the relationship between the base-line values of FVC and the PNV of FVC, it also shows

TABLE 6

Baseline values of FVC as related to PNV and initial post-bronchodilator values

Study Number	Age (years)	PNV of FVC	IPRB value of FVC(L)	% PNV of IPRB value	IPOB value of FVC(L)	% IPOB value of IPRB value	% Increase in IPRB value
Experimental Group							
E1	8	1.47	0.95	64.63	1.3	136.84	36.84
E2	8	1.47	0.75	51.02	1.05	140.0	40.0
E3	7	1.36	1.05	77.21	1.3	123.81	23.81
E4	10	1.89	1.05	55.56	1.5	142.86	42.86
E5	11	1.95	1.35	69.23	1.7	125.93	25.93
E6	6	1.27	0.7	55.12	1.1	157.14	57.14
E7	8	1.47	0.85	57.82	1.1	129.41	29.41
E8	10	1.89	1.7	89.95	1.95	114.71	14.71
E9	10	1.89	1.1	58.2	1.35	122.73	22.73
E10	11	1.95	1.4	71.8	1.85	132.14	32.14
E11	8	1.47	1.3	88.44	1.6	123.08	23.0
E12	10	1.89	1.4	74.07	1.7	121.43	21.43
E13	12	2.04	1.4	68.63	1.8	128.57	28.57
E14	10	1.6	1.15	71.88	1.45	126.09	26.09
Mean	9.21	1.69	1.15	68.1	1.48	137.48	37.48
S.D.	1.71	0.268	0.286	12.0	0.29	29.32	37.48
Control Group							
C1	9	1.66	1.45	87.35	1.7	117.24	17.24
C2	7	1.29	0.7	54.26	1.0	142.86	42.86
C3	10	1.89	1.05	55.56	1.25	119.05	19.05
C4	12	2.04	1.4	68.63	1.65	117.86	17.86
C5	7	1.29	0.5	38.76	0.7	140.0	40.0
Mean	9	1.63	1.02	60.9	1.26	127.4	27.4
S.D.	2.12	0.34	0.419	18.8	0.43	12.86	12.86
Overall Mean	9.15	1.67	1.118	66.2	1.42	134.83	34.83
S.D.	1.77	0.28	0.311	13.73	0.34	26.04	26.04

FVC - Forced Vital Capacity
PNV - Predicted Normal Value
IPRB - Initial pre-bronchodilator
IPOB - Initial post-bronchodilator.

the relationship between the baseline value of FVC and the initial post bronchodilator value. All the subjects had baseline FVC less than PNV of FVC. No subject had baseline value below 40% of PNV; while no subject had baseline value above 90% of PNV. There was no significant difference in the % PNV of the initial FVC in the two groups ($X_3^2 = 3.386$; $P > 0.05$).

From Tables 4, 5 and 6, the relationship between % PNV of baseline PFR and % PNV of baseline FVC and FEV_1 can be determined. Also the relationship between % PNV of baseline FEV_1 and % PNV of baseline FVC can be determined.

The correlation between % PNV of FVC and % PNV of FEV_1 is 0.9858.

$r = 0.9858$

$t = 24.07$

$p < 0.01$

The correlation between % PNV of FVC and % PNV of PFR is 0.7614

$r = 0.7614$

$t = 4.842$

$p < 0.01$

The correlation between % PNV of FEV_1 and % PNV of PFR is 0.7195

$r = 0.7195$

$t = 4.2685$

$P < 0.01$.

Fifteen minutes after the administration of ventolin inhalation, all the subjects had increased FVC values. The increase ranged from 14.7% to 57.14% with a mean and S.D. of 34.83 ± 26.04%. The mean and S.D. of percent increase in the experimental group were 37.48 ± 29.52 while they were 27.4 ± 12.86 in the control group (Table 6).

4.1.3.4 Baseline chest expansion (Appendix B5)

The chest expansion measurements at the three levels were the differences between maximum inspiration and maximum expiration.

Apical chest expansion measurements in the entire subjects ranged from 1cm to 4cm with a mean and S.D. of 2.79 ± 0.98. Apical measurements in the experimental group ranged from 1cm to 4cm with a mean and S.D. of

2.71 ± 1.03cm. The range in the control group was 2cm to 4cm with a mean and S.D. of 3 ± 1.0cm (Table 7).

The range of lateral costal expansion in the experimental group was 1.5cm to 6cm while it was from 1cm to 4cm in the control group. The mean and S.D. of lateral costal chest expansion in the experimental group were 3.14 ± 1.29cm while they were 2.4 ± 1.14cm in the controls.

Diaphragmatic expansion in the experimental group ranged from 1cm to 2.5cm with a mean and S.D. of 1.64 ± 0.57cm. While the controls had mean and S.D. of 1.4 ± 0.55cm (Table 7).

TABLE 7

MEAN BASELINE CHEST EXPANSION MEASUREMENTS

Level of chest expansion.	Experimental	Control
Apical	2.714 ± 1.032	3.0 ± 1.0
Lateral Costal	3.143 ± 1.292	2.4 ± 1.14
Diaphragmatic	1.643 ± 0.569	1.4 ± 0.548

There were no significant differences in the baseline chest expansion measurements at the three levels in the experimental and control groups.

t (apical) = 0.546)
t (lateral costal) = 1.207) P > 0.05
t (diaphragmatic) = 0.843)

4.1.4 Endurance exercise programme
(See Appendices D1 to D10)

The total attendance at exercise sessions by the experimental group ranged from 25 days (73.5% of regular attendance) to 33 days (97.1% of regular attendance) The regular attendance was 34 days as there were two public holidays during the programme. The mean and S.D. attendance were 27.1 ± 1.9 days. This was 79.7% of regular attendance (Table 8). Table 8 shows the number of times each subject was considered suitable for the day's exercise. Appendix D8 shows the individual mean repetition per minute for the entire 12 weeks of training for each exercise station. Table 9 shows the group weekly mean repetition per minute for each of the exercise stations. The pre- and post-exercise respiratory and pulse rates monitor are contained in Appendices D9 and D10 respectively.

T A B L E 8

Attendance and observations at exercise sessions

Study Number	Total attendance	Suitability for exercise (Number of times)	Occurrence of exercise-induced wheezing and discontinuation of exercise	Number of post-exercise bronchodilator inhalation	Severity of asthma
E1	27	26	1	1	Moderate
E2	25	25	0	0	Moderate
E3	27	26	0	0	Moderate
E4	27	25	1	5	Severe
E5	33	33	0	0	Moderate
E6	25	25	0	1	Moderate
E7	27	27	0	0	Mild
E8	28	28	0	0	Mild
E9	25	25	1	1	Moderate
E10	27	25	2	5	Moderate
E11	27	27	0	0	Moderate
E12	27	27	0	0	Mild
E13	27	26	0	2	Moderate
E14	27	27	0	0	Moderate
Mean	27.1	26.6	0.36	1.1	-
S.D.	1.9	2.1	.63	1.8	-

TABLE 9

Weekly mean repetition per minute for exercise performance at the stations

Week	Weekly mean repetition per minute						
	Station 1	Station 2	Station 3	Station 4	Station 5	Station 7	Station 10
1	3.3	50.9	46.8	14	31.3	-	-
2	3.0	41	40.1	7.7	27	-	-
3	3.4	46.7	46.1	8.7	29.9	-	-
4	2.9	41.1	36.0	7.6	25.3	-	-
5	3.2	45.5	42.2	0.1	28.5	3.3	-
6	3.0	41.6	40.2	8.4	25.6	3.8	-
7	3.2	43.6	43.1	8.2	26.4	4.4	-
8	2.9	34.6	38.2	7.1	23.3	4.1	-
9	2.9	38.2	35.7	5.9	22.6	3.8	-
10	2.5	31.3	30	5.4	19.6	3.3	-
11	2	28.2	26.5	5.0	17.8	3	24.9
12	1.5	22.7	20.9	3.8	14.1	4.3	22.5
Mean	2.8	39.2	37.2	7.6	24.3	3.8	23.7
S.D.	0.56	8.1	7.9	2.6	5.1	0.5	1.7

4.1.4.1 Discontinuation of exercise due to onset of exercise induced wheezing

None of the 14 subjects in the experimental group had full blown acute attacks of asthma as a result of exercise. Ten of the experimental subjects never had to discontinue from exercise due to onset of exercise induced wheezing. Three of these were mild asthmatics, while the remaining had moderate asthma.

The four subjects who had to discontinue exercise due to onset of wheezing, did so on a number of occasions which ranged from one to two times. Three of these subjects were moderate asthmatics, the fourth was a severe asthmatic (Table 8). Three of the subjects discontinued from the day's exercise only once. The only subject who discontinued twice was a moderate asthmatic. Table 10 shows the stage of the exercise programme at which discontinuation occurred. It shows that exercise was discontinued five times during the eighth week and four times during the twelfth week.

4.1.4.2 Administration of post exercise bronchodilator inhalation

Eight of the subjects in the experimental group did not require post exercise bronchodilator (Salbutamol) inhalation throughout the 12 weeks of exercise.

TABLE 10

Discontinuation of exercise and post-exercise bronchodilator inhalation

Week	Number of exercise stations	Duration per station (mins)	Discontinuation of exercise	Number of post-exercise inhalations of bronchodilator
1	5	1.0	0	1
2	5	1.5	1	1
3	6	1.5	0	0
4	6	2.0	0	0
5	7	2.0	1	1
6	7	2.5	0	0
7	8	2.5	0	1
8	8	3.0	1	5
9	9	3.0	1	2
10	9	3.5	0	0
11	10	3.5	0	0
12	10	4.0	1	4
Total	-	-	5	15

This included all the three mild asthmatics who were in the experimental group.

The six subjects who required post-exercise bronchodilator inhalation, had it from between one and five times throughout the 12 weeks of exercise. Post-exercise salbutamol inhalation was required 15 times out of a total of 372 possible times, this was about four per cent of the total times possible(4% of 372 times)

Three of these subjects required bronchodilator inhalation just once, they were both moderate asthmatics. One subject required two inhalations. He was a moderate asthmatic. The two subjects who required five inhalations each, were made up of one moderate and one severe asthmatic. Table 10 shows the stage of the exercise programme of which post-exercise bronchodilator inhalations were required.

4.1.5 Effects of training on pulmonary function tests (See Appendices B2, B3, B4 and B5).

The effects of training or lack of training on the pulmonary function tests were determined by the changes from the baseline pulmonary function tests through the six fortnightly reassessments to the final assessments. The number of subjects who were present for each of these assessments had effect on the mean values. Table 11 shows the attendance at the testing sessions.

TABLE 11

Attendance at pulmonary function testing sessions

Testing Session	Number and per cent of subjects present		
	Experimental n = 14	Control n = 5	Total n = 19
Initial or baseline	14(100%)	5(100%)	19 (100%)
Reassessment 1 (At the end of 2 weeks)	11(78.6%)	5(100%)	16(84.2%)
Reassessment 2 (At the end of 4 weeks)	11(78.6%)	3(60%)	14 (73.7%)
Reassessment 3 (At the end of 6 weeks)	14(100%)	2(40%)	16(84.2%)
Reassessment 4 (At the end of 8 weeks)	10(71.4%)	4(80%)	14(73.7%)
Reassessment 5 (At the end of 10 weeks)	11(78.6%)	3(60%)	13(68.4%)
Reassessment 6 (At the end of 12 weeks)	9(64.3%)	2(40%)	11(57.9%)
Final	14(100%)	5(100%)	19(100%)

4.1.5.1 Peak Flow Rate (PFR)

The final value of PFR (Final pre-bronchodilator value) in the subjects at the end of 12 week-programme ranged from 140 litres/minute to 350 litres/minute with a mean and S.D. of 241.58 ± 64.16 litres/minute (Table 12). The range of final pre-bronchodilator (FPRB) value in the experimental group was 170 litres/minute to 350 litres/minute with a mean and S.D. of 257.14 ± 61.85 litres/minute. The range in the control group was 140 litres/minute to 270 litres/minute with a mean and S.D. of 198.53 ± 53.57 litres/minute. Table 13 shows the relationship between initial pre-bronchodilator and final pre-bronchodilator values of PFR.

Analysis of the relationship between the initial and final pre-bronchodilator values of PFR to predicted normal value showed that five experimental subjects had final pre-bronchodilator PFR greater than 100% of PNV but none of the controls did.

The changes which occured in the mean resting PFR values from initial pre-bronchodilator value through the six fortnightly re-assessments to the final pre-bronchodilator value are shown in Table 14.

Table 15 shows the changes which occurred in the per cent differences between mean PNV and mean resting values of PFR (initial and final pre-bronchodilator and pre-exercise values of reassessments one to six).

TABLE 12

Changes in % PNV of initial and final pre-bronchodilator PFR values

Study Number	Age/Sex	Severity of Asthma	Final Pre-bronchodi-lator value	% PNV of I.PR.B. value	% PNV of F.PR.B. value	Diffe-rence	Increase (Change) in % PNV
Experimental Group							
E1	8/M	Moderate	280	88.5	107.7	19.2	21.7
E2	8/M	Moderate	220	71.1	84.6	13.5	19.0
E3	7/M	Moderate	200	82.9	97.2	9.3	11.2
E4	10/M	Severe	190	61.2	64.2	3	4.9
E5	11/M	Moderate	340	80.6	106.7	26.1	32.4
E6	6/F	Moderate	170	55.2	93.9	38.7	70.1
E7	8/M	Mild	185	57.7	71.2	13.5	23.4
E8	10/M	Mild	350	81.6	119.1	37.5	46.0
E9	10/M	Moderate	210	54.4	71.4	17	31.3
E10	11/M	Moderate	255	64.5	82.3	17.8	27.6
E11	8/M	Moderate	290	80.8	111.5	30.7	38
E12	10/M	Mild	290	61.2	98.6	37.4	61.1
E13	12/F	Moderate	340	28.3	102.4	24.1	30.8
E14	10/F	Moderate	280	76.2	99.6	23.4	30.7
Mean	9.2	-	257.14	71.0	93.2	22.23	32.0
S.D.	1.7		61.85	11.7	16.5	11.0	17.64
Control Group							
C1	9/M	Moderate	210	66.7	77.8	11.1	16.6
C2	7/F	Moderate	150	60.2	69.4	9.2	15.3
C3	10/M	Moderate	220	68.0	74.8	6.8	10.0
C4	12/F	Severe	270	78.3	81.3	3	3.8
C5	7/F	Mild	140	55.6	64.8	9.2	16.5
Mean	9	-	198.0	65.76	73.62	7.86	12.44
S.D.	2.1	-	+ 53.57	3.62	6.58	3.12	5.36
Overall Mean	9.1	-	241.58	69.6	88.08	18.45	26.86
S.D.	1.8	-	64.16	11.0	16.9	11.48	17.64

I.PR.B - Initial pre-bronchodilator
F.PR.B - Final pre-bronchodilator
PNV - Predicted Normal Value.

T A B L E 13

Differences between the means of the initial and final pre-bronchodilator PFR values

Group	Mean initial pre-bronchodilator PFR(l/min)	Mean final pre-bronchodilator PFR (l/min)	Difference	Per cent increase	t-value	P-value
Experimental n = 14	197.5 ± 44.49	257.14 ± 61.85	59.6	30.2	2.84	P < 0.01
Control n = 5	178.0 ± 56.75	198.0 ± 53.57	20	11.2	0.62	N.S

N.S. = Not Significant

TABLE 14

Changes in mean resting PFR values during the programme

Testing Session	Resting PFR (litres/minute)	
	Experimental	Control
Initial pre-bronchodilator	197.5 ± 44.5	178 ± 56.75
Reassessment 1	199.09 ± 47.82	179 ± 56.5
Reassessment 2	215.00 ± 52.15	176 ± 32.14
Reassessment 3	220.71 ± 51.25	200 ± 75.5
Reassessment 4	240.5 ± 49.35	188.75 ± 64.85
Reassessment 5	261.82 ± 60.84	193.33 ± 37.86
Reassessment 6	260.55 ± 72.91	205 ± 91.92
Final pre-bronchodilator	257.14 ± 61.85	198 ± 53.57

There was a significant difference ($t = 4.076$; $P < 0.01$) between the % PNV of the initial and final pre-bronchodilator PFR values in the experimental group, while the difference was not significant ($t = 1.62$; $P > 0.05$) in the control group (Table 12).

TABLE 15

Changes in % difference between mean PNV and mean resting PFR values

Testing Session	% difference between Mean PNV and Mean resting values	
	Experimental	Control
Initial pre-broncho-dilator	-28.31 ± 12.21	-34.25 ± 8.64
Reassessment 1	-28.04 ± 11.87	-33.87 ± 8.97
Reassessment 2	-20.45 ± 11.56	-32.26 ± 2.77
Reassessment 3	-21.42 ± 12.94	-28.45 ± 13.97
Reassessment 4	-15.22 ± 16.36	-28.43 ± 10.67
Reassessment 5	-6.21 ± 14.9	-25.88 ± 6.45
Reassessment 6	-6.12 ± 18.62	-26.93 ± 11.68
Final pre-broncho-dilator	-6.51 ± 16.67	-26.362± 6.58

Table 16 shows the paired t-tests between the initial pre-bronchodilator PFR values and each of the subsequent assessments. Table 17 shows the analysis of variance (ANOVA) of PFR values for the eight stages of the programme.

TABLE 16

Paired t-tests between the initial pre-bronchodilator PFR and each of the subsequent assessments.

