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Effect of deep breathing training on exercise induced changes of respiratory parameters in normal young volunteers

Dissertation submitted in partial fulfillment for the Degree of Bachelor of Health Sciences (Biomedicine)

Wee Siok Hun

School of Health Sciences
Universiti Sains Malaysia
16150 Kubang Kerian, Kelantan
Malaysia

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CERTIFICATE

This is to certify that the dissertation entitled "**EFFECT OF DEEP BREATHING TRAINING ON EXERCISE INDUCED CHANGES OF RESPIRATORY PARAMETERS IN NORMAL YOUNG VOLUNTEERS**" is the bonafide record of research work done by **Ms. WEE SIOK HUN** during the period from November 2003 to February 2004 under our supervision.

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Wee Siok Hun

CONTENTS

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ABBREVIATIONS AND TERMS

Rf	Respiratory frequency
VC	Vital capacity
TV	Tidal volume
MVV	Maximum voluntary ventilation
PEF	Peak expiratory flow
BHT	Breath holding time
VE	Minute ventilation
FVC	Forced vital capacity
FEV1	Forced expiratory volume in one second
Sec	Second
Min	Minute
L	Litre
ml	Mililitre
MI	Myocardial infarction
COPD	Chronic obstructive pulmonary disease
DB	Diaphragmatic breathing
PLB	Pursed-lip breathing
IQ	Intelligent Quotient
BP	Blood pressure
BMI	Body mass index
*	Versus

ABSTRACT

The effectiveness of deep breathing training on exercise induced changes of respiratory parameters was studied on normal young volunteers. 34 male students were recruited from the University Sains Malaysia, Kubang Kerian as the subjects. All the subjects were normal and healthy. The subjects were divided into two groups: 1. Experimental group (n=17) and 2. Control group (n=17). The parameters included respiratory frequency (Rf), vital capacity (VC), tidal volume (TV), minute ventilation (VE), maximum voluntary ventilation (MVV), forced vital capacity (FVC), forced expiratory volume in one second (FEV1), peak expiratory flow (PEF) and breath holding time (BHT).

When the subject reported in laboratory, basal recordings for all parameters were recorded. Then subjects were asked to perform physical exercise on cycle ergometer with 40-45 rpm against the load of 3.0 kg for 5 minutes. At the end of 5 minutes, the subjects were allowed to rest for 3 minutes and all the parameters were recorded. Then, the deep breathing exercise was taught to the subjects of experimental group. They were instructed to practice breathing exercise 15 minutes in the morning and 15 minutes in the evening. Control subjects were not asked to do deep breathing exercise. All the subjects reported in the laboratory on the 8^{th}, 16^{th} and 24^{th} day. Every time, the parameters were recorded before and after cycle ergometry. The data obtained were analyzed by using 3-way (Group*Exercise*Time) ANOVA with repeated measures on the second and third factors. The results revealed that deep breathing exercise had beneficial effect on the breath holding time. Other parameters did not show significant change after deep breathing exercise.

INTRODUCTION

Life begins with our first breath and ends with our last breath. Through the process of breathing man is connected to the world around him. One can live for a long time without food, few days without water, but without breathing, man's life is measured in minutes (Kanty Koontz, 2000). Something so essential definitely deserves our attention.

Breathing is the most important of all the bodily functions; in fact all the other bodily functions depend on breathing. According to Rev. James Vinson Wingo (2000) humans are dependent on breathing for life and correct breathing habits are important for continued vitality of the body and freedom from diseases.

Breathing is important for two reasons. First, it is the only means by which our body receives the supply of oxygen which is vital for our survival. Second, breathing is one of the routes through which waste products and toxins are removed from the body (Rosemary A. Payne, 2000).

Breathing is an act in which we take air from atmosphere into our lungs, absorb the oxygen from it into our blood, and expel the air again into the atmosphere together with carbon dioxide and water vapour. During normal relaxed breathing, abdomen gently moves forward and backward as the air moves in and out. This is due to the fact that the diaphragm presses down on contents of the stomach during inspiration causing it to bulge out (Jacob Mathew, 1998). This act of inhalation and exhalation is repeated every 4 to 5 seconds. Thus normally we breathe about 15 times every minute and 20,000 times per day, each time taking about 500 ml of air per breath (Benjamin Levine MD, 1998; Nancy Zi, 1998).

