Efficacy of 12-week Pulmonary Rehabilitation Program on Exercise Capacity of Burned Children: A Randomized Control Study

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Abstract

The purpose of this study was to evaluate the therapeutic efficacy of 12 weeks of pulmonary rehabilitation program with a treadmill on exercise capacity of burned children measured by maximum oxygen consumption (VO_{2max}). Methods: thirty children from both sexes with healed partial thickness thermal burns participated in this study one month after being discharged from hospital. The patients' age ranged from 7-17 years with total body surface area (TBSA) of 20-40 %. Patients were randomized to either group A (control) who received their traditional physical therapy program, or group B (pulmonary rehabilitation group) who received in addition to traditional physical therapy program a pulmonary rehabilitation program in the form of aerobic exercises on a treadmill. The treatment was continued for 12 weeks at the frequency of 3 times per week. VO_{2max} and treadmill time were measured before treatment and after 12 weeks after treatment. Results: there were significant differences between the groups. VO_{2max} and treadmill time improvements for groups A and B were 26.9%, 25.6% and 58.6%, 60.5% respectively. Conclusion: adding aerobic exercises to traditional rehabilitation program is more effective in improving exercise capacity of burned children rather than performing traditional rehabilitation program alone, which accelerates the return of the children to their schools and perform their daily living activities.

Key words: Burn; Aerobic exercise; Exercise capacity

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1. INTRODUCTION

Burns have a catastrophic impact in terms of loss of human life, suffering, disability, and financial loss (Edlich et.al.,2010). Severe burns represent a major physical and psychological event in a child's life. Progress in the treatment of burns, such as fluid resuscitation, early burn wound excision, new antibiotics, and nutritional support has reduced burn mortality (Przkora et al., 2005). Burned children living beyond the acute phase of injury often have extensive physical functional limitations (Suman et al., 2002). In addition they suffer from a decrease in pulmonary function, marked prolonged skeletal muscle weakness and low physical and functional capacity (exercise capacity), which are major obstacles preventing the burn victim from returning to school and performing daily living activities (Suman et al., 2001; Dasu et.al., 2004; Willis et.al., 2011).

The majority of existing rehabilitation programs were designed focusing on short term outcomes. They emphasize relief of scar contractures and generally do not incorporate a quantifiable exercise prescribed to increase musculoskeletal strength and functional outcome (Cucuzzo, 2001). Such reduction in exercise capacity of burned patients indicates a need for rehabilitative interventions that improve physical function and performance (Suman et al., 2002).

Pulmonary rehabilitation is a multidisciplinary program for patients with respiratory disease. Potential benefits include reduced symptoms, improved exercise tolerance and quality of life. It varies widely in duration, frequency and structure as well as the nature of health care professionals involved (Rochester, 2000). The exercise session lasts from 20- 90 minutes and therapy duration ranges from 6 to 12 weeks with 2 or 3 sessions/week (Reina-Rosenbaum, 1997). Some programs routinely include upper extremity exercises such as pulley weights and arm ergometry, and exercise training to lower extremities such as floor or treadmill walking, bicycling ergometry or stair climbing, they may include also breathing retraining such as diaphragmatic breathing and pursed lip breathing (Rochester, 2000) .

Aerobic exercises are considered an important component of pulmonary rehabilitation programs as they improve the patient’s functional status and if the intensity of training is adequate, they result in a physiological training effect in patients with pulmonary dysfunctions (Larson et.al., 1999; Cheng et.al., 2003). Aerobic exercise is any activity that uses large muscle groups which overloads the heart and the lungs and causes them to work harder than at rest for a period of 15 to 20 minutes or longer while maintaining during 60-80% of this period maximum heart rate (Panton et al., 2004). Randomized controlled trials have demonstrated consistently that lower limb training of several types increases exercise capacity (Rochester, 2003). The motorized treadmill is the most common device used in pulmonary rehabilitation programs (Cucuzzo et.al., 2001).