Paired tests	Experimental		Control	
	t-value	P-value	t-value	P-value
Initial pre-bronchodilator versus reassessment 1	-0.04	N.S	-0.02	N.S
Initial pre-bronchodilator versus reassessment 2	-0.76	N.S	-0.03	N.S
Initial pre-bronchodilator versus reassessment 3	-1.09	N.S	-0.53	N.S
Initial pre-bronchodilator versus reassessment 4	-1.99	N.S	-0.35	N.S
Initial pre-bronchodilator versus reassessment 5	-2.88	P<0.01	-0.34	N.S
Initial pre-bronchodilator versus reassessment 6	-2.66	P<0.05	-0.62	N.S
Initial pre-bronchodilator versus final pre-bronchodilator	-2.84	P<0.01	-0.62	N.S

N.S = Not Significant.

TABLE 17

Analysis of variance table for PFR for the eight stages of the programme

Source of variance	Degrees of freedom		Sum of squares		Mean squares		F-ratio		F-probability	
	Expt.	Control	Expt.	Control	Expt.	Control	Expt.	Control	Expt.	Control
Between groups	7	7	59808.20	4314.70	8544.03	616.39	2.84	0.16	P<0.05	N.S
Within groups	87	22	261403.90	83132.0	3004.64	3778.74				
Total	94	29	321212.10	87447.0						

Pooled estimate of S.D. - Expt. = 54.81462

Control = 61.471464

N.S. = Not significant

Post exercise fall in resting (pre exercise) value of PFR constituted exercise induced broncho-constriction (EIB) or EIA. The severity of EIB was determined by the degree of fall in the resting value at any given time post exercise. EIB was represented in this study as percent of resting value at one minute and 10 minutes post exercise (Table 18). Changes in EIB which only applied to subjects in the experimental group were as shown in Table 18. Figure 14 shows changes in EIB with total duration of exercise while Figure 15 shows changes in EIB with number of exercise stations.

4.1.5.2 Forced Expiratory Volume in the First Second (FEV_1)

The final pre-bronchodilator value of FEV_1 in the subjects ranged from 0.4 litre to 1.85 litres with a mean and S.D. of 1.176 ± 0.34 litres. The range of final pre-bronchodilator FEV_1 in the experimental group was 0.8 litre to 1.85 litres with a mean and S.D. of 1.27 ± 0.273 litres. The range in the control group was 0.4 litre to 1.35 litres with a mean and S.D. of 0.91 ± 0.4 (Table 19).

TABLE 18

Changes in exercise-induced bronchoconstriction (EIB) as % difference from mean pre-exercise values of PFR

Testing session	% difference from mean pre-exercise PFR	
	EIB at 1 minute post exercise	EIB at 10 minutes post exercise
Reassessment 1	10.20 ± 3.29	-1.28 ± 3.49
Reassessment 2	15.15 + 6.52	2.7 + 3.75
Reassessment 3	14.77 ± 5.29	0.74 ± 3.84
Reassessment 4	15.68 ± 6.12	3.82 ± 1.28
Reassessment 5	13.07 ± 6.97	3.89 ± 1.17
Reassessment 6	14.07 ± 6.97	3.98 ± 1.48

EIB = Exercise-Induced Bronchoconstriction.

t(EIB at 1 min for R_1 versus R_6) = -1.88 (N.S)

t(EIB at 10 mins for R_1 versus R_6) = -5.19 ($P < 0.01$)

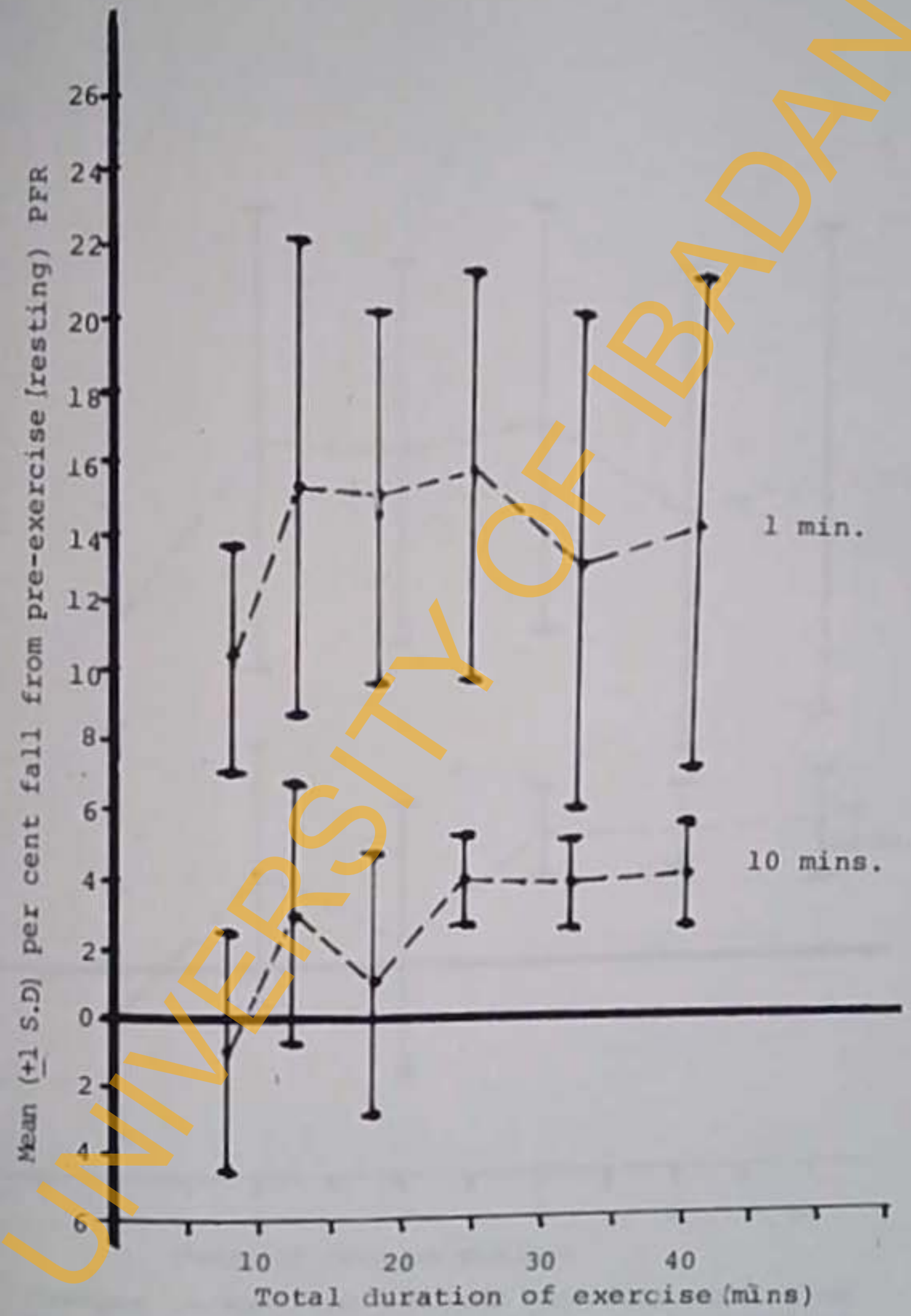

Figure 14: Relationship between changes in exercise-induced bronchoconstriction (EIB) (from PFR) and total duration of exercise.

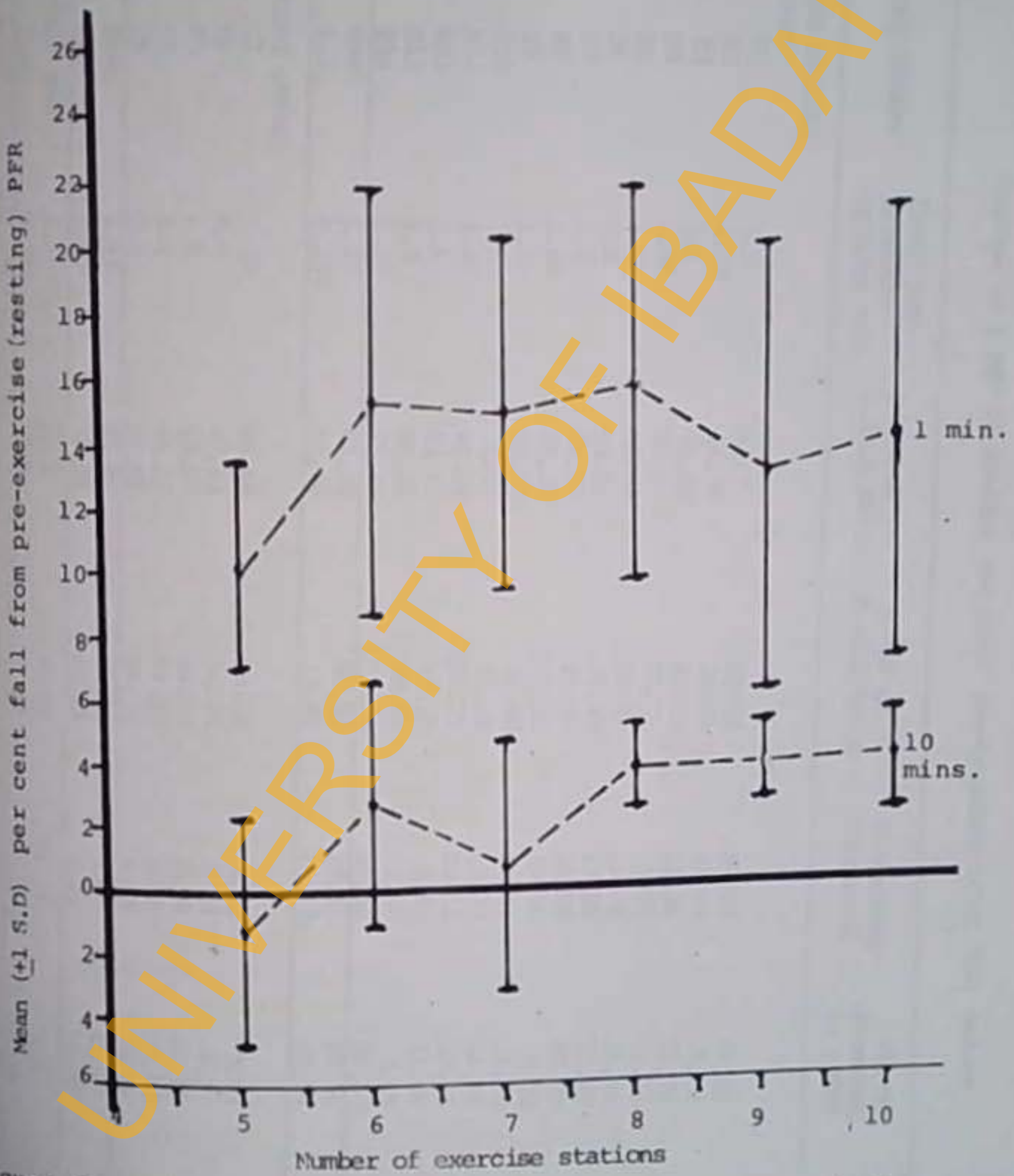

Figure 15: Changes in exercise-induced bronchoconstriction (EIB) (from PFR) and number of exercise stations.

TABLE 19

Changes in % PNV of initial and final pre-bronchodilator FEV_1 values

Study Number	Final pre-bronchodilator FEV_1	% PNV of I.PR.B.Value	% PNV of F.PR.B.Value	Difference (increase)	change (increase) in % PNV
Experimental group:					
E1	1.2	59.7	89.55	29.85	50.00
E2	1.05	44.78	78.36	33.58	75.00
E3	1.1	71.97	83.33	11.36	15.78
E4	0.95	50.6	56.55	5.95	11.76
E5	1.45	67.04	81.01	13.96	20.84
E6	0.8	53.57	71.43	17.85	33.20
E7	1.2	55.97	89.55	33.58	60.00
E8	1.85	80.36	110.12	29.76	37.03
E9	1.1	53.57	64.48	10.91	15.08
E10	1.6	72.63	83.38	10.75	14.80
E11	1.45	80.09	108.21	28.12	35.11
E12	1.4	74.41	83.33	8.92	11.99
E13	1.3	66.85	69.52	2.67	3.99
E14	1.35	71.43	91.84	20.41	28.57
Mean	1.27	64.50	82.90	18.41	29.50
S.D.	0.237	11.40	14.98	10.73	20.54
Control group:					
C1	1.35	86.68	90.00	3.32	3.83
C2	0.6	47.83	52.17	4.34	8.1
C3	1.0	53.57	59.52	5.95	11.11
C4	1.2	64.17	64.17	0.00	0.00
C5	0.4	26.09	34.78	8.69	33.31
Mean	0.91	55.81	60.13	4.46	11.27
S.D.	0.40	72.30	20.09	3.21	13.02
Overall Mean	1.197	62.2	76.90	14.74	24.7
S.D.	0.355	14.8	10.92	11.19	20.26

I.PR.B. = Initial pre-bronchodilator F.PR.B. = Final pre-bronchodilator

Table 20 shows the changes which occured in the initial and final pre-bronchodilator values of FEV_1. The changes which occurred in the mean resting FEV_1 values from the initial pre-bronchodilator values through the six fortnightly reassessments to the final pre-bronchodilator values are shown in Table 21.

Table 19 shows that two (10.5%) patients had final pre-bronchodilator FEV_1 greater than 100% of PNV none of the baseline values exceeded 90% of PNV. The relationship between the initial and final pre-bronchodilator FEV_1, to PNV of FEV_1 is as shown in Table 19. The changes which occurred in the per cent difference between mean PNV of FEV_1 and mean resting values of FEV_1 (initial and final pre-bronchodilator values of FEV_1 and pre-exercise FEV_1 of reassessments 1 to 6) are shown in Table 22. There was a significant difference ($t = 3.06$; $P<0.01$) between the mean % PNV of the initial and final pre-bronchodilator FEV_1 values in the experimental group, while the difference was not significant ($t = 0.322$; $P>0.05$) in the control group (Table 19).

Table 23 shows the paired t-tests between the initial

TABLE 20

Differences between the means of the initial and final pre-bronchodilator values of FEV_1

Group	Number of subjects	Initial pre-bronchodilator FEV_1 (L)	Final pre-bronchodilator FEV_1 (L)	Difference	% Difference	t-value	P-value
Experimental	14	0.996 ± 0.225	1.27 ± 0.237	0.274	27.5	2.66	P<0.05
Control	5	0.85 ± 0.424	0.91 ± 0.4	0.06	7.059	0.46	N.S

L = litres

N.S = Not Significant

TABLE 21

Changes in mean resting FEV_1 during the programme

Testing Session	Resting FEV_1 (litres)	
	Experimental	Control
Initial pre-bronchodilator	0.996 ± 0.255	0.85 ± 0.424
Reassessment 1	1.0 ± 0.25	0.82 ± 0.41
Reassessment 2	1.013 ± 0.25	0.917 ± 0.325
Reassessment 3	1.1 ± 0.26	1.2 ± 0.07
Reassessment 4	1.265 ± 0.29	0.788 ± 0.42
Reassessment 5	1.295 ± 0.3	0.966 ± 0.35
Reassessment 6	1.255 ± 0.31	0.8 ± 0.566
Final pre-bronchodilator	1.27 ± 0.273	0.91 ± 0.40

TABLE 22

Changes in % difference between mean PNV and mean resting FEV_1 values

Testing Session	% difference between mean PNV and resting FEV_1 values	
	Experimental	Control
Initial pre-bronchodilator	-35.36 ± 11.63	-44.34 ± 22.22
Reassessment 1	-35.78 ± 11.37	-43.73 ± 23.24
Reassessment 2	-31.98 ± 11.44	-36.97 ± 17.6
Reassessment 3	-28.43 ± 11.78	-28.58 ± 4.21
Reassessment 4	-18.66 ± 16.81	-38.88 ± 27.54
Reassessment 5	-18.09 ± 14.73	-33.88 ± 18.17
Reassessment 6	-17.94 ± 17.18	-38.49 ± 37.8
Final pre-bronchodilator	-16.60 ± 15.0	-35.6 ± 23.2

pre-bronchodilator FEV_1 values and each of the subsequent assessments. Table 24 shows the analysis of variance (ANOVA) of FEV_1 values for the eight stages of the programme.

The changes in EIB as determined by post exercise measurements of FEV_1 at one minute and 10 minutes are as shown in Table 25.

4.1.5.3 Forced Vital Capacity (FVC)

The range of final pre-bronchodilator FVC in the entire subjects was 0.6 litre to 1.9 litres with a mean and S.D of 1.3 $\pm$ 0.346. FVC in the experimental subjects ranged from 0.95 litre to 1.9 litres with a mean and S.D. of 1.35 $\pm$ 0.3. The range of pre-bronchodilator FVC in tne control subjects was from 0.6 litre to 1.6 litres with a mean and S.D. of 1.15 $\pm$ 0.455 litres (Table 26).