However, the respiratory rate is not constant and the breathing pattern changes markedly under various physiological and pathological conditions. Simple physiological activities like walking, lifting some articles, carrying loads, climbing the stairs, running, doing any simple physical exercise or emotional disturbances increase the rate and depth of respiration. Some pathological changes that affect lungs like tuberculosis and bronchitis also change the pattern of breathing (Benjamin Levine MD, 1998).

A new born baby breathes with the abdomen. As the child gets older, breathing becomes partially intercostal (chest breathing). During adult life, most of the people breathe only through the chest. Abdominal breathing (maximal use of the diaphragm) is almost forgotten (Jacob Mathew, 1998), so much so that when the person tries to inhale, his chest expands but the abdomen moves in, which is abnormal. It makes the breathing process less effective because it not only promotes shoulder muscle tension, but also prevents the air from getting to the base of the lungs (Randall Helm. P.T, 1997).

Breathing is something that occurs automatically, spontaneously and naturally. Yet, one's breathing becomes modified and restricted in various ways, not just momentarily, but habitually (Hu Bin, 1991). People develop this type of unhealthy habits without being aware of it. They tend to assume position (slouched position) that diminishes lung capacities and take shortened breaths. Moreover, the social conditions and style of life also do not promote the healthy breathing. People are in a hurry most of the time and their movements and breathing also follow this pattern (Jacob Mathew, 1998). Furthermore the increasing stress of modern living makes people breathe more quickly and less deeply (Richard Rafoth MD, 2000). As life advances this unhealthy breathing – what is now called as shallow breathing, become part of their life.

Shallow breathing is breathing that is not deep enough to perform "normal" functions of life. By shallow breathing, sufficient oxygen can not enter into the body and sufficient carbon dioxide cannot be eliminated out of the body. As a result, body faces oxygen starvation and toxic build-up (Rosemary A. Payne, 2000). Levine has proved that ninety-nine percent of our energy should come from breathing, yet most of us access only 10-20% of our full breathing capacity, leaving us short of energy and compromising optimum health and well being (Levine S. et al., 1986).

An editorial in the Journal of the Royal Society of Medicine suggested that fast, shallow breathing can cause fatigue, sleep disorders, anxiety, stomach upsets, heart bum, gas accumulation, muscle cramps, dizziness, visual problems, chest pain and heart palpitations. In fact, scientists have also found that lot of people who believe that they have heart disease are really suffering from improper breathing (Rick Davids, 1997).

Studies have shown that cancer, strokes, pneumonia, asthma, speech problems and almost every disease known to mankind is worsened or improved by depending upon how well we breathe and the quality of our breathing. According to several European medical doctors and numerous Taoist, Buddhist, Hindu, Hawaiian and Native American healers and spiritual teachers, there are at least 200 conditions of life and diseases that relate directly to improper breathing (Kauffmann F et al., 2000).

Dr. Andrew Weil states that "*Improper breathing is a common cause of ill health.*" Self-evaluation of respiratory deterioration is significantly predictive of death among all causes. Breathing is the first place and not the last place to be investigated when any disordered energy presents itself. People who breathe optimally rarely or never get sick. They live a lot longer too (Kauffmann F et al., 2000).

Unless something is done to correct the bad breathing habits (shallow breathing), one can suffer permanent problems. The good news is that these are reversible. The bad news is that before one can change these habits, he should recognize and accept that his behavior needs to be changed. This means that he looks for himself the benefits of good breathing techniques.

Normal metabolic processes, tissue healing, and athletic performance all depend on effective breathing. There are at least 2 aspects to effective breathing: the proper use of the breath controlling musculature, including the muscles of the abdomen, the diaphragm, and the intercostal muscles of the thorax; and the functioning of the lungs themselves (Dee A.B and Lee E., 2000). By training these, the breathing can be changed into deep and slow breathing referred to as 'complete breathing' or 'master breathing'. It is great for stimulating internal visceral organs and pushing out the stale, stagnant air that collects in the lower lungs (Rick Davids, 1997).