VO_{2max} is the gold standard measurement of cardiovascular fitness. It provides an objective and reproducible assessment of patient's functional capacity or exercise capacity (Opasich et al., 2002).

Therefore the aim of this study was to evaluate the therapeutic efficiency of aerobic exercise using treadmill on the burned children's exercise capacity. As these results may help in planning a physical therapy program, which enhances the improvement of exercise capacity of burned children.

2. MATERIAL AND METHODS

2.1. Subjects:

Thirty children from both sexes and of age 7-17 years with healed partial thickness thermal burn injuries of 20- 40% TBSA were included in this study one month after their discharge from hospital. The patients were selected from teaching hospitals in Cairo, Egypt. The study was conducted in the out clinic of the Faculty of Physical Therapy, Cairo University. The faculty's Human Research Committee approved this study and written informed consents were obtained from the parents of all participants prior to their involvement. Patients were excluded from the study if they had one or more of the following: leg amputation, limitation of range of motion (ROM) of lower limb joints, anoxic brain injury, psychological or severe behaviour disorders (Suman et al., 2002). Patients were randomized into two equal groups; group A (control group) received traditional physical therapy program only (activities of daily living 'ADL', stretching, strengthening, and breathing exercises) three times per week for 12 weeks, and group B (pulmonary rehabilitation group) who received pulmonary rehabilitation program inform of aerobic exercise using a treadmill in addition to their physical therapy traditional program three times per week for 12 weeks.

2.2. Measurement procedures:

Zan-680 Ergospiro "Ergospirometry System" was used to measure patients' exercise capacity (VO_{2max}) and treadmill time in both groups, before and at the end of conducting treatment period (12 weeks). A treadmill exercise test was done by following the Modified Bruce protocol as shown in (Table 1). The mask was fixed by straps then the triple V. tube was connected to the mask. The starting speed and angle of elevation were 1.7 miles/ hour and 0% respectively; they were subsequently increased every 3 minutes. Patients were constantly encouraged to complete 3 minutes for each stage and the test was terminated once the peak volitional effort was achieved (Suman et al., 2002; Suman et al., 2001). The patients were instructed not to tightly grasp the side rails of the treadmill since this leads to decrease VO_{2max} and increases the time of exercise (Fletcher et al., 2001).

Table 1.The Modified Bruce protocol for treadmill exercise testing

Duration of interval (minutes)	Treadmill speed (miles/hour)	Grade of elevation (%)
3	1.7	0
3	1.7	5
3	1.7	10
3	2.5	12
3	3.4	14
3	4.2	16
3	5	18
3	5.5	20
3	6.0	22

2.3. Treatment procedures

Treatment was started one month after the patients' discharge from hospital for 12 weeks for both groups. RAM model 770 CF electronic treadmill was used for exercising group B at a rate of 3 sessions/week, each session was lasting from 20-40 minutes. The participant exercised at 70-85% of his previously determined individual VO_{2max} (Suman et.al. ,2002). Treadmill running exercises at a moderate pace began and ended with warming-up and cooling-down periods in the form of walking on the treadmill for about 3-5 minutes at speed 1- 1.5 kilometre/hour with zero inclination**.** With cooling down the speed was gradually decreased until reaching to zero (Perna et.al.,1999; San Juan et.al.,2007). Traditional physical therapy program for both groups was in the form of stretching and strengthening exercises of all involved areas in addition to diaphragmatic breathing exercises while activities of daily living were performed daily.

2.4. Data analysis

Student's t-test was used to compare pre and post- treatment program VO_{2max} and treadmill time values within each group. Paired t-test was used to compare both groups. P-value < 0.05 was considered statistically significant. Statistical analyses were performed with Statistical Package for Social Science (SPSS Inc., Chicago, Illinois), version 17 for Windows.

3. RESULTS

3.1. Patients' demographic data:

Table 2 shows patients' demographic data, and it demonstrates that there were no significant differences between both groups regarding the patients' age, weight , height and TBSA.