Table 27 shows the changes which occurred in the initial and final pre-bronchodilator values of FVC during the programme. The changes which occurred in the mean resting FVC values from the mean initial pre-bronchodilator FVC through the six fortnightly

TABLE 23

Paired t-tests between initial pre-bronchodilator FEV_1 and each of the subsequent assessments

Paired tests	Experimental		Control	
	t-value	P-value	t-value	P-value
Initial pre-bronchodilator versus reassessment 1	-0.16	N.S	0.07	N.S
Initial pre-bronchodilator versus reassessment 2	-0.16	N.S	-1.19	N.S
Initial pre-bronchodilator versus reassessment 3	-1.07	N.S	-1.31	N.S
Initial pre-bronchodilator versus reassessment 4	-2.37	P<0.05	-0.23	N.S
Initial pre-bronchodilator versus reassessment 5	-2.71	P<0.05	-0.33	N.S
Initial pre-bronchodilator versus reassessment 6	-2.22	P<0.05	-0.37	N.S
Initial pre-bronchodilator versus final pre-bronchodilator	-2.66	P<0.01	-0.46	N.S

N.S = Not Significant

TABLE 24

Analysis of variance for FEV_1 for the eight stages of the programme

Source of variance	Degrees of freedom		Sum of squares		Mean squares		F-ratio		F-probability	
	Expt.	Control	Expt.	Control	Expt.	Control	Expt.	Control	Expt.	Control
Between groups	7	7	1.41	0.46	0.20	0.07	2.70	0.29	P<0.05	N.S
Within groups	85	21	6.36	4.81	0.07	0.23				
Total	92	28	7.77	5.27						

Pooled estimate of S.D. - Expt = 0.27355244

Control = 0.47869286

N.S = Not Significant

TABLE 25

Changes in EIB as % difference from mean pre-exercise values of FEV_1

Testing Session	% difference from mean pre-exercise FEV_1	
	EIB at 1 minute post exercise	EIB at 10 minutes post exercise
Reassessment 1	13.07 ± 7.67	6.1 ± 2.86
Reassessment 2	16.05 ± 6.13	6.15 ± 2.57
Reassessment 3	16.59 ± 6.69	3.89 ± 4.9
Reassessment 4	16.32 ± 6.32	5.57 ± 4.2
Reassessment 5	19.84 ± 5.61	6.92 ± 2.9
Reassessment 6	22.38 ± 8.95	6.85 ± 4.28

EIB = Exercise-induced bronchoconstriction

t(EIB at 1 min. for R_1 versus R_6) = -3.0 ($P < 0.01$)

t(EIB at 10 mins. for R_1 verus R_6) = -0.547 (N.S)

TABLE 25

Changes in EIB as % difference from mean pre-exercise values of FEV_1

Testing Session	% difference from mean pre-exercise FEV_1	
	EIB at 1 minute post exercise	EIB at 10 minutes post exercise
Reassessment 1	13.07 ± 7.67	6.1 ± 2.86
Reassessment 2	16.05 ± 6.13	6.15 ± 2.57
Reassessment 3	16.59 ± 6.69	3.89 ± 4.9
Reassessment 4	16.32 ± 6.32	5.57 ± 4.2
Reassessment 5	19.84 ± 5.61	6.92 ± 2.9
Reassessment 6	22.38 ± 8.95	6.85 ± 4.28

EIB = Exercise-induced bronchoconstriction

t(EIB at 1 min. for R_1 versus R_6) = -3.0 ($P < 0.01$)

t(EIB at 10 mins. for R_1 verus R_6) = -0.547 (N.S)

TABLE 26

Changes in % PNV of the initial and final pre-bronchodilator FVC values

Study Number	Final pre-bronchodilator FVC (Litre)	% PNV of I.PR.B.FVC	% PNV of F.PR.B.FVC	Difference	% Difference
Experimental Group					
E1	1.2	64.63	81.63	17.00	26.3
E2	1.0	51.02	68.03	17.01	33.3
E3	1.2	77.21	88.24	11.03	14.29
E4	1.3	55.56	68.78	13.22	23.74
E5	1.7	69.23	87.18	17.95	25.93
E6	0.95	55.12	74.8	19.68	35.7
E7	1.0	57.82	68.03	10.21	17.66
E8	1.9	89.95	100.53	10.58	11.71
E9	1.2	58.2	63.49	5.29	9.09
E10	1.55	71.8	79.49	7.69	10.71
E11	1.4	88.44	95.24	6.8	7.69
E12	1.5	74.07	79.37	5.3	7.16
E13	1.8	68.63	88.24	19.61	28.57
E14	1.3	71.88	81.25	9.37	13.04
Mean	1.36	68.11	80.31	12.2	18.92
S.D	0.3	12.0	10.89	5.2	9.8
Control Group					
C1	1.6	87.35	96.39	9.04	10.35
C2	0.8	54.36	62.02	7.76	14.2
C3	1.15	55.56	60.85	5.76	10.37
C4	1.6	68.63	78.43	9.8	14.28
C5	0.6	38.76	46.7	7.74	19.97
Mean	1.15	60.91	68.84	8.02	13.85
S.D	0.45	18.18	19.11	1.54	3.94
Overall Mean	1.3	65.69	77.29	11.1	17.59
S.D	0.35	14.96	13.91	4.9	8.85

I.PR.B. = Initial pre-bronchodilator F.PR.B. = Final pre-bronchodilator

TABLE 27

Differences between the means of the initial and final pre-bronchodilator values of FVC

Group	Number of subjects	Initial pre-bronchodilator FVC (Litres)	Final pre-bronchodilator FVC (Litres)	Difference	% Difference	t-value	P-value
Experimental	14	1.15 ± 0.286	1.36 ± 0.3	0.21	18.26	1.99	N.S
Control	5	1.02 ± 0.419	1.15 ± 0.45	0.31	12.75	0.21	N.S

reassessments to the final pre-bronchodilator FVC are shown in Table 28.

The relationship between the initial and final pre-bronchodilator FVC and the predicted normal FVC is shown in Table 26. It shows that only one subject had a final pre-brochodilator FVC more than 100% of PNV of FVC. The changes which occurred in the per cent difference between mean PNV of FVC and mean of the resting values are shown in Table 29. There was a significant difference ($t = 2.82$; $P<0.01$) between the mean % PNV of the initial and final pre-bronchodilator FVC values in the experimental group, while the difference was not significant ($t = 0.066$; $P>0.05$) in the control group (Table 26).

Table 30 shows the paired t-tests between the initial pre-bronchodilator FVC values and each of the subsequent assessments. Table 31 shows the analysis of variance (ANOVA) of FVC values for the eight stages of the programme.

Changes in exercise induced bronchoconstriction (EIB) is determined by post exercise fall in pre-exercise FVC at 10 minutes and at one minute are shown in Table 32.

TABLE 28

Changes in mean resting FVC values during the programme

Testing Session	Resting FVC (Litres)	
	Experimental	Control
Initial pre-bronchodilator	1.15 ± 0.29	1.02 ± 0.41
Reassessment 1	1.18 ± 0.3	1.01 ± 0.41
Reassessment 2	1.19 ± 0.32	1.07 ± 0.33
Reassessment 3	1.23 ± 0.29	1.45 ± 0.07
Reassessment 4	1.33 ± 0.29	1.06 ± 0.53
Reassessment 5	1.36 ± 0.28	1.13 ± 0.35
Reassessment 6	1.38 ± 0.36	1.075± 0.74
Final pre-bronchodilator	1.36 ± 0.3	1.15 ± 0.45

TABLE 29

Changes in % difference between mean PNV of FVC and mean resting FVC values

Testing Session	% difference between mean PNV and resting FVC values	
	Experimental	Control
Initial pre-bronchodilator	-32.01 ± 12.15	-39.09 ± 18.18
Reassessment 1	-31.08 ± 11.03	-42.14 ± 16.48
Reassessment 2	-27.7 ± 12.45	-33.99 ± 15.92
Reassessment 3	-26.79 ± 12.61	-29.65 ± 19.77
Reassessment 4	-22.94 ± 14.37	-41.68 ± 22.3
Reassessment 5	-22.18 ± 9.49	-29.81 ± 17.57
Reassessment 6	-19.86 ± 13.77	-49.27 ± 11.45
Final pre-bronchodilator	-19.85 ± 11.13	-35.05 ± 18.65

TABLE 30

Paired t-tests between initial pre-bronchodilator FVC and each of the subsequent assessments

Paired tests	Experimental		Control	
	t-value	P-value	t-value	P-value
Initial pre-bronchodilator versus reassessment 1	-0.41	N.S	-0.25	N.S
Initial pre-bronchodilator versus reassessment 2	-0.45	N.S	-0.17	N.S
Initial pre-bronchodilator versus reassessment 3	-0.35	N.S	-0.80	N.S
Initial pre-bronchodilator versus reassessment 4	-1.79	N.S	-0.37	N.S
Initial pre-bronchodilator versus reassessment 5	-1.92	N.S	-0.71	N.S
Initial pre-bronchodilator versus reassessment 6	-1.92	N.S	-0.46	N.S
Initial pre-bronchodilator versus final pre-bronchodilator	-1.99	N.S	-0.21	N.S

N.S = Not Significant

TABLE 30

Paired t-tests between initial pre-bronchodilator FVC and each of the subsequent assessments

Paired tests	Experimental		Control	
	t-value	P-value	t-value	P-value
Initial pre-bronchodilator versus reassessment 1	-0.41	N.S	-0.25	N.S
Initial pre-bronchodilator versus reassessment 2	-0.45	N.S	-0.17	N.S
Initial pre-bronchodilator versus reassessment 3	-0.35	N.S	-0.80	N.S
Initial pre-bronchodilator versus reassessment 4	-1.79	N.S	-0.37	N.S
Initial pre-bronchodilator versus reassessment 5	-1.92	N.S	-0.71	N.S
Initial pre-bronchodilator versus reassessment 6	-1.92	N.S	-0.46	N.S
Initial pre-bronchodilator versus final pre-bronchodilator	-1.99	N.S	-0.21	N.S

N.S = Not Significant

TABLE 31

Analysis of variance table for FVC for the eight stages of the programme

Source of variance	Degrees of freedom		Sum of squares		Mean Squares		F-ratio		F-probability	
	Expt.	Control	Expt.	Control	Expt.	Control	Expt.	Control	Expt.	Control
Between groups	7	7	0.93	0.28	0.13	0.04	1.49	0.28	N.S	N.S
Within groups	85	21	7.60	3.04	0.09	0.14				
Total	92	28	8.53	3.32						

Pooled estimated of S.D - Expt = 0.29897118

Control = 0.38055936

N.S = Not Significant

TABLE 32

Changes in EIB as % difference from mean pre-exercise value of FVC.

Testing Session	% difference from mean pre-exercise FVC	
	Experimental	Control
Reassessment 1	16.6 ± 9.2	8.0 ± 7.6
Reassessment 2	15.4 ± 4.6	6.0 ± 3.7
Reassessment 3	16.5 ± 10.1	4.0 ± 4.3
Reassessment 4	23.3 ± 5.1	5.6 ± 2.1
Reassessment 5	24.0 ± 5.2	6.7 ± 3.4
Reassessment 6	25.1 ± 6.8	9.2 ± 7.5

t(EIB at 1 min. for R1 versus R6) = -2.77 ($P < 0.05$)
t(EIB at 10 mins. for R1 versus R6) = -0547 (N.S)

4.1.5.4 Chest expansion

The effect of the programme on the chest expansion measurements at various levels was as shown in Table 33. There were increases in the chest expansion at the three levels in both groups. However, only the increases in the apical and diaphragmatic expansions in the experimental group were significant.

TABLE 33

Effect of training on the mean values of chest expansion measurements

Test	Apical Expansion		Lateral Costal Expansion		Diaphragmatic Expansion	
	Expt.	Control	Expt.	Control	Expt.	Control
Pre-programme	2.71 ± 1.03	3.0 ± 1.0	3.14 ± 1.29	2.4 ± 1.14	1.61 ± 0.53	1.4 ± 0.55
Post-programme	4.14 ± 1.2	3.7 ± 1.2	3.96 ± 1.41	3.2 ± 1.15	2.40 ± 1.06	2.3 ± 1.2
Mean difference	1.43	0.7	0.82	0.8	0.85	0.9
t-value	3.38	1.0	1.58	1.11	2.68	1.52
P-value	P<0.01	N.S	N.S	N.S	P<0.05	N.S

N.S = Not Significant

4.1.6 Effects of training on the clinical status of asthma during the programme (See Appendix E1)

The number of asthmatic attacks in the entire subjects during the 12-week period of the programme ranged from no attack to three attacks with a mean and S.D of 0.63 ± 0.80. Nine of the subjects had asthma attacks during the programme while the remaining ten were symptom-free. Four of the nine subjects who had asthma during the programme were in the control group while five subjects were in the experimental group. The relationship between number of asthma attacks before programme and during programme is shown in Table 34.

None of the subjects was admitted into hospital on account of asthma throughout the 12-week period of the programme.

The number of attendances at the Asthma clinic in the entire subjects ranged from one to six times with a mean and S.D. of attendance of 3.4 ± 1.6. The mean and S.D. of attendance in the experimental subjects were 3.1 ± 1.5, while the mean and S.D. of attendance in the controls were 4.0 ± 1.7. The frequency of intermittent bronchodilator were 1.8 and 3.0 times for the experimental and control groups respectively.

TABLE 34

Differences between mean number of asthmatic attacks three months before the programme and during the programme

Group	Number of subjects	Before programme	During programme	Difference	% Decrease	t-value	P-value
Experimental	14	1.6 ± 1.4	0.36±0.48	1.24	77.5	-3.135	P<0.01
Control	5	2.4 + 1.5	1.4 +1.0	1.00	41.7	-1.25	N.S

N.S = Not significant

The daily dosage of salbutamol (routine bronchodilator) required by the experimental subjects ranged from 2 mg to 12 mg with a mean and S.D. of 6.0 ± 3.5 mg. The daily dosage of salbutamol required by the control subjects ranged from 2 mg to 12 mg with a mean and S.D. of 6.4 ± 3.2 mg. Table 35 shows an overall reduction (though not statistically significant) in the daily dosage of salbutamol during the programme.

In the 12-week period of the programme, the 17 subjects who were attending school missed an aggregate of 24 school days on account of asthma compared with the 73 school days missed during three months before the programme. The 12 subjects in the experimental group missed ten days compared with 56 days before the programme. This was a significant reduction ($t = -2.29$; $P<0.05$). The five subjects in the control group missed 14 days compared with the 28 days before the programme (Table 36). The decrease was not significant in the controls ($t = -0.732$; $P>0.05$).

TABLE 35

Differences between mean daily dosage of salbutamol three months before the programme and during programme

Group	Number of subjects	Mean dosage of salbutamol before programme (mg)	Mean dosage during programme (mg)	Mean difference (mg)	% decrease	t-value	P-value
Experimental	14	6.6 ± 3.2	6.0 ± 3.5	0.6	9.1	-0.474	N.S
Control	5	6.5 ± 3.2	6.4 ± 3.2	0.1	1.5	-0.049	N.S

TABLE 36

Difference between absenteeism from school on account of asthma three months before programme and during programme

Group	Number of subjects	Absenteeism (days) before programme	Absenteeism (days) during programme	Difference (days)	% decrease	t-value	P-value
Experimental	12	56	10	46	82.1	-2.229	P<0.05
Control	5	28	14	14	50.0	-0.732	N.S

4.1.6.1 Six weeks post-programme follow-up

The clinical status of each of the subjects was followed up for a period of six weeks after the programme (See Appendix E2). On the whole, there was no worsening of the clinical status of the children. Nine of the subjects in the experimental group and four controls were symptom-free during the follow-up period.

4.1.7 Effects of training on the physical characteristics of the entire subjects (See Appendix C2)

The changes in some anthropometric features of the subjects are shown in Table 37. Both the experimental and control groups had increases in the mean lean body weight by the end of the programme. The experimental group had a mean increase in the per cent body fat while the controls had a mean decrease. However, none of the changes were significant.

4.1.8 Subjective evaluation of programme by parents (See Appendices F1 and F2)

This evaluation was done by the parent or guardian of the 14 experimental subjects who usually brought the subjects for the exercise sessions.

TABLE 37

Effect of training on the mean values of some anthropometric features

Test	Per cent body fat		Lean Body Weight (kg)	
	Experimental	Control	Experimental	Control
Pre-programme	18.0±1.9	19.6±2.6	19.6 ± 4.6	16.6 ± 4.3
Post-programme	18.5±1.9	19.4±2.4	20.4 ± 4.6	17.7 ± 4.3
Mean difference	0.5	-0.2	0.80	1.10
t-value	0.696	-0.127	0.46	0.404
P-value	N.S	N.S	N.S	N.S

N.S = Not significant

No parent wanted the training programme to discontinue; some wanted the frequency to remain at three times weekly while others wanted a weekly exercise session. Most parents felt that the exercise was not too strenuous; it was just alright. No parent wanted the intensity increased while two parents wanted the intensity reduced. On getting home after exercise, most of the children were not tired but remained playful and excited all day. Most of the children looked forward to the next exercise session. During the programme, the parents noticed that the intensity of group plays at home increased in nine subjects. The intensity of running around and doing other household chores increased in seven subjects.

Twelve of the parents felt that the frequency of asthmatics attacks had decreased in their children although the clinical records of three of the subjects showed no change in the frequency; no parent felt that the frequency had increased. All the parents observed a decrease in the frequency of their children being unwell during the programme while seven parents reported that they observed increased activity and alertness in

their children during the programme. Ten parents saw the exercise as part of the treatment of asthma while four (21.1%) parents were not sure of this.

4.1.9 Hypotheses testing (using paired t-tests)

Hypothesis 1:

There would be no significant difference between the initial and final pre-bronchodilator values of FEV_1 of the asthmatic children following a 12-week endurance exercise programme. The observed t-value of 2.66 was greater than the tabulated t-value. The null hypothesis is therefore REJECTED. This implies that the final pre-bronchodilator value of FEV_1 was significantly greater than the initial pre-bronchodilator value of FEV_1.