This type of slow and deep breathing is also known as "diaphragmatic" or “belly breathing” (Randall Helm. P.T., 1997). When one breathes properly, using his diaphragm, oxygen is able to reach all parts of the lungs and more oxygen can then get into the bloodstream. More oxygen in our body provides improved energy and health.

Normally, lower lobes of the lungs are perfused with greater amount of blood than the upper and middle lobes. By deep breathing (diaphragmatic breathing) lower lobes get properly ventilated (Rosemary A. Payne, 2000). Unfortunately, most people do not make use of their diaphragm, and breathe with the help of their chest muscles.

Pranayama is one of the breathing exercises. Yet little is known to a layman till recently. It is considered as part of Yoga and during the last three decades topics such as Yoga, Pranayama, meditation etc are being discussed all over the world, not only by Yoga teachers, but also by the general public and by scientists and doctors (Joshi K.S., 2001).

More recently, various techniques of Yoga, especially breathing techniques have begun to attract the attention of physicians, therapist and medical consultants. It has been proved beyond doubt that breathing exercise (Pranayama) is a very important means for preventing and curing many ailments. It can be used without much external help for maintenance as well as restoration of health (Joshi K.S., 2001).

Besides Yoga, Tai Chi Chuan which is a combination of deep diaphragmatic breathing and relaxation with slow gentle movements is also popular among Chinese. A lot of researches have been carried out on the effect of Tai Chi Chuan on human health (*Li* JX et al., 2001). Tai Chi has been used to reduce pain in different groups of people suffering from osteoarthritis and to enhance balance in frail older people (Wolf SL et al., 1996; Wolf SL et al., 1997; Lan C et al., 1998).

Numerous studies have concluded that routine exercise is a good way to manage stress. Further, it is a simple solution for most. It has been suggested that it is not necessary to go to a gym or to run miles a day to get the beneficial effect of routine exercise in lowering heartbeat, slowing breathing, and improving bodily functions; instead even 10 minutes of stretching and slow, deep breathing can make a difference. And a few exercises incorporated easily into the workday can begin to offer immediate stress reduction (Ellen Serber, 2002).

A good number of sleep problems are shown to be solved by deep breathing exercises before bedtime (Sahasi G. et al., 2001). Research has shown that proper way of breathing with awareness can be used as a tool for increasing stamina and endurance, improving athletic performance, aiding digestion, lowering high blood pressure, helping weight loss, relieving constipation, enhancing memory and mood, increasing libido and improving work efficiency (Micheal G. White, 2000). Another research has shown that practicing slow and deep breathing is beneficial in heart failure or in other diseases like coronary disease (Goso Y et al., 2001). It is reported that deep breathing also was an effective technique for alleviating depression (Khumar S. S. et al., 1993).

In deep, abdominal breathing, the downward and upward movements of the diaphragm, combined with the outward and inward movements of the belly, ribcage, and lower back, help to massage and detoxify our inner organs, promote blood flow and peristalsis, and pump the lymph more efficiently through our lymphatic system. The lymphatic system, which is an important part of our immune system, has no pump other than muscular movements, including the movements of breathing (Jacob Mathew, 1998).

REVIEW OF LITERATURE

There are a lot of evidences in the literature to show beneficial effects of deep breathing exercise with or without yogic postures. Yoga is known to induce beneficial effects on physiological, biochemical and mental functions in man. Commonly practiced Yoga methods are 'Pranayama' (controlled deep breathing), 'Asanas' (physical postures) and 'Dhyana' (meditation) that are mixed in varying proportions depending on the type of Yoga (Yardi N., 2001).

Deep breathing had been shown to be useful in improvement of various physiological functions, clinical diseases and disorders. Robert Freeman from University of Wayne State (1998), Detroit, pointed out that the symptoms like hot flashes could be reduced by about 50 percent through slow, deep breathing in women going through the menopause. The severity of hot flashes in such women was shown to be reduced by about 50% simply by belly breathing and slowing down the respiratory rate at the onset of hot flashes (Carol Krucoff, 1998).