Table 2. Patients demographic data

Variables	Groups	
	Group (A)	Group (B)
Age(years)	12.5±3.1	11.4±3.02
Weight (Kg)	38.2±6.55	37.9±6.33
Height (cm)	137.9±9.2	135.7±10.9
TBSA(%)	32.89±6.56	29.45±5.11
Gender (M/F)	9/6	7/8

3.2. Results of control group (group A):

The mean values and standard deviations of VO_{2max} and treadmill time for the control group before and after treatment showed that there were significant improvements in the patients' VO_{2max} and treadmill time with *P* value <0.05 and with 26.9% and 25.6% improvement respectively (Table 3).

Table 3. The statistical analysis of mean differences of VO_{2max}, and treadmill time pre and post treatment (after 12 weeks) for control group

Statistical value	VO_{2max} (mL/Kg/ min)		Time (minute)	
	Pre	Post	Pre	Post
$\bar{X} \pm$ S.D	18.98±4.12	24.1±4.21	11.22±1.61	14.1±1.23
t- value	24.3		-10.1	
% of improvement	26.9%		25.6%	
P- value	< 0.05			

3.3. Results of pulmonary rehabilitation group (group B):

The mean values and standard deviation are represented in table 4 and showed highly significant improvements in the patients' VO_{2max} and treadmill time after pulmonary rehabilitation for 12 weeks with 58.6% and 60.5% improvement respectively.

Table 4. The statistical analysis of mean differences of VO_{2max} and treadmill time pre and post treatment (after 12 weeks) for pulmonary rehabilitation group

Statistical value	VO_{2max} (mL/Kg/ min)		Time (minute)	
	Pre	Post	Pre	Post
$\bar{X} \pm$ S.D	17.9±4.2	28.4±3.2	10.94±1.72	17.56±1.65
t- value	18.56		-18.88	
% of improvement	58.6%		60.5%	
P- value	0.0001			

3.4. Comparative Analysis of VO_{2max} and treadmill time between both groups of the study:

Figure 1 shows the mean values of patients' $VO_{2\ max}$ and treadmill time for groups A and B at the beginning of the study .The mean values were 18.98±4.12, 17.9±4.2 and 11.22±1.61, 10.94±1.72 respectively. The results represented that, there were no significant differences between both groups for $VO_{2\ max}$ and treadmill time with P value =0.34 and 0.71 respectively.