Hypothesis 2:

There would be no significant difference between the initial and final pre-bronchodilator values of FVC of asthmatic children following a 12-week endurance exercise programme. The observed t-value of 1.99 was less than the tabulated t-value. The null hypothesis is therefore ACCEPTED.. This implies that the final pre-bronchodilator value of FVC was not significantly greater than the initial

pre-bronchodilator value of FVC.

Hypothesis 3:

There would be no significant difference between the initial and final pre-bronchodilator values of PFR of asthmatic children following a 12-week endurance exercise programme. The observed t-value of 2.84 was greater than the tabulated t-value. The null hypothesis is therefore REJECTED. This implies that the final pre-bronchodilator value of PFR was significantly greater than the initial pre-bronchodilator value.

Hypothesis 4:

There would be no significant difference between the pre- and post-training values of chest expansions of asthmatic children following a 12-week endurance exercise programme.

Since chest expansion was measured at three levels: apical, lateral costal and diaphragmatic, observed t-values of the difference will be given for each level.

Observed t (apical) - 3.38 ($P < 0.01$)

Observed t (lateral costal) - 1.58 (N.S)

Observed t (diaphragmatic) - 2.68 ($P < 0.05$)

On the basis of the above given data, the observed t-values at only two levels of chest expansion measurements were greater than the tabulated t-value. The null hypothesis is therefore PARTIALLY ACCEPTED. This implies that not all the post-training values of chest expansion measurements were significantly greater than the pre-training values.

Hypothesis 5:

There would be no significant difference between the frequency of asthmatic attacks throughout the 12 weeks of endurance exercise programme and the 12 weeks pre-programme period. The observed t-value of -3.135 was greater than the tabulated t-value. The null hypothesis is therefore REJECTED. This implies that the frequency of asthma attacks during the programme was significantly less than the frequency of asthma attacks before the programme.

Using analysis of variance (ANOVA) procedure to test some of the specific hypotheses, gave the same picture:

Hypothesis 1: The observed F-value of 2.70 for FEV_1 was greater than the tabulated value of 2.12. The null

hypothesis is therefore REJECTED. This suggests that the exercise programme was responsible for the larger difference between the pre- and post-exercise FEV_1 values.

Hypothesis 2: The observed F-value of 1.49 for FVC was less than the tabulated value of 2.12. The null hypothesis is therefore ACCEPTED. This suggests that the exercise programme had no significant effect on the post-exercise FVC values.

Hypothesis 3: The observed F-value of 2.84 for PFR was greater than the tabulated value of 2.12. The null hypothesis is therefore REJECTED. This suggests that the exercise programme was responsible for the larger difference between the pre- and post-exercise PFR.

4.2 Discussion

This study took 14 asthmatic boys and girls between the ages of six and 12 years through 12 weeks of endurance exercise programme. The exercise training was designed to improve the physical conditioning of the subjects. This was aimed at improving the ability of the asthmatic children to cope with the physical demands of life without undue respiratory distress.

It is known that exercise can make asthma worse (McNeil, 1966; Femi-Pearse, 1974). The fear of exercise-induced asthma (EIA) makes asthmatic children to subscribe to low level of physical exercise. This is a sort of physical handicap which can have adverse effects on the physical and psychological growth of the asthmatic child. It is known that some exercises (such as running on the flat surface) are highly asthmagenic (Godfrey, 1975; Jones, 1976; and Silverman and Anderson, 1972) and should be avoided. On the other hand, swimming, which is known to be one of the least asthmagenic forms of exercise, is highly recommended for asthmatics.

The outcome of this study has demonstrated that asthmatic children can participate safely in a general conditioning exercise programme. It has also demonstrated that asthmatics can participate in exercises of high asthmagenicity. This result confirms previous studies (Graff-Lonnevig et al, 1980; Nickerson et al, 1983; and Henriksen and Nielsen, 1983) which have shown that carefully graded exercise programme has no adverse effects on the respiratory function of asthmatic children.

The 14 asthmatic subjects who participated in the exercise programme showed greater changes in their respiratory function measurements than the controls who were also asthmatic subjects but who did not participate in the exercise programme. The changes in the respiratory function parameters reflect physiological adjustments due to improved physical conditioning.

4.2.1 Baseline pulmonary function measurements

All the subjects had baseline pulmonary function measurements less than the predicted normal values for their age and sex. The mean and S.D. of per cent predicted normal values (PNV) of the baseline values of PPR, FVC and FEV_1 were 69.6 $\pm$ 10.96, 66.2 $\pm$ 13.37 and 62.2 $\pm$ 14.8 respectively. It could thus be inferred that the subjects in this study were poor in pulmonary function when compared with normal Nigerian children (See Appendices B6 and B7). This is similar to the findings of Nickerson et al (1983) in which 15 asthmatic children between the ages of seven to 14 years had mean baseline FEV_1 values of 68.9% of PNV. Aderele and Oduwole (1983b) found that out of 145 asymptomatic asthmatic children

studied, 61(42.1%) had PFR values below predicted mean (PM) minus two standard deviations.

There was no obvious relationship between the per cent PNV of pulmonary function tests and the severity of asthma. Aderele and Oduwole (1983b) also reported this same finding.

The mean baseline pulmonary function measurements in the experimental group were higher than the control group. Statistical analysis however, showed no significant difference in the mean age and in the mean per cent PNV of PFR, FEV_1 and FVC in both groups. This shows that no group had better baseline pulmonary function than the other. The fact that all the subjects recorded higher pulmonary function measurements after salbutamol inhalation implied that they all had some degree of bronchial obstruction. It was found that the post-bronchodilator per cent increase in lung function measurement also had no obvious relationship with severity of asthma. The fact that Chi square analysis showed no significant difference in the per cent increase

in baseline pulmonary function post-bronchodilator, implied that the initial degree of pulmonary obstruction was similar in both groups.

4.2.2 Exercise programme

The circuit training design for physical conditioning exercise programme in this study was similar to that used by Henriksen and Nielsen (1983). Sly (1976) and McNeil et al (1966) have advocated the administration of a suitable bronchodilator before such training sessions. However, no pre-exercise bronchodilator was given to subjects in this study just as was the case in the study reported by Graff-Lonnevig et al (1980).

Swimming is recommended for asthmatics because it is known to be one of the least asthmagenic exercises (Fitch et al, 1975; Fitch and Morton, 1971; Silverman and Anderson, 1972; and Godfrey, 1975). However, swimming training for asthmatic children in Nigeria is unsuitable because of inadequate swimming facilities. To insist on swimming in this situation is like prohibiting asthmatic children from exercising and thus from attaining and maintaining adequate fitness level. Other forms of

exercises can be safely given to asthmatic children provided they are well monitored. Running, which is known to be most asthmagenic was safely used by Nickerson et al (1983) for training cardio-respiratory endurance in asthmatics. Similarly, the use of circuit training consisting of exercises of varying asthmagenicity in the present study was safe and was not associated with adverse effects on the subjects.

Several authors, including Femi-Pearse (1974), have reported that running for six minutes will provoke EIA in an asthmatic subjects; this will probably occur only during exercise tests and in unconditioned subjects. It is believed that carefully graded and supervised endurance exercise training programme even if it is made up of running (Nickerson et al, 1983; Mahler et al, 1981) will not provoke asthma but would rather build up physical fitness in the subjects just as reported by Graff-Lonnevig et al (1980); Henriksen and Nielsen (1983); Peterson and McElhenny (1965); Scherr and Frankel (1958) and Nickerson et al (1983).

Even though exercise-induced wheezing occurred in this study, none of the subjects went into frank or full

blown asthmatic attacks probably because they were helped to recover promptly by the administration of post-exercise salbutamol inhalation. It is probable that the subjects would have recovered spontaneously without medication as was reported by Henriksen and Nielsen (1983) among asthmatics in whom EIA which occurred during exercise subsided spontaneously within five to 10 minutes without medication. Spontaneous recovery was not encouraged in this study so as not to alarm or frighten the parents who might default from the programme as a result of prolonged exercise-induced wheezing.

Since there was no pre-exercise bronchodilator administration, as recommended, one would have expected more severe EIB which might have progressed to frank asthmatic attack in the subjects, or there should have been more cases of exercise-induced wheezing than reported in this study. The fact that these did not happen was probably due to the following reasons:

1. All the subjects were on intermittent broncho-dilator therapy in the form of oral salbutamol. The subjects who were on 2 or 4 mg salbutamol

twice or thrice daily probably took the second dose by lunch time which would be between two to three hours to the exercise session. According to Walker et al (1972), salbutamol reaches its peak plasma level about three hours after oral ingestion. This probably prevented the development of severe EIA and exercise-induced wheezing. This reason cannot always hold for every exercise session as none of the subjects was on continuous bronchodilator therapy. It was discovered that many of the parents were not giving the oral salbutamol to their children as prescribed. They were in fact giving underdoses for the expressed reason of non-availability of the drug to buy and for the probably unexpressed reason of financial constraints. Most of the parents by virtue of their level of education and their occupation could be categorised into the lower socio-economic group. (Appendix A).

2. The type of exercise included in the circuit probably did not allow for development of severe EIA. It was a combination of exercises of varying

asthmagenicity with a resultant low asthmagenic effect. The overall low asthmagenicity is evident from the fact that the highest post-exercise fall in PFR in this study was 15.6%. This value is comparable to the 13% and 15% fall in PFR reported by Fitch and Morton (1971) after swimming and walking respectively.

3. The intensity and duration of exercise were gradually built up from five exercise stations to 10 exercise stations. This allowed for gradual build-up of physical conditioning, hence the failure to obtain the typical response as from exercise testing,

4. One important factor which can account for the non-development of frank or full blown asthma during exercise programme is the one minute rest periods between exercise stations. Several studies (Jones et al, 1962 and 1963; Godfrey, 1975; Jones, 1976; Fitch and Morton, 1971; Silverman and Anderson, 1972) have shown that intermittent exercise design as used in this study, produce less severe EIA than continuous exercise design.

5. Close and constant observation of the subjects pre-exercise, during exercise and post-exercise most probably contributed immensely to the non-development of full blown asthmatic attacks at exercise sessions. Ill and wheezing subjects were not allowed to participate in the day's exercise. When wheezing

was observed during exercise, further participation was stopped for the day.

6. Salbutamol inhalation was the bronchodilator of choice in this study for the arrest of exercise-induced wheezing because, according to Sly (1984), Godfrey (1975) and Walker et al (1972), it is an effective bronchodilator. It acts quickly, lasts long and is relatively free from side effects. It is also convenient and easy to administer. Prompt post exercise salbutamol inhalation quickly reversed the exercise-induced wheezing episode and did not lead to frank asthmatic attack requiring additional treatment.

The weekly mean repetition per minute per station was found to diminish gradually, though unevenly as the number of exercise stations and the total duration of exercise increased. This could be explained by the fact that no fixed cadence of exercise performance was dictated to the subjects. Each subject was allowed to adjust to his own pace. The subjects probably slowed down as duration increased, the slowing down could also be due to having more work to do since the number of

exercise stations also increased.

Stoppage of exercise due to onset of exercise-induced wheezing and post-exercise need for broncho-dilator inhalation did not seem to have any obvious relationship with the number of exercise station or with the total duration of exercise. Discontinuation of exercise and post-exercise bronchodilator inhalation seemed to occur mainly between the 7th and the 9th week. They also occurred at the 12th week and the first and 2nd weeks. The need for post-exercise ventolin inhalation for 15 out of a possible 372 times implies that the subjects did not develop severe EIA for 357 times.

The degree of exercise-induced bronchoconstriction (EIB) (post-exercise fall in resting pulmonary function measurements) at one minute and 10 minutes were determined as per cent fall from resting pulmonary function measurement. A similar method of estimating EIB was used by Henriksen and Nielsen (1983). The changes in the degree of EIB as the programme progressed bore no consistent relationship with increase in the number of exercise stations and increase in the total duration of

exercise. From Table 18 and Figures 14 and 15, it could be seen that, on the whole (when the degree of EIB at five exercise stations is compared to the degree of EIB at 10 exercise stations), the degree of EIB at one minute post-exercise; had increased though insignificantly as the exercise progressed. However, the changes in the degree of EIB at the various stages of the exercise programme were inconsistent. The sharpest increase in the degree of EIB (from PFR) at one minute post-exercise occurred in the fourth week when the number of exercise stations was six and the total duration of exercise was 12 minutes. This stage also had the greatest per cent fall of PFR at one minute post-exercise from the pre-exercise PFR. The sharpest decrease in the degree of EIB from PFR occurred in the tenth week when the number of exercise stations was nine and the total duration of exercise was 31.5 minutes. This stage did not however, coincide with the stage of least per cent fall from pre-exercise PFR. The least per cent fall from pre-exercise PFR occurred in the second week when the number of exercise stations was five and the total duration of exercise was 7.5 minutes. The least EIB occurred in the second week

probably because progression of exercise at this stage was by increase in the total duration only. The inconsistent increase and decrease in the degree of EIB as the exercise progressed can be attributed to the fact that there was no fixed cadence for exercise performance. Each subject responded to the progression of exercise differently, each subject worked himself up at the various stages inconsistently. If the cadence was fixed or uniform for all subjects, one would be able to attribute a fall in the degree of EIB at one minute post-exercise to the response of the respiratory function of the subjects to the more strenuous work as a result of progression of exercise.

Tables 25 and 32 show an overall significant increase in the degree of EIB by the end of the programme. The increase in the EIB was more consistent with FEV_1 and FVC. The least post-exercise fall (at one minute) in FEV_1 and FVC from the pre-exercise values occurred in the second week when the number of exercise stations was five and the total duration of exercise was 7.5 minutes.

The greatest post-exercise fall in FVC and FEV_1 from the pre-exercise value occurred at the twelfth week when there were 10 exercise stations and the subjects worked for a total duration of 40 minutes. The pattern of change in EIB from FEV_1 and FVC (at one minute post-exercise) as the exercise progressed, suggests that the increased work caused greater post exercise fall.

The difference in the changes in EIB (as exercise progressed) from PFR compared with the changes from FEV_1 and FVC cannot easily be explained because the same subjects were involved in the same exercise situations, and the tests were taken one after the other at about the same time. The possible explanation could be the difference between relative ease of obtaining the PFR which requires forceful expiration for only 0.01 second compared to the forced expiratory spirogram which requires sustained forceful expiration for six seconds. Especially since the measurements were taken post-exercise when the subjects were very tired and getting out of breath.

The changes in the degree of EIB at 10 minutes post-

exercise showed an overall increase (significant only in PER) by the end of the programme. The difference in the pattern of EIB at one minute and 10 minutes is mainly seen from the eighth week for PFR, FEV_1 and FVC. From the eighth week, the degree of EIB at 10 minutes remained about the same till the twelfth week. Apart from serving as a pointer to the effect of progressive exercise programme on the ventilatory response of asthmatic children, the degree of EIB at 10 minutes post-exercise could also be seen as a measure of recovery from exercise. The constant degree of EIB from the eighth week to the twelfth week could be seen as a pointer to improved exercise tolerance in spite of progression of exercise.

The overall increase in the degree of EIB with exercise progression as seen in this present study differs from other graduated endurance exercise programmes on asthmatic children. Nickerson et al (1983) reported reversed episodes of EIB in their study on distant running for asthmatic children. Henriksen and Nielsen (1983) found a significant reduction in the degree of EIB in the subjects while Fitch et al (1972)

found no change in the frequency and severity of EIA after five months of swimming training. However, while Nickerson et al (1983) and Fitch et al (1972) measured EIB from FEV_1, Henriksen and Nielsen (1983) measured EIB from PFR. The design of this programme whereby there is progression in the number of exercise stations and the duration of exercise, makes it difficult to effectively assess the effect of the training, on EIB. The situation is further complicated by the fact that each subject exercised at his own pace, which was not necessarily consistent during the programme for the same subject. If the duration of exercise, number of exercise stations and cadence of performance were fixed, one would be able to assess more effectively, the effect of endurance training on the degree of EIB.

4.2.3 Effects of exercise training

Similar to the outcome of other studies (Nickerson et al, 1983; and Henriksen and Nielsen, 1983), there were no adverse effects of endurance exercise programme on the respiratory function of asthmatic children in this study. Rather than being adverse, exercise training

in this study improved the respiratory function tests. This is similar to the results of Fitch et al (1976); Graff-Lonnevig et al (1980) and Scherr and Frankel (1958). Itkin (1964) and Nickerson et al (1980) did not report improved pulmonary function measurements after endurance exercise programme. They, however, reported no adverse effects of training.

The fact that the control group showed some improvement or increase (though not significant) in the pulmonary function measurements in spite of non-participation in exercise programme could be attributed to improved parents education or awareness of the physical capabilities of asthmatics. It is however, more likely that the improved pulmonary function measurements in the controls are due to improved familiarity with or understanding of test procedures resulting in improved performance.