Proper breathing techniques had been proved to improve the cardiac function and endurance and also performance of skeletal muscle; it was also shown to increase the concentration, reduce tension and stress and decrease back pain (Farhi, 1995; Hendricks, 1996).

In a feasibility study in patients undergoing interventional cardiology procedures, Appels et al. (1997) found that breathing exercise therapy after percutaneous transluminal angioplasty reduced exhaustion, hostility, and apprehension. Following Yoga training, improvements in cardiovascular function (increased endurance and aerobic power) have been documented (Bera TK and Rajapurkar MV, 1993).

Previous reports had indicated that breathing and relaxation instruction added to a program of exercise rehabilitation improved psychological and physical outcome of rehabilitation after myocardial infarction (MI) and reduced the occurrence of cardiac problems over a 2-year follow-up period (Van Dixhoorn et al., 1987).

A slow rate of breathing (in the range of 6 breaths/min) was found to have several favorable effects on the cardio-respiratory system in patients with chronic heart failure: it increased resting oxygen saturation, improved ventilation/perfusion mismatching, and improved exercise tolerance by reducing the sensation of dyspnea (Bernardi L. et al., 1998); it also reduced chemoreflex activation and muscle nerve sympathetic activity (Luciano Bernardi et al., 2002).

Breathing exercises along with Yoga, meditation, and biofeedback technique had been shown to be successful in treating high blood pressure (BP) (Patel C and North WRS, 1975; Patel C et al., 1985; J. Irvine et al., 1986). There might be some rationale to accept the therapeutic effect of the breathing exercise because of its beneficial effects on the cardiovascular system, both at the systemic and the microvascular levels, these include increased baroreflex sensitivity, heart rate variability, microvascular flow and venous return, resulting in reducing BP and peripheral resistance (Novak V et al., 1994; De Daly MB, 1995).

Kim NC and Kanhohak Tamgu (1994) carried out a study to assess the effect of Dan Jeon breathing on blood pressure in hypertensive patients. The Dan Jeon breathing method is composed of thirty minutes program which including Dan Jeon breathing – a kind of abdominal-deep breathing, free gymnastics, mental concentration and physical strength exercise. The result proved that the Dan Jeon breathing method was an effective behavioral therapy to reduce blood pressure in the patient with essential hypertension.

Jennifer Chodzinski from University of Florida (2000) assessed at the effect of rhythmic breathing on blood pressure in hypertensive adults. Six female hypertensive adults were taught a 15 minutes breathing technique. At the end of the study, a significant decrease in their mean arterial blood pressure and heart rate were noticed.

In 2001, another group of researchers evaluated the efficacy of the Breath Interactive Music (BIM) in lowering the blood pressure in hypertensive patients. Using this new technology, patients were guided towards slow and regular breathing. It was found that breathing exercise guided by the BIM device for 10 minutes daily was an effective non-pharmacological modality to reduce blood pressure (Grossman E. et al., 2001).

Breathing exercise was used as a therapeutic agent in chronic obstructive pulmonary disease (COPD) patients also. These patients were found to have difficulty in breathing because of the cardiac problem and physical limitations. Breathing exercise in the form of diaphragmatic breathing (DB), pursed-lip breathing (PLB) and/or combination of these two were proved to be beneficial where the patients showed improvement in pulmonary functions by increasing tidal volume, improved arterial oxygenation, decreased respiratory rate and better alveolar ventilation (Donahoe M et al., 1989; Vitacca M. et al., 1998; Lareau SC. et al., 1999; Cahalin LP et al., 2002).

Breathing exercise was also shown to be beneficial in bringing out the long lasting effect on contractility of respiratory muscles; voluntary application of slow diaphragmatic breathing was found to increase tidal volume and decrease the rate of respiration (Fried R, 1987; Tibbets and Peper, 1993).