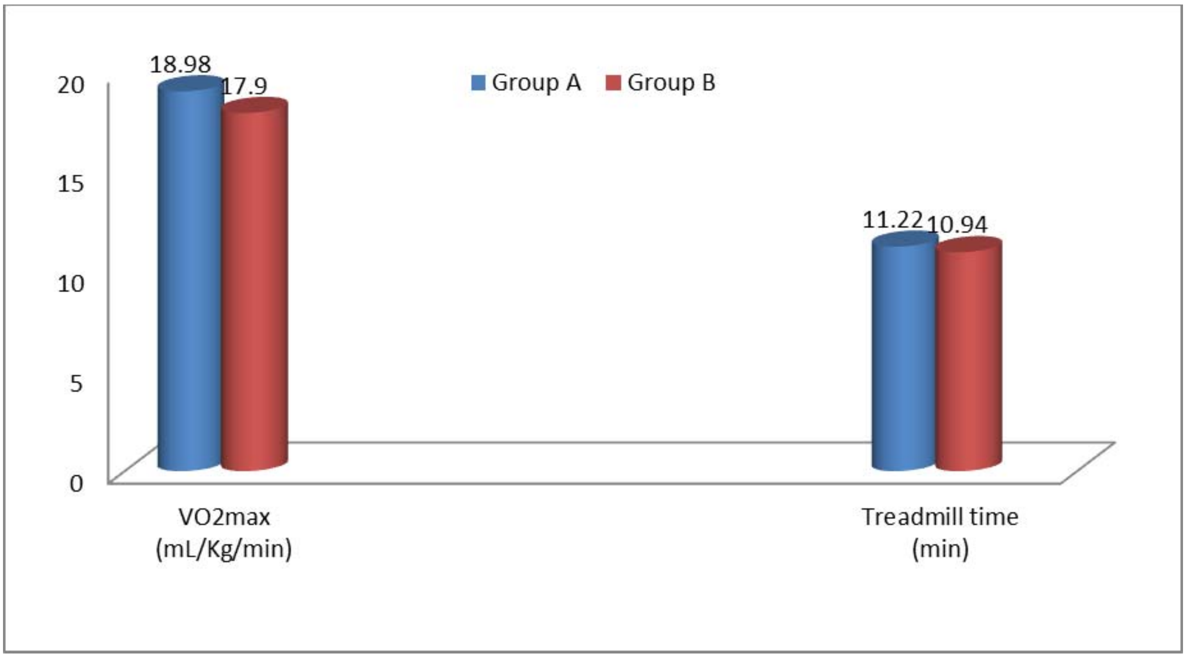

Figure 1. The mean value of VO_{2max} and treadmill time at the beginning of study for both groups.

After 12 weeks from the beginning of the study (post treatment) the results showed that there were significance differences regarding the patients' $VO_{2\ max}$ and treadmill time between both groups with P value = 0.001.The mean values for group A and B were 24.1±4.21, 14.1±1.23 and 28.4±3.2, 17.56±1.65 respectively (Figure 2).

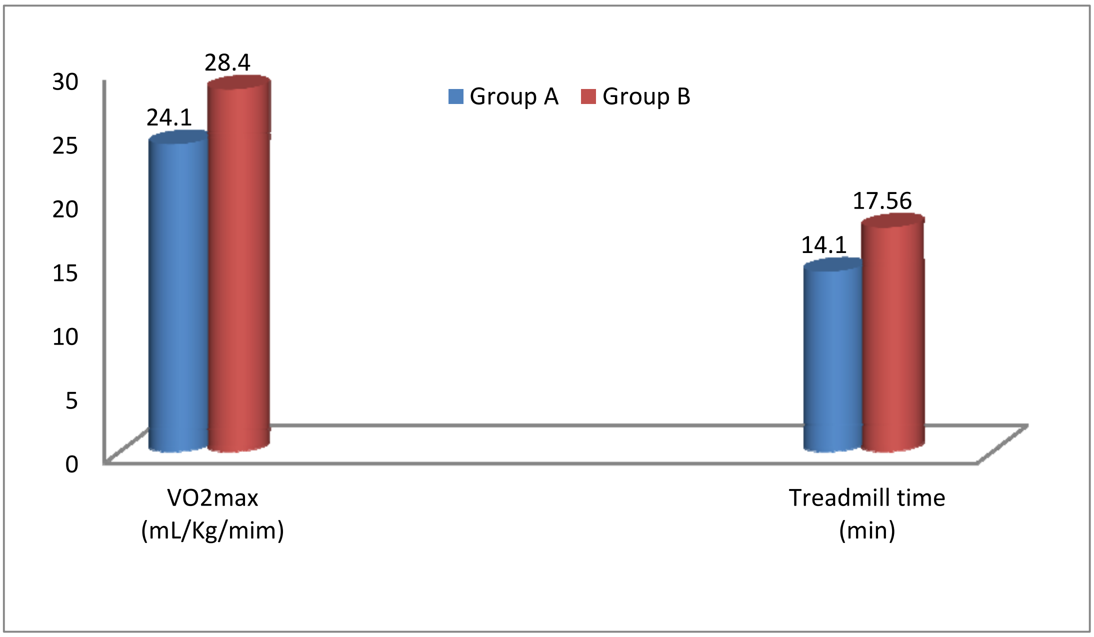

Figure 2. The mean value of VO_{2max} and treadmill time at post treatment for both groups (after 12 weeks).