Since there was no significant difference in the per cent PNV of PFR, FVC and FEV_1 in the baseline values in both groups, and since the improvement in the pulmonary function measurements in the experimental group was more than that in the controls, the difference could be attributed to the effect of endurance exercise training. While

there were significant increases by the end of the programme. Only in the PFR and FEV_1 measurements of the experimental group, none of the measurements showed significant increases in the controls. This is in spite of the fact that there was no significant difference in the baseline values in both groups. The difference in the post programme respiratory function measurements in both groups was also highlighted by the analysis of variance (ANOVA) of the respiratory function indices. There were significant F-ratio (2.84 and 2.70 respectively) in the PFR and FEV_1 measurements in the experimental group, while neither the F-ratio of the FVC in the experimental group nor in any of the three indices in the control group were significant. (Tables 17, 24 and 31). This suggests that the experimental treatments (endurance exercise programme) is responsible for the larger "between group variance", to produce significant F in the experimental group. It also shows that there are more extreme scores of both ends of the distribution in the experimental than in the control group. This difference can only be due to the effect of the endurance exercise programme. The non-significant F-ratio in the

FVC of the experimental group when the FEV_1 had significant F could be due to the relative difficulty of obtaining FVC in a forced expiratory spirogram than the FEV_1. Forced expiration has to be sustained for only one second to obtain the FEV_1, whereas it has to be sustained for about six seconds in order to obtain the FVC. If the subject gets tired during the forced expiratory procedure, the FVC is more likely to be severely affected than the FEV_1.

Paired t-tests between the initial pre-bronchodilator values and each of the subsequent assessments were meant to show the stage of the training programme at which significant change (increase) started to occur. This was with the aim of recommending a minimum duration of exercise training for building respiratory endurance in asthmatic children. It was observed from two of the three measures of respiratory function utilized in this study (PFR, FEV_1 and FVC), that significant increase started to occur after eight weeks of exercise programme for FEV_1 and after 10 weeks for PFR. From this study, it has been demonstrated that a minimum of eight weeks of endurance exercise training at three exercise sessions per week

was required to bring about significant improvement in the respiratory function of asthmatic children. Winder et'al (1979) demonstrated that three weeks of endurance training were enough to demonstrate increase in the working capacity in healthy adults. Henriksen and Nielsen (1983) demonstrated that six weeks of endurance training were enough to bring about improvement in the physical working capacity of asthmatic children.

A pattern of better (or relatively higher) PFR result than FEV_1 and FVC in both experimental and control groups prevails throughout this report. This can probably be explained by the fact that both FEV_1 and FVC are obtained from the same spirogram and according to Jones (1976), many patients get tired during forced expiration. There is a stronger correlation between per cent PNV of FVC and FEV_1 ($r = 0.9858$) than between per cent PNV of FVC and PFR ($r = 0.7614$). The strong correlation between per cent PNV of FVC and FEV_1 should be expected since they were got from the same spirogram. The lower values of per cent FEV_1 and FVC compared to the values of the per cent PNV of PFR can be attributed to the relative difficulty of obtaining the forced expiratory spirogram. The forced expiratory spirogram requires that

a subject expires forcefully and maintains it for about six seconds. This, particularly in children, could be tiring and the inability to blow forcefully and sustain the force could be the cause of low FVC results especially with repeated attempts. Oduwole et al (1983) had a similar experience especially with children below the age of six years who were unable to blow forcefully and sustain the forceful expiration beyond one second. Jones (1976) and Herxheimer (1976) have expressed a similar view. On the other hand, PFR is obtained easily, it is not tiring even with several attempts, it is more convenient in terms of being less cumbersome and it is independent of electricity supply.

All the subjects had increases (though not significant in all cases) in the degree of chest expansion at the three levels. The increase could be due to improved familiarity of the subjects with the technique of localised and deep breathing which constituted the test procedure. The experimental subjects had significant increases in apical and diaphragmatic chest expansion measurements probably because they carried out breathing exercises during the one-minute rest periods between

exercise stations and possibly because the exercise training developed some of the respiratory volumes. The non-significant increase in lateral costal measurement in the experimental group could be due to the difficulty of understanding instructions for localised breathing at this level.

From the clinical status of asthma of each subject during the 12-week period of the programme compared to the three months pre-programme period, it could be inferred that all the subjects had improved clinically during the programme. Improvement was observed in terms of number of asthmatic attacks, admissions into hospital on account of asthma, attendance at clinic on account of asthma, frequency and dosage of intermittent bronchodilator therapy and absenteeism from school on account of asthma. From the fact that none of the children required admission during the programme, one could infer that the few subjects who had asthmatic attacks had mild attacks which were not severe enough for admission into hospital. A similar report was given by Scherr and Frankel (1958). Since clinical improvement occurred in both experimental and control subjects, the general clinical improvement can be attributed primarily to the

enlightenment of the asthmatic children and their parents concerning asthma. This probably resulted in better cooperation with the various aspects of the treatment of asthma. The better clinical improvement in the experimental group is attributable to the effect of exercise training for 12 weeks.

Nine of the experimental subjects were symptom-free during the programme compared to two (14.3%) who were symptom-free three months before programme. Eleven (78.6%) subjects in the experimental group had reduction in the number of asthmatic attacks during the programme compared to pre-programme, while three (21.4%) did not have any change in the number of asthmatic attacks. None of the subjects in both groups had an increase in the number of asthmatic attacks, however, only the experimental group had significant reduction in the number of asthmatic attacks.

Fitch et al (1972) and Scherr and Frankel (1958) also reported significant decrease in the number of asthmatic attacks in the children after endurance exercise programme, while Itkin (1964) and Nickerson et al (1983) reported no change in the number of

asthmatic attacks. There must be other factors (in the present study) apart from the effect of exercise training to account for the reduction in asthmatic attacks especially in the control subjects. Although the improvement could be just by chance, it is more probable that improved parents' education about asthma could be a strong factor. According to Fitch et al (1976), the parents who participated in their swimming training had a better insight into their children's asthma. In the present study, parents education came in the form of

a. regular counselling especially on the importance of the routine asthmatic drugs and the general care of their children, as it concerns close observations at all times for the signs of asthma and other illness, adequate feeding and clothing, and general hygiene;

b. more frequent visits to the hospital to attend exercise sessions or the fortnightly reassessment sessions (in the case of the control subjects). These visits afforded the subjects the opportunity of frequent respiratory function tests and close observations. An ill child or a child showing

features such as running nose or cough was advised to consult the paediatrician immediately. This could have helped to abort some attacks of asthma.

There were reductions (though statistically insignificant) in the mean daily dosage of oral salbutamol in both groups. Going by the mean difference between the pre- and post-programme dosages in both groups, there was a more marked reduction in the mean daily dosage of intermittent bronchodilator therapy in the experimental subjects which could be attributed to the exercise training. The frequency of intermittent bronchodilator therapy, three months before the study was 2.9 and 3.2 times in the experimental and control groups respectively. By the end of the 12 weeks of the study, the frequency of intermittent bronchodilator had reduced to 1.8 and 3.0 times in the experimental and control groups respectively. Less frequent intermittent bronchodilator therapy during the programme indicates reduced requirement. Nickerson et al (1983) and Itkin (1964) found no change in the medication required by the children. While Fitch et al (1972) and Scherr and Frankel (1958) reported significant decrease in the medication required. This improved

clinical status in the present study could be as a result of exercise and improved parents' education on asthma.

Absenteeism from school on account of asthma also reduced significantly (t = 2.274) during the exercise training in the experimental group. The 12 subjects in the experimental group who were attending school, missed an aggregate of 56 school days three months before the programme compared to an aggregate of 10 school days during the programme. The five controls missed an aggregate of 28 school days before the programme and an aggregate of 14 school days during the programme, the decrease in the controls was not statistically significant. The reduced absenteeism from school in the experimental and control groups could be considered as one of the indications of improved clinical status. A similar reduction in the number of missed school days as a result of asthma was reported by Peterson and McElhenny (1965) following eight months of endurance physical training for 20 asthmatic boys.

At the end of the 12 weeks of study, the subjects were followed up for a period of six weeks mainly via

hospital case notes and during courtesy calls at the Physiotherapy Department, U.C.H. Nine of the experimental subjects and four controls were found to be symptom-free during the follow-up period. From the results, it could be seen that none of the subjects got worse during the follow-up period compared with the study period. Having observed no adverse effects from the programme, the parents probably allowed their children to take more active parts in physical exercise while they continued to be observant of them.

The post-programme changes in the mean per cent body fat and the lean body weight in both groups were not statistically significant. On the contrary, Henriksen and Nielsen (1983) reported significant increase in body weight after six weeks of physical training programme in the training group and in the control group at 0.01 level. The subjects who participated in the five months swimming training reported by Fitch et al (1976) had post-training increased body weight but reduced body fat. The increase in body weight (though insignificant) in all the subjects in this study can be attributed to the normal growth of children. This

agrees with the observation of Aderele (1981) that asthma is not a usual cause of significant growth retardation in children.

4.2.4 Subjective evaluation by parents (Appendix F_2)

Post-programme subjective evaluation by the parents of experimental subjects indicate a high degree of enthusiasm and acceptance of the exercise training by the asthmatic subjects and their parents. This is similar to the report by Scherr and Frankel (1958). Peterson and McElhenny (1969) reported that 16 out of the 20 mothers of their subjects felt that there was a marked reduction in the number and severity of asthmatic attacks in their children. Seven of the mothers in the study of Peterson and McElhenny (1965) observed excellent overall improvement in their children while nine mothers classified the observed overall improvement as being good. Itkin (1964) also reported a subjective belief of improvement in the patients even though there were no objective changes in the FEV_1 and in the medication required. From the response in the present study, especially from the fact that no parent wanted the intensity of exercise increased, it could be seen that

while the parents were still slightly sceptical about exercise, most of the children wanted more exercise. It could be inferred that the fear of exercise was expressed by the parents more than by the asthmatic children themselves.

Ten of the parents in the programme who saw exercise as part of the treatment of asthma probably felt like this from their experience with the study and the observed effects of exercise training on their children. Four of the parents were not sure that exercise was part of the treatment of asthma. This is not because they were not convinced about the observed benefits of the exercise training for their children, they probably felt that only drugs can be used for treatment, and that treatment can only be effected when the subject is in acute attack of asthma.

4.2.5 Overall effects of exercise training

Based on the subjective evaluation by parents and the objective observations from the respiratory function measurements, it can be seen that the 14 asthmatic subjects who participated in the exercise programme had benefitted from it. The exercise training did not have

any adverse effects on the respiratory function of the asthmatic subjects. Rather, there were some improvements in all the respiratory function measurements as well as in the clinical status of asthma. Hence, three of the hypotheses which stated that there would be no significant changes in the respiratory function tests and the clinical status of asthma as a result of 12 weeks of exercise training were rejected because there were changes indicating improvement at the end of the programme.

The beneficial effects of endurance exercise programme were achieved in this study probably because the asthmatic children exercised under supervision. Exercise in a non-clinical set-up cannot be avoided for asthmatic children, because it is impossible to prevent the asthmatic children from joining peer group plays at school and at home to varying extents; from mere spectatorship to the most aggressive participants. In order to encourage asthmatics to exercise but to exercise within safe limits, there is need for some sort of supervision at all times. Supervision of asthmatic children should be done at all times but in particular,

during exercise outside a clinical setting.

4.2.6 Response rate

The response rate of 54.3% in this present study was very poor when compared with the 99.9% reported by Burr et al (1974) where only one subject out of 817 defaulted. Sixteen subjects defaulted in the present study out of a total of 35 subjects recruited.

The experimental group attended exercise sessions for a mean of 27.1 days which was less than 80% of regular attendance (34 days) and defaulted for more than 20% of the time. The irregular attendance could have had dampening effect on the results in terms of exercise performance, respiratory function measurements and effect of exercise on the clinical status of the subjects. A similar pattern of irregular attendance was found at the fortnightly pulmonary function reassessment sessions (Appendix B8). The irregular attendance was more marked among the controls who recorded 40% attendance at two testing sessions and 60% attendance at another two testing sessions. Since more emphasis was placed on group rather than individual results, the group mean values kept fluctuating not as a result of changes due

to the programme but due to the varying number of subjects at the testing and exercise sessions. Attendance at fortnightly testing session was fairly better in the experimental group probably because they were required to attend more often in order to exercise. Some of the experimental subjects attended fairly regularly because they felt they were benefitting from the programme.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The aim of this study was to find out whether asthmatic children can safely engage in general conditioning exercises on regular basis without a pre-exercise administration of bronchodilator drug, with the hope of gradually training their respiratory endurance. The aim was to determine the effects of graduated general conditioning exercise of 12-week duration at a frequency of three exercise sessions per week on the respiratory function of asthmatic children without a pre-exercise administration of a bronchodilator. One general hypothesis and five specific hypotheses were put forward.

Pulmonary function was investigated using the Vitalograph spirometer and the Mini-Wright Peak Flow Meter. Some anthropometric features of the subjects were measured using the skinfold calliper and the tape measure. Nineteen asthmatic subjects of both sexes who

were aged six to 12 years, completed the study, 14 in the experimental group and five in the control group.

The experimental group went through an endurance exercise programme of 12-week duration at a frequency of three exercise sessions per week. Aerobic exercises of varying asthmagenicity were arranged in a circuit. Progression was by increasing either the number of stations (From five to 10) or the time spent at each station (from one minute to four minutes) every week for the 12-week duration.

All the subjects in the experimental group were closely observed during pre-exercise, exercise and post-exercise sessions for symptoms of asthma and EIA. Any subject who was found to be wheezing or in acute attack was disallowed from further participation in exercise and given appropriate medical treatment.

The pulmonary function tests were repeated at two weekly intervals for both the experimental subjects and the controls. At the end of the programme, all the children had their pulmonary function and anthropometric measurements taken. The data obtained were analysed both manually and using a computer.

The mean age at onset of asthma in the entire subjects was three years while the mean duration of illness was 5.25 years. Four of the subjects were classified as mild asthmatics, 13 as moderate asthmatics and two as severe asthmatics. Statistical analyses showed no significant differences between the age, the duration of illness, the age at onset of asthma and the severity of asthma in the experimental and control groups. The mean number of asthmatic attacks in the experimental subjects three months before the programme was 1.64 attacks while it was 2.4 in the controls. Two experimental and one control subjects were symptom free during three months before programme. All the subjects were routinely placed on intermittent bronchodilator (Salbutamol) therapy by their doctors. The subjects in the experimental group were absent from school for an aggregate of 56 school days during three months pre programme while the subjects in the control group were absent for an aggregate of 28 days.

All the subjects had baseline peak flow rate (PFR) values below the Predicted Normal Value (PNV) for their age and sex. The mean per cent PNV of PFR in the control

and experimental groups were 65.76 and 71 respectively. Fifteen minutes after ventolin inhalation, mean baseline PFR increased by 19.28% and 12.27% in the experimental and control groups respectively.

The mean per cent PNV of baseline forced expiratory volume in the first second (FEV_1) were 64.5 in the experimental group and 55.81 in the controls. Post bronchodilator increase in baseline FEV_1 were 35.9% and 36.2% in the experimental and control groups respectively.

Mean baseline forced vital capacity (FVC) values in the experimental and control groups were 68.1% and 60.9% of PNV of FVC respectively. Statistical analyses showed no significant differences between the per cent PNV of initial PFR, FVC and FEV_1 as well as the pre-exercise chest expansion measurements in the experimental and control groups.

The mean attendance at exercise sessions was 27.1 days out of a maximum of 34 days. The repetition per minute per station decreased though unevenly, as the number of exercise stations increased from five to 10 and the total duration of exercise increased from five to 40 minutes.

Exercise induced wheezing occurred on five occasions in four subjects who were stopped from further participation with the day's exercise and given salbutamol inhalation to aid prompt recovery from exercise. Post-exercise wheezing also qualified some subjects for ventolin inhalation. On the whole, six subjects required ventolin inhalation for a total of 15 times (4% of a total of 372 possible times) throughout the 12 weeks of the study. None of the subjects went into full blown or frank attacks of asthma.

The six fortnightly reassessments of respiratory function tests as well as the final assessments, showed gradual increase from the baseline measurements for both the control and the experimental groups. Per cent increases in PFR, FEV_1 and FVC were 30.2, 27.5 and 18.26 respectively in the experimental subjects and 11.2, 7.06 and 12.27 respectively in the control subjects. Only the increase in PFR and FEV_1 in the experimental subjects were significant, while the increases in the PFR, FVC, FEV_1 in the control group were not significant. Analysis of variance (ANOVA) gave significant F-ratio in the PFR and FEV_1 for the experimental group. The FVC

in the experimental group and the PFR and FEV_1 in the control group did not have significant F-ratio. Paired t-tests between the initial pre-bronchodilator values and each of the subsequent assessments, showed that significant increases in the PFR and FEV_1 respectively were first observed in the experimental group after 10 and eight weeks of training. The post programme per cent PNV of PFR, FEV_1 and FVC in the experimental group were 93.2, 82.9 and 81.25 respectively while in the control subjects they were 73.62, 60.13 and 68.84 respectively. While the differences in the initial and final pre-bronchodilator per cent PNV of PFP, FVC and FEV_1 were significant in the experimental group, they were not significant in the control group.

Both groups showed decrease in the number of asthmatic attacks during the programme. While the experimental group showed a decrease of 77.5%, the control subjects had 41.7% decrease. However, only the experimental group had significant reduction in the number of asthmatic attacks.

None of the subjects was admitted into hospital on account of asthma during the programme. There was 9.1%

decrease in the daily dosage of salbutamol in the experimental subjects and 1.5% decrease in the control subjects, neither of these was significant. The frequency of intermittent bronchodilator therapy during the 12 weeks of programme was 1.8 times in the experimental group and three times in the control group.

The experimental subjects were absent from school on account of asthma for an aggregate of 10 days giving 82.1% decrease in absenteeism from school while the control subjects missed a total of 14 school days giving a 50% decrease in absenteeism from school. However, only the reduction in absenteeism from school in the experimental group was statistically significant.