Another group of researchers looked at the effect of breathing exercise and meditation on ninety children with mild, moderate and severe degree of mental retardation. A significant improvement in Intelligent Quotient (IQ) and social adaptation were noticed in the yoga group as compared to that of control group (Uma K. et al., 1989).

Harvey J. R. (1983) noticed that learned breathing exercises showed significant changes on several dimensions of mood, including increased vigor and decreased tension, fatigue and depression in normal healthy young subjects.

Bhargava et al. (1988) had studied the autonomic responses to breath holding and its variations following Pranayama in twenty healthy young men for a period of 4 weeks. Baseline heart rate and blood pressure- the autonomic parameters (systolic and diastolic) were noticed to be decreased significantly after Pranayamic breathing. Thus Pranayama breathing exercise appears to alter autonomic responses to breath holding probably by increasing vagal tone and decreasing sympathetic discharges.

The effect of Pranayama on sub-maximal and maximal exercise tests was studied in athletes by Raju et al. (1994). The results showed that the subjects who practiced Pranayama could achieve higher work rates with reduced oxygen consumption per unit work and without increase in blood lactate levels.

It had been reported that practice of Prayanama modulated cardiac autonomic status and improved cardio-respiratory functions (Pandya D and Vyas V., 1999). Keeping this in view, Udupa K. et al. (2003) designed a study to determine whether Pranayama training had any effect on ventricular performance as measured by systolic time interval and cardiac autonomic function test on twenty four school children. They found out that three months of Pranayama training modulated ventricular performance by increasing parasympathetic activity and decreasing sympathetic activity.

There were some direct studies which showed the effects of Yoga breathing exercises (Pranayama) on airway reactivity on subjects with asthma (Singh V et al., 1990; Sathyaprabha TN et al., 2001). The results showed significant improvement in peak expiratory flow (PEF), vital capacity (VC), forced vital capacity (FVC), forced expiratory volume in one second (FEV1), FEV/FEC %, maximum voluntary ventilation (MVV) and absolute eosinophil count. The patients reported a feeling of well being, freshness and comfortable breathing. Thus Yoga seems to help in inducing positive health, alleviating the symptoms of disease by acting at physical and mental levels.

In another study, it was reported that the sympathetic activity was reduced following Yoga training without any change in parasympathetic activity. The FVC, FEV1 and PEF did not show any significant change. However, breath holding time showed significant improvement. The results indicated the decrease in sympathetic activity and improvement in pulmonary ventilation by way of relaxation of voluntary inspiratory and expiratory muscles (Khanam A. A. et al., 1996).

A comprehensive study was done by comparing the asthma patients who underwent training for two weeks in an integrated set of Yoga exercise including breathing exercise, physical postures, breath slowing techniques, meditation and a devotional session with a control group of asthmatic patients who did not have any of such training. At the end of the session, a significant improvement was noticed in the experimental group with less number of asthmatic attacks, decreased in the dosage of drug and increased in peak flow rate (Nagarathna R. and Nagendra HR., 1985). This study enlightened the efficiency of Yoga with breathing training in the long term management of asthmatic problems.

In another interesting study, effect of Yoga was explored on blood coagulation. Seven untrained male adults underwent a combination of Yogic exercises, daily for one hour, over a period of four months. At the end of the study, a state of hypocoagulability was noticed; this reveals the impact of Yoga on prevention of thrombotic disorder (Chohan I.S. et al., 1984).

Khumar et al. (1993) examined the effectiveness of Shavasana (a type of yoga exercise) in subjects suffering from depression. They found that Shavasana was an effective therapeutic technique for alleviating depression. In diabetic patients also, Yoga with breathing exercise was found to be very effective in lowering the blood glucose level within as short period as 40 days (Jain S.C. et al., 1993).

In 2001, U.S. Ray et al. had studied the effect of Hatha yogic exercise on aerobic capacity and perceived exertion after maximal exercise in Indian army (aged 19-23 year) men. The results revealed that absolute value of VO_2max increased significantly in the Yoga group after 6 months of training and the perceived exertion score after maximal exercise also was decreased significantly.