4. DISSCUSION

The results of the current study pointed out that (1) there was reduction in the burned children exercise capacity represented by reduction in the VO_{2max} and treadmill time. This finding is supported by the results achieved by (Mlcak et.al., 1995), who reported abnormal cardiopulmonary functions in a patient survived after thermal injury, in addition to (Suman et.al., 2002; Abd El Baky et.al., 2006; willis et.al., 2011), who documented that there were deteriorations in both pulmonary function and exercise capacity resulting from burn injury, in addition our results showed that (2) there were improvement in the burned children exercise capacity and treadmill time after 12 weeks of pulmonary rehabilitation program in the form of aerobic exercise to the lower limbs using electronic treadmill.

There is a large body of literature supports the effectiveness of pulmonary rehabilitation program especially lower limb aerobic exercise; it is reported that an exercise training program consisted of aerobic exercise of 30-40 minutes duration for 59 patients suffering from obstructive pulmonary disease significantly improved the patient's peak exercise oxygen consumption (exercise capacity), and work output (Carter et.al.,1988).

Brdareski et.al.,2012 showed that, training involvement two times a week moderate intensity for 15 minutes is enough to achieve some improvement in aerobic capacity. Moreover, improvements in VO_{2max} and treadmill time were demonstrated following the application of moderate to high intensity aerobic exercise (Punzal et.al.,1991). In addition (Ortega et.al., 2002; Rhoades and Tanner, 2003) concluded that aerobic exercise resulted in improvements in exercise capacity, treadmill time and dyspnea of patients with varying degree of obstruction who experienced low VO_{2max}. Significant increase in patient's exercise capacity, forced vital capacity (FVC), and forced expiratory volume after 1 second (FEV_1) were achieved by the application of pulmonary rehabilitation program consisted of 10 minutes warm up, 25 minutes aerobic exercise and 10 minutes cool down (Finnerty et.al.,2001). (Suman et al, 2002) succeeded to conclude that children with thermal injury also benefit from exercise training, which was evidenced by increase in pulmonary function (PF) and exercise capacity.

It is reported that running, bicycling and other forms of aerobic exercise provide a sufficient stimulus to improve cardio-respiratory function (Porcari et.al.,2002). Similar findings were also supported by (Normandin et.al., 2002; and Rochester 2003), who showed improvement in PF and exercise capacity of patients with obstructive disease.

Several studies had shown that leg exercise program benefits patients with lung disease. Peripheral muscle training on treadmill has proven to be a valid tool for improving symptoms of dyspnea, quality of life, and capacity for exercise in patients with chronic obstructive pulmonary disease (COPD) (Ruiz de Oña Lacasta et.al., 2004). (Janos et.al., 2005) concluded that, lower extremity training for 8 weeks caused improvement in exercise capacity and dyspnea reduction measured with Modified Borg Scale.

Improvement in the VO_{2max} may be due to an increase in the blood flow to the active muscle mass because of an increase in maximal cardiac output and the changes within muscle also contribute to this increase, primarily the increases in capillarization, myoglobin and oxidative enzyme activity (Bouchard et.al.,1999). In addition, it was suggested that the significant increase in VO_{2max} might be related -in part- to the effect of aerobic exercise that improves the respiratory function and - on the other hand- to an increase in the stroke volume of the heart by the effect of regular exercise. These respiratory adaptations facilitate oxygen supply to tissues and add further evidence to the improvement of respiratory fitness (Carsten et.al., 2004). Recently (Kolt and Snyder-Mackler, 2007) concluded that The mechanism underlying improvement in VO_{2max} after aerobic training may be attributed to improved central adaptations (increased heart rate and stroke volume at maximal exercise would produce elevated cardiac output) along with peripheral adaptations (improved cardiac output redistribution, improved endothelial function, increased capacity of the muscle to extract oxygen owing to an increase in capillary density). Additional benefits of increased capillary density include decreased diffusion distance, and increased red blood cell transit time, providing enough time for oxygen diffusion which is facilitated by the increase in the number of mitochondria that increase the surface area for oxidation. Also, temperature elevation and decreased pH in the active muscle facilitate oxygen unloading from haemoglobin. The combined effects of increased capillarity and enhanced oxygen unloading result in an increase in the arteriovenous oxygen difference . Current theory states that, the increases in the arteriovenous oxygen difference and increases in cardiac output contribute equally to the increased VO_{2max} observed after aerobic training**.**

The results of this study and previous studies prompt us to conclude that addition of aerobic exercise to the traditional rehabilitation program is effective means for improving burned children exercise capacity rather than application of the traditional rehabilitation program alone.