During six weeks post programme follow-up, the subjects did not have poorer clinical status, there were improvements in some aspects and no changes in others.

Subjective evaluation of programme by parents of experimental subjects revealed that all of them wanted the programme to continue. Most parents felt that the number of asthmatic attacks and the frequency of feeling unwell had decreased during the programme while they

observed increased activeness and alertness in their children.

Three of the specific hypotheses were rejected because there were changes which can be attributed to the effect of exercise.

From the baseline pulmonary function measurements, one could infer that the subjects in this study were poor in pulmonary function and that they all had some degree of bronchial obstruction even though they were not in acute attacks. The insignificant differences in the statistical analyses in the per cent PNV of the baseline FEV_1, FVC and PFR of the experimental and control groups, imply that no group started the programme with better pulmonary function measurements. The observed changes at the end of the programme could therefore be attributed to the effect of exercise.

No pre-exercise bronchodilator was given to the subjects. None of them had frank asthmatic attacks during exercise. There were no adverse effects as a result of exercise, rather, the experimental group showed improved respiratory function.

The controls also showed clinical improvements

though not as much as the experimental subjects and in most cases, statistically insignificant. The improvement in the controls can be attributed to improved familiarity with test procedures, improved parental education on asthma and the frequent visits to the hospital for the fortnightly reassessments during which the subjects were observed and advised to consult their doctors early, if necessary.

5.2 Conclusions

The subjects in the experimental group showed more improvement in their respiratory function indices than the subjects in the control group. They also showed better clinical improvement than the control subjects. One could therefore infer that the differences in the results of the experimental and control groups were due to the endurance exercise programme. Even if the results had shown no significant differences in the two groups at the end of the programme, the fact that the subjects in the experimental group did not get worse in their respiratory function and their clinical status were indications that the endurance exercise programme was safe for

asthmatic children. However, with the better improvement in the experimental group, one could generally conclude that well graded and supervised exercise programme is both safe and beneficial to asthmatic children, it should be encouraged.

The following specific conclusions were also drawn from the outcome of this study:

1. Asthmatic children are poor in pulmonary function with varying degrees of pulmonary obstruction even when they are symptom free.
2. Regular physical exercise is safe and can increase the physical conditioning in asthmatic children even without pre-exercise bronchodilator administration, provided that the exercise is carefully designed and graded and there is some form of supervision or monitoring.
3. An asthmatic patient should not be restricted to swimming as the only safe type of exercise, especially where facilities and the skill for swimming are lacking. An asthmatic can participate in exercise of varying asthmagenicity including runnin provided it is carefully graded and the patient is

closely monitored.

4. Physical conditioning exercise programme has no adverse effects on the respiratory functions of asthmatic children. Rather, it causes clinical improvement of asthma and improves the pulmonary function measurements.

5. Frequent follow-up appointments for asthmatic patients can contribute immensely to clinical improvement as it affords the patients more frequent observations which can help to abort asthmatic attacks quickly.

6. Assessment of pulmonary function is easier, quicker and less cumbersome via PFR measurement than FEV_1 and FVC which tend to give low values (especially FVC) in children.

7. There is need to formalize and intensify parents' and patients' education on many aspects of asthma. Such as the need to use routine asthmatic drugs as prescribed, close observation of asthmatic children at all times and the need to seek medical attention promptly. They should know the physical capabilities of the asthmatic child and the benefits

of regular physical exercise. Parents should be educated on the limits and the place of exercise in the management of asthma.

8. An endurance exercise programme of 12-week duration at three exercise session per week will bring about change (improvement) in the respiratory function of asthmatic children.

9. An endurance exercise programme for asthmatic children should be of at least, eight weeks' duration at a frequency of three exercise sessions per week in order to obtain a significant increase in the respiratory function test values.

5.3 Recommendations

The following recommendations are pertinent for effective and safe exercise conditioning programme for asthmatic children and for further studies:

1. The complete therapeutic programme for asthmatic children should include exercise conditioning. Physical conditioning should, however, not be taken as a substitute to the use of drugs, they should both go on together.

2. Asthmatic children should be encouraged to participate in physical education (PE) sessions in schools. These exercises should be made up of short bouts of exercise of varying asthmagenicity.

3. In order that the asthmatic child can participate safely in the P.E. sessions in school, he should take his routine bronchodilator drug in the morning before going to school so that the two to three hours for the oral drug to reach peak plasma level will coincide with the break period or P.E. session.

4. Parents should be encouraged to discuss their children's medical condition with the class teacher so that the teacher can put the asthmatic child into consideration when planning physical education exercises and when assigning school duties to students.

5. Teachers should, as part of their training, know a few things about the classroom management or care of children with certain medical conditions such as asthma. Teachers, for example, should know that asthmatics can participate in exercise but that they can go into asthmatic attacks if the exercise is inappropriate for type, duration and intensity.

6. The parents should be in the habit of regular observation of their children for signs of running nose, cough, wheezing, dyspnoea, sudden decrease in physical activities and other behavioural changes suggestive of the child being unwell. These signs will warn the parents to be extra vigilant on the asthmatic child and exercise, since exercise induced wheezing could easily progress to frank attack of asthma.

7. Parents should not discourage their children from joining peer group play at home or sporting activities in school. They should on their own part, ensure adequate use of prescribed drugs.

8. Follow-up appointments at children's asthma clinics should not be less frequent than once a fortnight.

9. Respiratory function measurement, preferably the PFR, should be assessed routinely at follow-up clinics for asthmatic children just as the routine weighing of patients.

10. Fitness clinics should be set up in every hospital, for asthmatic children where they can be carefully progressed on exercise programme.

11. The asthmatic child should be taught to monitor himself and be able to interprete changes in himself during exercise at home or in school. The self discipline to be able to pull out of the game even when it is most exciting, should be inculcated in him. He should be taught to report promptly to his parents if he has difficulty in breathing or has a feeling of constriction within the chest.

12. Suggestions for further studies

a. Changes in physical working capacity of the asthmatics should be determined objectively as the exercise programme progresses. This could serve as an objective measurement of physical fitness.

b. Spontaneous recovery of exercise induced wheezing should be studied. If it is easily reversible, the dependency of asthmatic patient for assisted recovery will be reduced to only the bad cases. This could make exercise less handicapping for asthmatic children.

c. The effects of specific training programme for the various sports on the respiratory function of asthmatic children should be studied. The outcome of this would make it easy to recommend specific sports to asthmatic children.

d. The effect of endurance exercise programme on the degree of exercise induced broncho-constriction (EIB) should be studied. The programme should be designed such that the duration, intensity and cadence of exercise are fixed. This will ensure a more reliable determination of the trend of changes in EIB.

e. The effect of exercise on the respiratory function of asthmatic children can also be determined by the changes in bronchial lability at the various stages of the exercise. This would however require the extra effort of monitoring respiratory function indices during exercise performance.

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APPENDICES

APPENDIX A

Appendix B_1

Individual total attendance at pulmonary function testing sessions

Study Number	Total attendance	(Regular attendance = 8) % Regular attendance
Experimental Group		
E1	6	75.0
E2	6	75.0
E3	7	87.5
E4	7	87.5
E5	8	100
E6	7	87.5
E7	6	75.0
E8	7	87.5
E9	7	87.5
E10	6	75.0
E11	7	87.5
E12	7	87.5
E13	6	75.0
E14	7	87.5
Mean and S.D.	6.7 ± 0.6	83.9 ± 7.6
Control Group		
C1	7	87.5
C2	6	75.0
C3	5	62.5
C4	6	75.0
C5	5	62.5
Mean and S.D.	5.8 ± 0.8	72.5 ± 10.5
Overall Mean and S.D.	6.5 ± 0.8	80.9 ± 9.7

APPENDIX B2

APPENDIX B2a

COMPUTER ANALYSIS OF FPS RESULTS

EXPERIMENTAL GROUP

TABLES OF MEANS, SD&SE

GROUP	MEAN	SD	SE	NO. OF OBS.
1	198.214	41.301	11.038	14
2	199.091	45.618	13.754	11
3	215.000	49.727	14.993	11
4	220.714	49.381	13.198	14
5	242.273	46.97.	14.162	11
6	241.818	57.811	17.431	11
7	260.556	68.736	22.912	9
8	257.143	59.603	15.930	14

ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SSQ	MSQ	F
BET. GROUPS	7	[illegible]	[illegible]	2.64
WITHIN GROUPS	87	261402.90	3004.64	
TOTAL	94	321212.10		

POOLED ESTIMATE OF SD= 54.81462

T-VALUE FOR GRP 1 VS 2 IS -.04

T-VALUE FOR GRP 1 VS 3 IS -.76

T-VALUE FOR GRP 1 VS 4 IS -1.09

T-VALUE FOR GRP 1 VS 5 IS -1.99

T-VALUE FOR GRP 1 VS 6 IS -1.88

T-VALUE FOR GRP 1 VS 7 IS [illegible]

T-VALUE FOR GRP 1 VS 8 IS -1.84

CONTROL GROUP

TABLES OF MEANS,SD&SE

GROUP	MEAN	SD	SE	NO. OF OBS.
1	178.[illegible]	30.734	22.698	5
2	179.[illegible]	50.537	22.601	5
3	176.667	26.247	15.154	3
4	[illegible].000	62.072	28.816	5
5	197.500	61.390	30.695	4
6	192.333	30.912	17.847	3
7	215.[illegible]	75.[illegible]	37.[illegible]	4
8	202.000	54.105	24.232	5

ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SSQ	MSQ	F
BET. GROUPS	7	4714.70	673.53	.14
WITHIN GROUPS	22	83122.30	3778.74	
TOTAL	29	87837.10		

POOLED ESTIMATE OF SD= 61.47464

T-VALUE FOR GRP 1 VS 2 IS [illegible]

T-VALUE FOR GRP 1 VS 3 IS .63

T-VALUE FOR GRP 1 VS 4 IS -.33

T-VALUE FOR GRP 1 VS 5 IS -.35

T-VALUE FOR GRP 1 VS 6 IS -.34

T-VALUE FOR GRP 1 VS 7 IS -.72

T-VALUE FOR GRP 1 VS 8 IS -.42

APPENDIX B3

APPENDIX B1 a

COMPUTER ANALYSIS OF P-V RESULTS

[illegible]

TABLES OF MEANS, [illegible]

GROUP	MEAN	SD	SE	NO. OF OBS.
1	1.132	.268	.072	14
2	1.182	.188	.087	11
3	1.184	.309	.093	11
4	1.171	.270	.072	14
5	1.361	.264	.088	9
6	1.264	.268	.081	11
7	1.378	.338	.113	9
8	1.357	.289	.077	14

ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM	MEAN	F
BET. GROUPS	7	.93	.13	1.44
WITHIN GROUPS	65	7.80	.09	
TOTAL	72	8.73		

POOLED ESTIMATE OF SD= .2989118

T-VALUE FOR GRP 1 VS 2 IS -.41

T-VALUE FOR GRP 1 VS 3 IS -.43

T-VALUE FOR GRP 1 VS 4 IS -.[illegible]

T-VALUE FOR GRP 1 VS 5 IS -1.[illegible]

T-VALUE FOR GRP 1 VS 6 IS -1.[illegible]

T-VALUE FOR GRP 1 VS 7 IS -1.92

T-VALUE FOR GRP 1 VS 8 IS -1.99

CONTROL GROUP

TABLES OF MEANS, [illegible]

GROUP	MEAN	SD	SE	NO. OF OBS.
1	[illegible]	[illegible]	.148	5
2	[illegible]	[illegible]	.144	5
3	[illegible]	.244	.153	7
4	[illegible]	.135	.086	2
5	.903	.361	.181	4
6	1.133	.767	.164	7
7	875	[illegible]	[illegible]	[illegible]
8	1.074	.346	.151	5

ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM	MEAN	F
BET. GROUPS	7	.28	.04	.28
WITHIN GROUPS	21	3.04	.14	
TOTAL	28	3.32		

POOLED ESTIMATE OF SD= .3[illegible]

T-VALUE FOR GRP 1 VS 2 IS -.[illegible]

T-VALUE FOR GRP 1 VS 3 IS -.17

T-VALUE FOR GRP 1 VS 4 IS -.[illegible]

T-VALUE FOR GRP 1 VS 5 IS -.77

T-VALUE FOR GRP 1 VS 6 IS -.41

T-VALUE FOR GRP 1 VS 7 IS -.[illegible]

T-VALUE FOR GRP 1 VS 8 IS -.24

APPENDIX 114

APPENDIX B4a

COMPUTER ANALYSIS OF PVC RESULTS

EXPERIMENTAL GROUP

TABLES OF MEANS, LOGUE

GROUP	MEAN	SD	SE	NO. OF OBS.
1	.996	.284	.066	18
2	1.015	.256	.081	10
3	1.014	.462	.075	11
4	1.107	.269	.067	16
5	1.165	.272	.086	10
6	1.295	.201	.065	11
7	1.256	.284	.096	9
8	1.271	.269	.070	16

ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM	MSD	F
BET. GROUPS	7	1.41	.20	2.74
WITHIN GROUPS	85	6.36	.07	
TOTAL	92	7.77		

POOLED ESTIMATE OF SD= .27388244

T-VALUE FOR GRP 1 VS 2 19 -.16

T-VALUE FOR GRP 1 VS 3 16 -.16

T-VALUE FOR GRP 1 VS 4 16 -1.07

T-VALUE FOR GRP 1 VS 5 16 -2.37

T-VALUE FOR GRP 1 VS 6 19 -2.71

T-VALUE FOR GRP 1 VS 7 16 -2.22

T-VALUE FOR GRP 1 VS 8 16 -2.66

CONTROL GROUP

TABLES OF MEANS, LOGUE

GROUP	MEAN	SD	SE	NO. OF OBS.
1	.[illegible]	.[illegible]	.179	5
2	.[illegible]	.[illegible]	.[illegible]	5
3	.917	.[illegible]	.153	3
4	1.[illegible]	.[illegible]	.[illegible]	2
5	.[illegible]	.496	.249	4
6	.[illegible]	.[illegible]	.[illegible]	3
7	.[illegible]	.[illegible]	.[illegible]	2
8	.[illegible]	.448	.[illegible]	5

ANALYSIS OF VARIANCE TABLE

SOURCE OF VARIATION	D.F.	SUM	MSD	F
BET. GROUPS	7	.46	.07	.24
WITHIN GROUPS	21	4.91	.23	
TOTAL	28	5.37		

POOLED ESTIMATE OF SD= .4796[illegible]

T-VALUE FOR GRP 1 VS 2 [illegible] -.07

T-VALUE FOR GRP 1 VS 3 12 -.19

T-VALUE FOR GRP 1 VS 4 12 -1.11

T-VALUE FOR GRP 1 VS 5 [illegible] -.[illegible]

T-VALUE FOR GRP 1 VS 6 12 -.32

T-VALUE FOR GRP 1 VS [illegible] [illegible] .[illegible]

T-VALUE FOR GRP 1 VS 8 12 -.44

Appendix B_5

Pre and post programme chest expansion measurements (cm)

Study Number	Apical expansion		Lateral costal expansion		Diaphragmatic expansion	
	Pre	Post	Pre	Post	Pre	Post
E1	3	4	3	3.5	2	3.5
E2	3.5	4	4	4	1	1
E3	3	6	3.5	3.5	1	1
E4	1.5	2.5	1.5	2.5	1	1.5
E5	4	5	5	5.5	2	4
E6	2	4	3	3.5	2	2
E7	3.5	3.5	3	3	2	2.5
E8	4	6.5	6	7	2.5	4
E9	2	3	1.5	4	1.5	1
E10	1.5	4	2.5	6	2	3
E11	4	5.5	4	4.5	1	2.5
E12	3	3.5	2	2	1	2.5
E13	1	2.5	2	2.5	1.5	2.5
E14	2	4	3	4	2	3.5
C1	4	4.5	2	4	2	4
C2	2	3	1	1.5	1	1.5
C3	3	4	2	2.5	1	1
C4	4	5	4	4	2	3
C5	2	2	3	4	1	2

Appendix B_6

Predicted normal values of peak flow rate (litres/min)

(Aderele and Oduwole, 1983a)

Age (Years)	Males			Females		
	No. of subjects	Mean	Standard Deviation	No. of Subjects	Mean	Standard Deviation
4	55	141.000	27.595	55	132.000	30.316
5	52	165.865	28.314	58	152.414	29.974
6	50	183.300	34.479	51	181.176	34.243
7	43	217.326	41.909	42	216.071	40.972
8	53	259.811	35.921	48	241.875	44.166
9	50	270.200	55.346	58	261.810	46.052
10	52	293.846	45.229	60	280.667	47.883
11	51	310.196	47.791	53	310.660	51.516
12	53	324.151	45.854	73	332.329	50.718
13	57	340.088	49.031	50	361.400	51.160
14	51	350.392	53.859	63	373.651	49.637
15	54	363.611	54.109	53	380.566	43.926
16	52	407.855	54.407	50	398.500	32.768

Appendix B_7

Predicted normal values of mean FEV_1 ((litres) and FVC (litres)
(Oduwole et. al, 1983)