The effect of 10 weeks of Yoga training on respiratory functional status had been evaluated through a prospective study on 25 men aged 20 to 50 years who performed Yoga Asanas and Pranayama for 90 minutes (Makwana et al., 1998; Joshi LN. et al., 1992). It was noticed that the subjects who practiced Yoga showed a lower respiratory rate and increased forced vital capacity (FVC), forced expiratory volume in one second (FEV1), maximum breathing capacity (MBC) and longer breath holding time, concluding that the practice of Yoga benefited respiratory efficiency. In another study done by Dee A.B and Lee E. (2000), it was found that breathing exercise and Yoga postures had a good effect on respiratory parameters also. The finding showed a significant improvement in vital capacity in different categories of people.

The practice of Yoga had been documented to have numerous beneficial cardiovascular effects (Kreitzer M.J., 2002). Pandya and Vyas (1999) had summarized physiologic changes associated with Yoga training. These changes included decreased sympathetic tone, improved control of sympathetic function, decreased peripheral vascular resistance, improved cardiac stroke output, reduction in blood pressure, reduced heart rate, and improved cardiovascular endurance.

The effect of Hatha Yoga exercise also was evaluated on physiological and psychological parameters. It was found that the heart rate was decreased and the life satisfactory score was improved with lower scores on excitability, aggressiveness, openness, emotionality and somatic complaints and coping with stress and mood by the end of the experiment. The yoga group also had higher scores on high spirits and extravertedness. (Schell F. J. et al., 1994).

Raju et al. (1986) examined the effect of Pranayama on exercise tolerance in normal healthy volunteers. There was significant reduction of minute ventilation and oxygen consumption with 80% of the predicted heart rate. In another study, it was found that Yoga training resulted in a significant increase in pulmonary function and exercise capacity in adolescents with childhood asthma. A follow-up study spanning for two years showed a good response with reduced symptom score and drug requirements in these subjects (Jain S. C. et al., 1991).

The beneficial effects of Yoga were evaluated on coronary atherosclerotic disease also (Manchanda SC. et al., 2000). Within a period of one year, the yoga groups showed significant reduction in number of anginal episodes per week, improved exercise capacity and decreased in body weight. Serum total cholesterol, LDL cholesterol and triglyceride levels also showed significant reduction.

Yogic breathing was employed as an effective method of re-expansion of lungs in patients with pleural effusion (Prakasamma M. and Bhaduri A., 1984). The patients who practiced nostril breathing demonstrated a quicker re-expansion of the lungs in most of the measures of lung function.

Tai Chi Chuan (TCC) which was a combination of deep diaphragmatic breathing and relaxation with slow gentle movements of the body was tested by Hong et al. (2000) to evaluate the impact of long-term TCC practice on cardiovascular fitness of adults over the age of 65. Compared to a control group, adults who practiced TCC for over 10 years had improved balance, flexibility, and cardiovascular fitness.

There were some negative reports also regarding the effect of the diaphragmatic breathing. Gosselink et al. (1995) provided compelling evidence that diaphragmatic breathing reduced rather than enhanced breathing efficiency in people with severe COPD. It was shown that diaphragmatic breathing contributed to inappropriate chest wall motion and decreased mechanical efficiency while increasing dyspnea. Furthermore, diaphragmatic breathing had been reported to provoke post-hyperventilation hypoxemia.

LACUNA

Thus, most of the informations regarding the benefits of breathing training are either on long-term study or in combination with Yoga exercise, that also, mostly on trained athletes or patients with respiratory disorder and cardiac problems. Effect of deep breathing training alone for a short period on the exercise-induced changes of respiratory parameters is scanty, especially in Malaysia. Hence this study is taken up.

OBJECTIVES OF THE STUDY

Objectives of this study are:

1. To record the basal values of the respiratory parameters.
2. To record the exercise-induced changes of these parameters.
3. To see the effect of deep breathing training on these parameters at basal level.
4. To assess the effect of deep breathing training on exercise-induced changes of these parameters.

MATERIALS AND METHODS

SUBJECTS

Thirty four normal young male subjects aged 18-30 years were recruited from the student population of University Sains Malaysia, Health Campus, Kubang Kerian, Kelantan.