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6. REFERENCES

Edlich, R.F., Drake, D.B, and Lsevieong Iii, W.B. (2010). Burns, thermal. Am J Emerg Med , 27: 227-35.

Przkora, R ., Jeschke, M.G., and Barrow, R.E. (2005). Metabolic and hormonal changes of severely burned children receiving long-term oxandrolone. Ann Surg , 242: 384–391.

Suman, O.E., Mlcak, R.P., and Herndon, D.N.(2002). Effect of exercise training on pulmonary function in children with thermal injury. J Burn Care Rehabil ,23: 288-293.

Suman, O.E., Spies, R.J., Celis, M.M., Mlcak, R.P., and Herndon, D.N. (2001). Effect of a 12-wk resistance exercise program on skeletal muscle strength in children with burn injuries. J Appl Physiol, 91:1168-1175.

Dasu, R.K., Barrow, R.E., and Herndon, D.N. (2004). Gene expression changes with time in skeletal muscle of severely burned children. Ann Surg , 241: 647–653.

Willis, C.E., Grisbrooka, T.L., Elliottb, C.M., Woodc, F.M., Wallmana, K.E., and Reida, S.L. (2011). Pulmonary function, exercise capacity and physical activity participation in adults following burn. Burns, 37 :1326-1333

Cucuzzo, A.N., Ferrando, A., and Herndon, D.N. (2001).The Effect of exercise programming vs tradional outpatient therapy in the rehabilitation of severely burned children. J Burn Care Rehabil, 22: 214-220.

Rochester, C.L.(2000). Which pulmonary rehabilitation program IS best for your patient? J Respir Dis, 21: 535-546.

Reina-Rosenbaum, R., Back, J.R., and Penak, J. (1997). The cost benefits of outpatient-based pulmonary rehabilitation. Arch phys Med Rehabil , 78: 240-244.

Larson, J.L., Covey, M.K., Wirtz, S.E., Berry, J.K., Alex, C.G., Edwin, A.W.,and Edwards, L. (1999). Cycle ergometer and inspiratory muscle training in chronic obstructive pulmonary disease.Am. J Respir, Crit. Car Med, 160: 500-507.

Cheng, Y.J., Macera, C.A., Addy, C.L., Wieland, D. and Blair, S.N. (2003). Effect of physical activity on exercise tests and respiratory function. Br J Sports Med , 37: 521-528.

Panton, L.P., Golden, I., Broeder, C.E., Browder, K.D., and Cestaro-Seifer, D.J.(2004). The Effect of resistance training on functional outcomes in patients with chronic obstructive pulmonary disease. Eur J Appl Physiol , 91: 443-449.

Rochester, C.L.(2003). Exercise training in chronic obstructive pulmonary disease. J Rehab , 40: 59-80.

Opasich, C., Criffo, A., and DeFeo, S.(2002). Cardiopulmonary exercise test for patients with heart failure. Am Heart J , 142: 465-475.

Fletcher, G.F., Balady, G., Bernard, G., Eskel, R., Fleg, J., and Froelicher, V.F.(2001) Exercise standards: a statement for health care professionals from the American Heart Association Writing Group. Circulation ,104:1694-1833.

Cherniack, N.S, Altose, M.D., and Homma, I.(1999). Rehabilitation of patient with respiratory disease. The McGraw-Hill Companies, Ch (18): 217-231

Perna, F., Bryner, R., Donley, D., Kolar, M., and Mornsby, G.(1999). Effect of diet and exercise on quality of life and fitness parameters among obese individuals. Journal of Physiology, 70: 125-131.