Age ((Years)	Males					Females				
	Number (No.)	Forced expiratory volume in the first second (FEV_1)	Standard Deviation (S.D.)	Forced vital capacity (FVC)	S.D.	No.	FEV_1	S.D.	FVC	S.D.
4	2	0.975	0.106	1.175	0.247	1	0.700	-	0.950	-
5	1	1.000	-	1.200	-	6	0.975	0.199	1.075	0.172
6	19	1.103	0.145	1.239	0.150	15	1.117	0.235	1.270	0.266
7	36	1.233	0.205	1.358	0.232	31	1.153	0.177	1.287	0.180
8	48	1.342	0.218	1.465	0.225	34	1.235	0.202	1.371	0.210
9	47	1.501	0.314	1.661	0.328	42	1.375	0.242	1.508	0.253
10	45	1.684	0.276	1.893	0.341	47	1.471	0.347	1.604	0.370
11	50	1.789	0.336	1.948	0.356	47	1.698	0.326	1.861	0.334
12	48	1.855	0.326	2.071	0.363	69	1.874	0.388	2.041	0.393
13	55	2.016	0.387	2.220	0.438	48	2.107	0.393	2.285	0.407
14	51	2.180	0.376	2.373	0.417	62	2.303	0.414	2.486	0.433
15	47	2.383	0.423	2.590	0.470	52	2.486	0.365	2.676	0.386
16	49	2.796	0.597	3.016	0.634	49	2.532	0.370	2.754	0.448

APPENDIX C

Physical Characteristics of Subjects

Pre Programme / Post Programme

Subject Number	Sex	Age (Years)	Height (cm)	Weight (kg)	Body Density g/ml	% Fat	Fat Weight (kg)	Lean Body Weight (kg)	Chest Diameter (cm) Lateral	Right Antero-Post	Left Antero-Post	Height (cm)	Weight (kg)	Body Density g/ml	% Fat	Fat Weight (kg)	Lean Body Weight (kg)	Chest Diameter (cm) Lateral	Right Antero-Posterior	Left Antero-Post
E1	M	8	116	15.2	1.060	16.98	2.6	12.6	29	28	28.5	114	18.0	1.059	17.43	3.1	14.9	29	28	29
E2	M	8	121	17.8	1.062	16.1	2.9	14.9	28	26	26	122	18.9	1.061	16.54	3.1	15.8	28	26	26
E3	M	7	115	18.4	1.060	16.98	3.1	15.3	30	29	28	117	19.1	1.061	16.54	3.2	15.9	30.5	29	[illegible]
E4	M	[illegible]	121	20.2	1.058	17.84	[illegible]	[illegible]	32	31	32	121.5	22.2	1.056	18.75	4.3	18.4	32	32	32
E5	M	11	134	27.1	1.06	16.98	4.6	22.5	33	32	32.5	135	27.3	1.058	17.84	4.9	22.4	33	32	32
E6	F	6	110.5	17.3	1.052	20.53	[illegible]	[illegible]	27	26	26	112	9.0	1.051	20.96	4	15	27	26	26
E7	M	8	133	26.2	1.060	16.98	4.4	21.8	31	30	30	133.5	25.5	1.060	16.98	4.3	21.2	31	30	30
E8	M	10	149	31.1	1.060	16.98	5.4	26.1	35	33	33	149	33.2	1.060	16.98	5.6	27.6	35.5	34	34
E9	M	10	125	23.9	1.060	16.98	4.1	19.8	33	31	31	125.5	22.7	1.058	17.84	4.1	18.6	33	32	32
E10	M	11	143.5	32.2	1.052	20.53	6.6	25.6	34	34	34	[illegible]	35.7	1.05	21.43	7.7	28	35	34.5	34.5
E11	M	8	125	23.0	1.061	16.54	3.8	19.2	33	32	32	126	24	1.058	17.84	4.3	19.7	34	33	33
E12	M	10	139	25.0	1.060	16.98	4.2	20.8	34.5	32	32	139.5	25	1.060	16.98	4.2	20.8	34	32	32
E13	F	12	147	33.8	1.048	22.33	7.5	26.3	35	34.5	34.5	147.5	35.5	1.048	22.33	7.9	27.6	35	35	35
E14	F	10	134	23.8	1.054	19.64	4.7	19.1	32	31	31	134	24.7	1.053	20.[illegible]	5	19.7	32	31	31
C1	M	9	138	20.7	1.060	16.98	3.5	17.2	31	30	30	139	22.00	1.060	16.98	3.7	18.3	32	31	31
C2	F	7	113	16.5	1.05	21.43	3.1	11.4	28	27	27	114	16	1.05	21.43	3.4	12.6	28	27.5	27
C3	M	10	120.5	16.5	1.061	16.54	2.7	13.8	30	30	30	121	18.2	1.061	16.54	3	15.2	30.5	30.5	30.5
C4	F	12	137	29	1.05	21.43	6.2	22.8	33	31	31	137	30.5	1.05	21.43	6.5	24.0	34	31.5	31.5
C5	F	7	122	22.7	1.050	21.43	4.9	17.8	27	26.5	26.5	122	23.1	1.054	20.53	4.7	18.4	27	26.5	27
Experimental Group Mean		9.18	129.36	23.97	1.058	18	4.4	19.6	31.9	30.7	30.7	130	25.1	1.057	18.5	4.7	20.6	32	31.0	31.0
S.D.		1.74	12.47	5.05	0.004	2.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Control Group Mean		9	124.1	20.48	1.054	19.6	4.1	16.6	29.8	28.9	28.9	126	22.0	1.055	19.4	4.3	17.7	30.3	29.4	29.4
S.D.		2.12	10.96	5.48	0.0052	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.9	2.2	2.2
Entire Subjects Mean		9.16	128.3	23.1	1.058	18.4	4.3	18.8	31.3	30.5	30.5	129.1	24.3	1.058	18.3	4.6	19.9	31.6	30.8	30.8
S.D.		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix D_1

Weekly repetition per minute at station 1(17 metre shuttle run)

Study Number	Weeks of training												Mean	S.D.
	1	2	3	4	5	6	7	8	9	10	11	12		
E1	3.2	3.3	-	3	3	3.3	3.7	3.2	3.2	3.3	3.2	2.4	3.2	0.3
E2	2.5	2.3	3.1	2.4	3	2.8	3.3	2.5	-	-	1.1	1.1	2.4	0.8
E3	3.2	3.2	-	1.8	2.8	2.5	2.5	2.3	2.5	1.9	1.5	1.3	2.3	0.6
E4	3	3.4	3.4	2.8	-	-	2.4	2.4	2	1.7	1.9	1.4	2.4	0.7
E5	2.8	4	3.3	3	3.5	2.5	2.9	2.9	3.0	2.3	1.9	1.8	2.8	0.6
E6	2	2.1	-	1.9	2.3	2.1	2.1	2.2	2.0	1.5	1.4	1.2	1.9	0.4
E7	2.3	2.2	3.3	3.2	3	3	2.9	1.8	1.8	-	-	0.9	2.4	0.8
E8	5.5	3.7	-	3.4	3.0	2.8	3.3	3.6	3.7	3.1	2.5	1.9	3.3	0.9
E9	2.3	-	1.3	1.9	3.5	3.1	2.9	2.8	2.3	1.6	1.4	-	2.3	0.8
E10	4.5	3.5	4	3.7	3.8	3.4	4.8	3	3.3	3.5	2.3	1.2	3.4	1.0
E11	4.5	3.2	4.3	3.8	4.1	3.2	2.9	2.8	3.8	3.3	3	2.5	3.5	0.6
E12	3.5	2.5	3.9	-	3	2.8	2.9	2.7	3.1	2.7	2.3	1.5	2.8	0.6
E13	3.2	2.7	3.4	3.8	4.4	3.6	3.2	2.5	-	-	1.4	1.1	2.9	1.0
E14	4	3	3.5	3.4	2.6	4.1	5.2	5.2	4.3	2.7	2.1	1.8	3.5	1.1
Mean	3.3	3.0	3.4	2.9	3.2	3.0	3.2	2.9	2.9	2.9	2	1.5	2.8	-
S.D.	1.0	0.6	0.8	0.7	0.6	0.5	0.9	0.8	0.8	0.7	0.6	0.5	0.5	-

Appendix D_2

Weekly repetition per minute at station 2 (rope skipping)

Study Number	Weeks of training												Mean	S.D.
	1	2	3	4	5	6	7	8	9	10	11	12		
E1	29.3	23.3	-	31.1	4.0	31.2	43.1	42.7	42.6	26.3	20.4	21.8	32.1	8.7
E2	20.3	20	37.1	30.8	35.7	35.1	34.1	28.7	-	-	15.1	11.7	26.9	9.3
E3	38.7	36	-	30	33.8	29.7	36.5	34.9	30.7	16.3	15.4	14	28.7	9.1
E4	17	16.7	31.5	25.2	-	-	28.7	33.1	30.9	23.0	20.4	14.9	24.1	6.7
E5	75.3	61.1	68.7	90.8	78	65.5	70.1	71.2	61.9	60.0	71.6	58	69.4	9.2
E6	35	26	-	24.5	30.3	28.9	28.7	23.3	22.0	19.6	13.4	11.7	23.9	7.1
E7	26.3	20.3	20	18	22	19.5	26.4	25.6	17.4	-	-	8.9	20.4	5.3
E8	90.7	80	-	60.5	72.3	68	72.3	64.3	63.7	51.7	52.4	45.4	65.6	13.2
E9	47	-	33.7	32.1	43.8	46.3	44.4	29.8	21.6	16.3	11.4	-	32.6	12.9
E10	74	65	83.3	66.5	52.7	51.2	55.6	51.6	44.3	38.8	38.8	26	54.0	16.2
E11	57	42.3	48.3	48	58.7	46.7	45.3	42.8	46.1	30.9	33.8	25.4	43.8	9.8
E12	82	59.7	64.2	-	35	35.6	37.6	41.9	43 3	36.2	30.1	21.4	44.3	17.5
E13	56.3	42	44.7	40.2	44.5	39.9	42.1	30	-	-	19.1	16.3	37.5	12.3
E14	63	40	35	36.3	44.5	43.5	45.3	34.7	33.3	25.6	23.9	19.8	37.1	11.6
Mean	50.9	41	46.7	41.1	45.5	41.6	43.6	39.6	38.2	31.3	28.2	22.7	38.6	-
S.D.	24.0	20.2	19.7	20.5	16.2	14.1	14.1	14.2	15.0	14.3	17.5	14.1	16.6	-

Appendix D_3

Weekly repetition per minute for station 3 (Ball bouncing on the wall)

Study Number	Weeks of training												Mean	S.D.
	1	2	3	4	5	6	7	8	9	10	11	12		
E1	32.2	33.2	-	24.5	26.8	27.2	32.4	27.4	23.3	16.9	18.3	12	25.1	6.8
E2	25.3	26.9	29.6	27	24.8	33.3	38.7	30.7	-	-	20	15.5	27.3	6.7
E3	33.3	29.6	-	23.5	26.7	28	34.8	26	23.2	18.9	19	16.6	25.4	5.9
E4	26	27.7	44.7	40	-	-	36	40.9	43.7	32.4	33.1	25	35	7.3
E5	55	57.3	54	50.3	62.7	61.7	74.7	74.4	61	52.6	30	32.3	55.5	13.7
E6	26	23.7	-	25.3	36.7	37.1	37.2	27	22	16.4	16.9	12.6	25.5	8.6
E7	43	30.3	28.7	25.2	34	31.6	35.5	31.4	27.4	-	-	14.4	30.1	7.4
E8	56.3	45.3	-	36.2	48.5	43.6	48.7	43.9	47.8	47.3	45.9	35.6	45.4	5.8
E9	47	-	32	29.8	39.2	45.1	45.1	28.7	23.1	23.6	25.1	-	33.9	9.4
E10	66.3	59.7	60	63.5	61.5	48.4	42.8	45.2	42.7	34.9	34.6	28.4	49	12.9
E11	51	35.7	37.7	36.3	45.2	35.5	24.1	22.5	22.3	20	17.9	14	30.2	11.6
E12	56	48.3	63.3	-	50	50.4	65.3	59.7	56.1	38.6	35.0	22.9	49.7	13
E13	67	48.7	50.4	38	41.5	38.1	44.4	38.3	-	-	22	19.3	40.8	13.7
E14	71	54.3	61	48	50.8	42.4	43.6	38	35.7	28.5	26.9	22.5	43.6	14.4
Mean	46.8	40.1	46.1	36.0	42.2	40.2	43.1	38.2	35.7	30	26.5	20.9	36.9	-
S.D.	16.1	12.6	13.5	12.1	12.4	9.7	13.1	14.1	14.3	12.4	8.8	7.6	10.3	-

Appendix D_4

Weekly repetition per minute for station 4 (38 metre walk/run)

Study Number	Weeks of training												Mean	S.D.
	1	2	3	4	5	6	7	8	9	10	11	12		
E1	6	7.3	-	4.8	8.5	7.5	7.3	5.6	5.6	3.4	6.3	5.9	6.2	1.4
E2	6	5.8	6.7	6.3	9.3	8	8.6	6.7	-	-	5.1	4.6	6.7	1.5
E3	5.7	4	-	5.5	8.7	9.9	12.2	9.8	7.5	5.1	3.7	2.6	6.8	3.0
E4	6	5.7	7.4	8	-	-	6.4	6.3	5.9	6.9	4.3	3.0	6	1.5
E5	10	7.6	8	9.5	9.5	9.3	8.8	8	7.4	7.4	7	6.7	8.3	1.1
E6	5	5	-	4.8	8.2	8.9	9	6.3	5.3	4.2	3.4	3.3	5.8	2.0
E7	6	8	7.3	6.5	8.7	8.1	8.4	6.1	4.6	-	-	1.9	6.6	2.1
E8	8.5	8	-	7.8	8.1	7.7	7.7	6.7	5.0	5.9	7	5.9	7.1	1.1
E9	8	-	7.8	7.4	8	7.7	7.5	6	4.4	4.6	4.6	-	6.6	1.5
E10	10.5	8.7	9.7	9.5	9.3	9.2	8.1	11.1	6.3	5.3	4.3	2.8	7.9	2.6
E11	5.5	4.5	6.5	6.4	7.8	6.8	7.3	7.3	5.5	4.3	3.9	2.8	5.5	1.5
E12	8	8	8.2	-	8	8	6.9	6.8	6.1	4.9	3.6	2.7	6.5	1.9
E13	12.3	10.7	10.9	8.3	8.9	7.1	7.1	5.8	-	-	4.3	3.8	7.9	2.9
E14	22	16.3	14	14.5	14.8	10.9	9.7	9.2	7.7	7.7	6.8	3.7	11.5	5.0
Mean	14	7.7	8.7	7.6	9.1	8.4	8.2	7.1	5.9	5.4	5.0	3.8	7.1	-
S.D.	4.5	3.2	2.3	2.6	1.8	1.2	1.5	1.7	1.1	1.4	1.3	1.5	1.5	

Appendix D_5

Weekly repetition per minute for station 5 (bench step)

Study Number	Weeks of training												Mean	S.D.
	1	2	3	4	5	6	7	8	9	10	11	12		
E1	24.7	24	-	17	27.7	30.4	25.5	25.7	21.8	14.3	15.9	13.9	21.9	5.7
E2	22.3	22.4	28.9	27.8	31	22	21.2	16.3	-	-	12.9	12.3	21.7	6.4
E3	19.5	21.6	-	27	29.8	28	27.9	19.6	20.5	15.4	15.7	14.4	21.8	5.6
E4	18	23.8	29.6	29	-	-	26.4	29.6	26.2	20.3	18.4	16.3	23.8	5.1
E5	32	34	35.7	31.8	35.3	32.1	34.1	35.3	29.2	26.7	24.4	17.7	30.7	5.4
E6	32	22.7	-	17.8	21.7	18.4	22.5	21	20.5	17.2	13.9	9.3	19.7	5.7
E7	21.7	17	13.3	15	22.8	23.2	26.1	19.6	17.9	-	-	8.5	18.6	5.4
E8	44.3	33.3	-	23	25.8	27.2	30.8	27.9	30.6	26.9	26.1	22	28.9	6.1
E9	24.5	-	22	22.8	28.3	23.5	21.5	18	16.8	16.6	16	-	21	4.0
E10	43.3	34	33.3	28	27.8	24.9	26.7	22.4	19.3	22.1	23.7	14.4	26.7	7.6
E11	33	26	28.7	23.8	25.3	22.1	20.3	16.7	15.9	12.8	9.6	10.3	20.4	7.1
E12	33	24	28.9	-	21	19.6	21.5	20.3	23	18.4	15.2	11.3	21.5	6.0
E13	40.3	28	28.9	23	24.7	20.9	25.7	22.3	-	-	16.4	14.2	24.4	7.3
E13	49	39.7	50	43.5	48.7	40.7	39.2	31	30	25.1	22.8	18.9	36.6	10.8
Mean	31.3	27	29.9	25.3	28.5	25.6	26.4	23.3	22.6	19.6	17.8	14.1	24.1	-
S.D.	10.0	6.4	9.4	7.4	7.2	6.1	5.3	5.8	5.2	5	5	3.9	6.5	-

Appendix D_6

Weekly repetition per minute for station 7 (Zig zag broad jump)