ETHICAL COMMITTEE APPROVAL

The test protocol was approved by the Ethical Committee of the University.

INFORMED CONSENT

The protocol was explained in detail to the subjects and written informed consent to participate in this study was obtained from them.

INCLUSION CRITERIA

All the subjects were normal and healthy. They were certified by the qualified doctor, who was one of the co-supervisors of this study.

EXCLUSION CRITERIA

- Smokers and drug addicts were not included.
- Subjects who had been treated for any cardiac problems, liver disease or renal diseases were not also included.
- Athletes or those who did regular exercise were not allowed to participate in this study.
- The suitability of the subject was determined by the doctor in charge.

SAMPEL SIZE DETERMINATION

Numbers of subjects were determined with the help of Dr. Than Winn, lecturer in statistics in PPSP, USM, who was also one of the co-supervisors of this study.

Sample Size Determination:

$$m = \frac{2\,(f_{\alpha} + f_{\beta})^2\,\delta^2\,(1-\rho)}{n\,s_{\chi}^2\,d^2}$$

δ^2 = Variance of

ρ = Error among Repeated Measures?

d = Detectable Difference

n = Number of repeated Measures per person

s_{χ}^2 = Subject Variation

FVC1	μ	= 4
	δ	=> 9
	d	= 0.5
	n	= 3
	s_{χ}^2	= 0.67
	p	= ?

$$m = \frac{2\,(1.96 + 0.84)^2\,0.4^2\,(1-0.2)}{3 \times 7}$$

PEF	μ	= 520
	δ	= 58
	d	= 10
	n	= 3
	s_{χ}^2	= 5
	p	= 0.2

$$m = \frac{2\,(1.96 + 0.84)^2\, 18^2\,(1 - 0.2)}{3 \times 4 \times 10^2}$$

S A M P L E S I Z E = 3 4

DOCTOR IN CHARGE TO SUPERVISE THE PROCEDURES

Dr. Paramasivam Arumugam, Medical Officer in Emergency Department, HUSM certified the subjects for their suitability to participate in the study and supervised the procedures. He was also one of the co-supervisors of the study.

STUDY DESIGN AND VARIABLES

Subjects were randomly divided into two groups:

1. Experimental group: 17 male subjects who practiced deep breathing exercise.
2. Control group: 17 male subjects who did not practice deep breathing exercise.

The experiments were conducted in well-lit laboratory in the Department of Physiology, PPSP.

MATERIALS

Materials used in this study were:

1. Cycle Ergometer (Monark Weight Ergometer Model 824E)
2. Computerized Spirometer (Pony Spirometer Graphic- Cosmed)
3. Stopwatch

PARAMETERS

Parameters assessed in this study were:

1. Respiratory frequency (Rf)
2. Vital capacity (VC)
3. Tidal volume (TV)
4. Maximum voluntary ventilation (MVV)
5. Peak expiratory flow (PEF)
6. Breath holding time (BHT)
7. Minute ventilation (VE)
8. Forced vital capacity (FVC)
9. Forced expiratory volume in one second (FEV1)

PROCEDURES

Subjects were made to get familiarized with the performance of cycle ergometry before starting the actual protocol. Then they were instructed to report in the laboratory at around 9 a.m. on a particular day. They were instructed to come with a light breakfast. After arrival to the laboratory, the testing procedures were explained in detail to the subjects.

Their height, weight and age were noted to calculate BMI on first day. Then the basal recordings were taken for each parameter.

Procedure for VC, FVC, FEV1 and PEF

1. Nose clip was applied and the subject was connected to the spirometer through the mouth piece.
2. Subject was instructed to breathe normally for 5 to 6 breaths through the mouth piece.
3. After his breathing was stabilized (noted in the spirometer), he was instructed to take maximum inspiration followed by forceful expiration.
4. The test was repeated for 3 times and the best one was printed and taken for analysis.

Procedure for Rf, TV and VE

1. The procedure was same as VC etc, but at the end of the forceful expiration, subject was instructed to breathe normally for 3-4 breaths through the mouth piece.