San Juan, A.F., Fleck, S.J., Chomorro-vina, C., Mate-Munoz, J.L., Moral, S., Perez, M., Cardona, C., Dell Valle, M.F., Hernandez, M., Romirez, M., Madero, L., and Lucia, A.(2007). Effects of an intrahospital exercise program intervention for children with leukemia . Med Sci Sports Exerc, 39:13-21.

Mlcak, R.P., Desai, E., Robinson, R., McCauley, R.L., and Richardson, J.(1995). Increased physiological dead space/tidal volume ratio during exercise in burned children. Bums , 21: 337-9.

Abd El Baky, A.M., Borhan, W.H., and Abd Ghani, S.(2006). Efficacy of aerobic and deep breathing exercises on pulmonary function and functional capacity in burned male patients. A thesis submitted to physical therapy department for surgery, in partial fulfilment of the requirement for doctoral degree in physical therapy, faculty of physical therapy, Cairo University.

Carter, R., Nicortra, B., Clark, L., and Williams, J. (1988). Exercise conditioning in the rehabilitation of patients with chronic obstructive pulmonary disease. Arch Phys Med Rehabil , 69: 118-22.

Brdareski, Z., Djurovic, A., Susnjar, S., and Zivotic-Vanovic, M., et al.(2012). Effects of a short-term differently dosed aerobic exercise on maximum aerobic capacity in breast cancer survivors: a pilot study. Vojnosanit Pregl, 69: 237-242.

Punzal, P.A., Ries, A., Kaplan, R., and Prewitt, L.(1991). Maximal inspiratory exercise training in patients with chronic obstructive pulmonary disease. Chest, 100: 618-623.

Ortega, F., Toral, J., Cejudo, P., Villagomez, R., Sanchez, H., Castillo, J., and

Montemayor T.(2002). Comparison of effects of strength and endurance training in patients with chronic obstructive pulmonary disease. American Journal of Respiratory and Critical Care Medicine, 166: 669-674.

Rhoades, R.A., and Tanner, G.A.(2003). Medical Physiology. 2nd Ed, Lippincott WiIIiams& Wilkins, Ch (19): 309-316.

Finnerty, J.P., Bullough, I., and Jones, J.(2001). The effectiveness of outpatient pulmonary rehabilitation in chronic lung disease. Chest , 119: 1705-1710.

Porcari, J., McCarron, K., and Kline, G.(2002). Is fast walking an adequate aerobic training stimulus for 30 to 69 year old men and women?. Phys. Sports Med,1: 119-129.

Normandin, E.G., McCusker, C., Connors, M.L., Vale, F., Gerardi, D., and ZuWaHack, R.L.(2002). An evaluation of two approaches to exercise conditioning in pulmonary rehabilitation. Chest, 121: 1085-1091.

Ruiz de Oña Lacasta, J.M., García de Pedro, J., Puente Maestu, L., Llorente, D.I, Celdrán, J.G., and Cubillo, J.M.(2004). Effects of muscle training on breathing pattern in patients with severe chronic obstructive pulmonary disease. Arch Bronconeumol, 40: 20 - 23

Janos, V., Krisztina, B., and Attila, S.(2005). The effect of controlled and uncontrolled dynamic lower extremity training in the rehabilitation of patients with chronic obstructive pulmonary disease. Orv Hetil , 146: 2249-2255.

Bouchard, C., Anna, P., and Rice, T.(1999). Familial aggregation of VO_{2max} response to exercise training results from the heritage family study. J Appi Physiol, 87: 1003-1008.

Carsten, J., Christima, K., Jens, J., Peter, K., Magni, M., and Jens, B.(2004). effect of high-intensity intermittent training on lactate and H^+ release from human skeletal muscle. Am. J. Physiol Endocrinol Metab, 286: 245-251.

Kolt, G.S, and Snyder-Mackler.(2007). Physical therapy in sport and exercise. 2nd ed London. Churchill livingstone, 160-165.