Study Number	Weeks of training								Mean	S.D.
	5	6	7	8	9	10	11	12		
E1	2.4	3.3	4	3	3	4.3	2.9	2.8	3.3	0.6
E2	2.6	4.5	5.3	4.7	-	-	2.9	2.8	3.8	1.2
E3	3.2	4.9	6.5	4.4	3.8	2.9	3	2.4	3.9	1.3
E4	-	-	2.4	2.3	2.9	2.2	2.2	2.0	2.3	.3
E5	4.7	4.4	5.2	4.9	6.4	6.3	6	4.1	5.3	0.9
E6	2.5	3.1	3.7	4	3.2	2.6	2.1	1.5	2.0	0.8
E7	1.7	2.3	3.3	4	3.2	-	-	1.9	2.7	0.9
E8	3.6	2.8	3.9	4.1	3.8	3.3	4.1	3.4	3.6	0.6
E9,	3.9	3.5	3.4	3.4	2.5	1.4	1.6	-	2.8	1.0
E10	3.6	3.4	3.9	4.1	3.8	4	4	1.5	3.5	0.9
E11	2.8	3.8	4.5	3.8	3.1	2.3	2.5	2.4	3.2	0.8
E12	3	2.9	4.3	3.4	3.3	2.4	1.7	1.1	2.8	1.0
E13	3.2	3.5	3.6	3.2	-	-	2.0	1.7	2.9	0.8
E14	5.3	6.8	7.9	7.4	6	4.8	3.6	2.9	5.6	1.8
Mean	3.3	3.8	4.4	4.1	3.8	3.3	3	4.3	3.5	-
S.D.	0.9	1.2	1.4	1.2	1.2	1.4	1.2	0.72	1.0	

Appendix D_7

Weekly repetition per minute for station 10
(jump to wall point)

Study Number	Weeks of training		Mean	S.D.
	11	12		
E1	27.4	30.8	29.1	2.4
E2	22.9	10.1	16.5	9.1
E3	12.3	12.9	17.6	0.4
E4	8.9	10.0	9.5	0.8
E5	40.6	28.5	34.6	8.6
E6	15.7	15.6	15.7	0.07
E7	-	11.5	11.5	-
E8	36.7	36.9	36.8	0.1
E9	9.4	-	9.4	-
E10	20.3	24.5	22.4	3
E11	27.4	25.8	26.6	1.1
E12	37.7	24.3	3.1	9.5
E13	26.7	24	25.4	1.9
E14	37.4	38	37.7	1.0
Mean	24.9	22.5	22.8	-
S.D.	11.1	9.8	10.2	-

Appendix D_8

Individual mean repetition per minute for the entire programme

Study Number	Mean repetition per minute for 12 weeks						
	Station 1	Station 2	Station 3	Station 4	Station 5	Station 7	Station 10
E1	3.2	32.1	25.1	6.2	21.9	3.3	29.1
E2	2.4	26.9	27.3	6.7	21.7	3.8	16.5
E3	2.3	28.7	25.4	6.8	21.8	3.9	12.6
E4	2.4	24.1	35	6	23.8	2.2	9.5
E5	2.8	69.4	55.5	8.3	30.7	5.3	34.6
E6	1.9	23.9	25.5	5.8	19.7	2.8	15.7
E7	2.4	20.4	30.1	6.6	18.6	2.7	11.5
E8	3.3	65.6	45.4	7.1	28.9	3.6	36.8
E9	2.3	32.6	33.9	6.6	21	2.8	9.4
E10	3.4	34.0	49	7.9	26.7	3.5	22.4
E11	3.5	43.8	30.2	5.5	20.4	3.2	26.6
E12	2.8	44.3	49.7	6.5	21.5	2.8	31
E13	2.9	37.5	40.8	7.9	24.4	2.9	25.4
E14	3.5	37.1	43.6	11.5	36.6	5.6	37.7
Mean	2.8	38.6	36.9	7.1	24.1	3.5	22.8
S.D.	0.5	16.6	10.3	1.5	6.5	1.0	10.2

Appendix D9

Weekly group mean pre- and post-exercise respiratory rate monitor

Week	Pre-exercise	1 minute post-exercise	5 minutes post-exercise	10 minutes post-exercise
Initial pre-bronchodilator	28.3 ± 4.4	-	-	-
1	23.2 ± 2.9	26.2 ± 2.7	24.2 ± 2.7	23.1 ± 3.2
2	23.5 ± 2.8	27.8 ± 3.5	25.2 ± 3.3	23.9 ± 3.2
3	24.6 ± 3.8	28.8 ± 3.6	26.3 ± 3.9	24.7 ± 4.2
4	24.1 ± 3.5	29.0 ± 3.7	26.2 ± 3.7	24.3 ± 3.7
5	22.8 ± 1.9	28.1 ± 2.6	25.5 ± 2.4	23.6 ± 2.5
6	23.2 ± 2.0	28.4 ± 1.8	25.8 ± 2.0	23.7 ± 2.1
7	23.4 ± 2.9	29.1 ± 2.6	26.1 ± 2.8	24.2 ± 3.0
8	24.7 ± 2.9	30.8 ± 3.1	27.7 ± 3.1	25.7 ± 3.2
9	24.3 ± 3.0	29.8 ± 3.2	27.3 ± 3.5	25.6 ± 4.1
10	25.1 ± 3.0	30.9 ± 3.5	28.4 ± 3.3	26.6 ± 3.0
11	25.1 ± 2.7	31.3 ± 3.8	28.3 ± 3.4	26.5 ± 2.9
12	23.9 ± 2.8	31.1 ± 3.1	28.2 ± 3.3	26.5 ± 3.3
Final pre-bronchodilator	27.7 ± 4.3	-	-	-

Appendix D10

Weekly group mean pre- and post-exercise pulse rate monitor

Week	Pre-exercise	1 minute post-exercise	5 minutes post-exercise	10 minutes post-exercise
Initial pre-bronchodilator	100.6 ± 9.8	-	-	-
1	84.3 ± 3.7	88.2 ± 3.7	85.8 ± 3.5	84.5 ± 3.6
2	85.3 ± 5.1	90.8 ± 5.8	87.2 ± 5.1	85.4 ± 5.0
3	87.0 ± 4.7	92.2 ± 5.4	88.9 ± 5.8	87.0 ± 5.1
4	86.6 ± 5.5	92.0 ± 5.3	88.8 ± 5.1	86.5 ± 4.6
5	85.5 ± 2.9	91.4 ± 3.4	88.3 ± 3.3	85.8 ± 3.2
6	87.6 ± 4.5	94.2 ± 4.6	90.8 ± 4.8	88.5 ± 4.8
7	86.6 ± 3.2	94.4 ± 4.5	91.1 ± 4.5	88.6 ± 3.5
8	88.4 ± 6.0	96.7 ± 6.2	92.6 ± 6.3	90.1 ± 6.3
9	88.3 ± 5.4	95.8 ± 5.9	91.3 ± 5.8	88.8 ± 5.2
10	88.4 ± 4.4	95.6 ± 4.4	91.9 ± 4.3	90.2 ± 4.4
11	89.5 ± 5.3	97.2 ± 6.3	94.0 ± 5.6	91.5 ± 6.0
12	89.5 ± 5.3	97.2 ± 6.3	94.0 ± 5.6	91.5 ± 6.0
Final pre-bronchodilator	101.1 ±10.5	-	-	-

APPENDIX E1

[illegible]

STUDY NUMBER	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	ADMINISTRATION OF [illegible] DURING PERIOD OF [illegible] PROGRAMME: NAME OF DRUG	DAILY DOSAGE	DURATION OF USE	FREQUENCY [illegible] PROGRAMME	DRUG USED FOR TREATMENT OF ACUTE ATTACK	OTHER MEDICAL CONDITIONS DURING PROGRAMME	[illegible]
P1	Nil	3	1	Nil	1	1	Ventolin(Tab)	1Tab,Thrice	4/12	2	I.V. Adrenalin	Nil	2
P2	Nil	1	Nil	Nil	Nil	Nil	Ventolin(Tab)	1Tab,Once	1/52	1	Not Applicable	Malaria	None
P3	Nil	4	Nil	Nil	Nil	Nil	Ventolin(Tab)	1Tab,Thrice	4/12	2	Not Applicable	Malaria	None
P4	Nil	4	1	Nil	2	5	Ventolin(Tab)	1Tab,Thrice	1/52	4	I.V. Adrenalin I.M. Aminophylline	Malaria	1
P5	Nil	2	Nil	Nil	Nil	Nil	Ventolin(Tab)	1Tab,Once	1/52	1	Not Applicable	Nil	None
P6	Nil	4	Nil	Nil	Nil	1	Ventolin(Tab)	1Tab,Twice	4/12	1	Not Applicable	Nil	Not Applicable
P7	Nil	1	Nil	Nil	Nil	Nil	Ventolin(Tab)	1Tab,Twice	4/12	1	Not Applicable	Malaria	None
P8	Nil	2	1	Nil	Nil	Nil	Ventolin(Tab)	1Tab,Once	1/52	1	Ventolin Inhalation	Nil	1
P9	Nil	3	Nil	Nil	1	1	Ventolin(Tab)	1Tab,Thrice	1/52	1	Not Applicable	Catharrh	None
P10	Nil	4	1	Nil	3	5	Ventolin(Tab)	1Tab,Thrice	1/52	2	I.V. Adrenalin I.V. Aminophylline	Catharrh Malaria	Temporary withdrawal
P11	Nil	5	Nil	Nil	Nil	Nil	Ventolin(Tab)	1Tab,Thrice	4/12	3	Not Applicable	Malaria	None
P12	Nil	1	Nil	Nil	Nil	Nil	Ventolin(Tab)	1Tab,Twice	4/12	1	Not Applicable	Nil	None
P13	Nil	4	1	Nil	Nil	2	Ventolin(Tab)	1Tab,Thrice	5/12	3	I.V. Adrenalin I.M. Aminophylline	Malaria	3
P14	Nil	6	Nil	Nil	Nil	Nil	Ventolin(Tab)	1Tab,Thrice	5/12	2	Not Applicable	Congenital Cardiac Defect and Malaria	1
C1	Nil	5	1	Not applicable	Not applicable	Not applicable	Ventolin(Tab)	1Tab,Thrice	5/12	2	I.V. Adrenalin	Nil	2
C2	Nil	4	2	Not applicable	Not applicable	Not applicable	Ventolin(Tab)	1Tab,Thrice	1/52	3	I.V. adrenalin	Malaria	5
C3	Nil	4	1	Not applicable	Not applicable	Not applicable	Ventolin(Tab)	1Tab,Thrice	1/52	2	I.V. Adrenalin	Malaria	2
C4	Nil	6	3	-do-	-do-	-do-	Ventolin(Tab)	1Tab,Thrice	1/52	4	I.V. Adrenalin I.M. Aminophylline	Nil	5
C5	Nil	1	Nil	-do-	-do-	-do-	Ventolin(Tab)	1Tab,Once	4/12	1	Not applicable	Nil	None

APPENDIX E2

ASSESSMENT OF ASTHMATIC STATUS SIX WEEKS POST PROGRAMME

STUDY NUMBER	NUMBER OF ADMISSIONS ON ACCOUNT OF ASTHMA SIX WEEKS POST PROGRAMME	NUMBER OF ATTENDANCE AT CLINIC ON ACCOUNT OF ASTHMA SIX WEEKS POST PROGRAMME	NUMBER HAVE ACUTE ASTHMATIC ATTACKS SIX WEEKS POST PROGRAMME	ADMINISTRATION OF ACTIVE ASTHMATIC DRUGS SIX WEEKS POST PROGRAMME				OTHER MEDICAL CONDITIONS SIX WEEKS POST PROGRAMME	PFR(L/MIN)
				NAME OF DRUG	DAILY DOSAGE	DURATION OF USE	FREQUENCY OF USE SIX WEEKS POST PROGRAMME		
E1	NIL	2	NIL	Ventolin(TAB)	1 Tab Thrice	4/7	2	NIL	160
E2	NIL	2	NIL	Ventolin(TAB)	1 Tab Once	4/7	1	Malaria	150
E3	NIL	2	1	Ventolin(TAB)	1 Tab Thrice	1/52	1	cough Malaria	155
E4	NIL	4	1	Ventolin(TAB)	2 Tab Thrice	1/52	2	NIL	-
E5	NIL	1	NIL	Ventolin(TAB)	1 Tab Once	4/7	NIL	NIL	250
E6	NIL	2	NIL	Ventolin(TAB)	1 Tab Thrice	4/7	2	Malaria	100
E7	NIL	1	NIL	Ventolin(TAB)	1 Tab Thrice	4/7	1	NIL	160
E8	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	-
E9	NIL	1	NIL	Ventolin(TAB)	1 Tab Once	4/7	1	NIL	200
E10	NIL	2	1	Ventolin(TAB)	2 Tab Thrice	1/52	2	Catarrh	220
E11	NIL	1	NIL	Ventolin(TAB)	1 Tab Twice	4/7	1	NIL	-
E12	NIL	2	1	Ventolin(TAB)	1 Tab Thrice	1/52	2	NIL	-
E13	NIL	2	1	Ventolin(TAB)	2 Tab Thrice	1/52	2	Malaria	315
E14	NIL	3	NIL	Ventolin(TAB)	1 Tab Thrice	1/52	1	Congenital Cardiac Defect	230
C1	NIL	2	NIL	Ventolin(TAB)	1 Tab Thrice	4/7	1	NIL	200
C2	NIL	1	NIL	Ventolin(TAB)	1 Tab Thrice	4/7	1	Malaria	-
C3	NIL	1	NIL	Ventolin(TAB)	1 Tab Thrice	4/7	1	NIL	-
C4	NIL	3	1	Ventolin(TAB)	2 Tab Thrice	1/52	3	NIL	270
C5	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	-

Appendix F1

Final subjective assessment

For the study on the effects of endurance exercise programme on the respiratory function of asthmatic children.

A. Personal Information

(1) Name: _____

(2) Hospital Number: _____ Study Number: _____

(3) Sex : _____

(4) Informant: _____

(5) Age: _____

_____

(6) Home Address: _____

B. Assessment of Programme

(7) Would you like this programme to continue? ☐

1 - Yes for some time

2 - Yes indefinitely

3 - No for some time

4 - No indefinitely

(8) What do you feel about the frequency of exercise session per week? ☐

1 - Too frequent

Appendix F1 (contd.)

2 - Not frequent enough

3 - Just all right

(9) What frequency would you recommend: ☐

1 - daily

2 - once a week

3 - twice a week

4 - as it is now

5 - fortnightly

(10) What do you feel about the intensity of exercise? ☐

1 - Too strenuous

2 - Alright

3 - Not strenous enough

(11) Do you see this as part of the treatment of asthma? ☐

1 - Yes

2 - No

3 - Not sure.

(12) On getting home after each exercise session, how does your child react? ☐

1 - Too tired to do any other work

2 - Not tired but playful and excited all day

3 - Not tired, ready to do household chores.

Appendix F1 (contd.)

(13) Does your child look forward to the next exercise session? ☐

1 - No

2 - Yes and excitedly

3 - Yes but not excitedly.

(14) Since the commencement of the programme, how would you described the intensity of your child's:

(a) Participation in group plays and games at home ☐

(b) Running errands and doing other household chores ☐

1. Same as before

2. More than before

3. Less than before.

(15) How would you describe the patients' general state of health since commencement of programme in terms of:

(a) Frequency of asthmatic attack ☐

(b) Frequency of feeling unwell ☐

(c) Activeness and alertness ☐

1 - Same as before

2 - More than before

3 - Less than before.

APPENDIX F2

[illegible] OF FACTORS OF [illegible] (SEE APPENDIX F1)

[illegible]	[illegible]	[illegible] LEVEL OF EDUCATION	OCCUPATION OF [illegible]	[illegible]	[illegible]	[illegible] OF CHILD DURING [illegible]	[illegible] (Rs.)	RESPONSES TO [illegible] ITEMS											
								7	8	9	10	11	12	13	14a	14b	15a	15b	15c
X1	Mother	Illiterate	Petty Trader	Self	Moderate	1 27	[illegible]	2	3	4	2	1	2	2	2	2	3	3	2
X2	Mother	Illiterate	Petty Trader	Self	Moderate	[illegible]	[illegible]	1	3	4	2	1	2	2	2	2	3	3	2
X3	Mother	Illiterate	Trader	Self	Moderate	None	[illegible]	2	3	1	2	1	1	1	2	2	3	3	2
X4	Aunt	Illiterate	Petty Trader	Self	Severe	1	[illegible]	3	1	5	1	1	2	2	2	3	3	3	2
X5	Father	Illiterate	Carpentry	Self	Moderate	None	33	1	3	2	2	1	2	2	2	2	3	3	2
X6	Father	Secondary Sch.	Trader	Self	Moderate	None	25	2	2	4	2	1	2	2	2	2	3	3	2
X7	Mother	Illiterate	Petty Trader	Self	Mild	None	27	3	1	2	2	3	1	2	2	3	1	3	1
X8	Mother	Uncompleted Secondary Edu.	Primary School Teacher	Cyc Stat Government	Mild	1	30	3	1	2	1	3	2	3	1	3	3	3	1
X9	Mother	Illiterate	Petty Trader	Self	Moderate	None	25	1	3	2	2	1	3	3	1	3	3	3	1
X10	Father	Secondary Education	Trader(Rtd Civil Servant)	Self	Moderate	1	27	2	3	1	2	1	1	2	3	1	3	3	2
X11	Mother	Secondary Education	Trader	Self	Moderate	None	27	1	1	2	2	1	2	2	2	3	3	3	1
X12	Uncle	Secondary Education	Civil Servant	Cyc Stat Government	Mild	None	27	3	1	3	2	3	1	3	1	1	3	3	2
X13	Father	Illiterate	Trader	Self	Moderate	1	27	2	3	4	2	3	3	2	1	2	1	3	1
X14	Mother	Illiterate	Petty Trader	Self	Moderate	None	27	2	3	4	2	1	2	2	2	2	3	3	2