IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 18, Issue 6 Ser. 14 (June. 2019), PP 79-83
www.iosrjournals.org

Cardio-Pulmonary Exercise Test in Health and Disease

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Abstract: *Cardio-Pulmonary Exercise (CPE) test provides precise physiologic profile in health and quantifies disability in pulmonary disease. However, CPE though so very informative for evaluating physiologic function of lungs is surprisingly less commonly used in pulmonary practice in India.*
This study shows results of VO2 Max in 40 healthy individuals and VO2 peak in 17 patients suffering from pulmonary disease. The results emphasize need for optimal fitness in health and importance of rehabilitation in pulmonary diseases.
Abbreviations :
(A-a)02: Alveolar arterial oxygen tension gradient; BR: Breathing Reserve; Eq.O2 : Equivalent Oxygen; Eq.CO2: Equivalent Carbon dioxide; HR: Heart Rate; HRR: Heart Ratio Reserve; 02/HR: Oxygen pulse and Heart rate; SpO2: Oxygen Saturation; VCO2: Amount of carbon dioxide breathed out; VO2 : Amount of oxygen consumed; VO2/Kg: Oxygen consumed per kg body weight; VO2 Max: Maximal amount of oxygen consumed; VO2 Peak : Peak Oxygen consumption; RER : Respiratory Exchange Ratio; METS:Metabolic Equivalents.

Date of Submission: 08-06-2019 Date of acceptance: 25-06-2019

I. Introduction

Maximal amount of physical work which can be performed by an individual depends on physiologic limits imposed by his oxygen transport system. This can be measured by oxygen uptake during incremental exercise testing. Cardio-Pulmonary Exercise (CPE) test provides precise measure of fitness in health and in sport medicine. It quantifies disability of the disease state, evaluates progress of the disease process and its response to treatment.

Exercise test is used routinely in cardiology practice to evaluate stress induced Ischemic heart disease and in sport medicine to assess limits of exercise tolerance. However, exercise test though so very useful and informative is not so well used in pulmonary practice in India. One of the possible reasons is lack of awareness of the usefulness of cardio-pulmonary exercise test amongst the chest physicians. We could find only one publication[1] limited to VO2 Max in COPD patients in academic journals of India on the subject.

OBJECTIVE: VO2 max also known as aerobic physical work capacity is the maximal oxygen uptake beyond which there is no further increase of VO2 uptake on incremental exercise. Peak VO2 is maximal oxygen uptake on exercise to the point of individual endurance.
Present study was designed to obtain fresh standard values of parameters measured during VO2 max testing in healthy subjects. Peak VO2 uptake was measured to estimate disability in patients suffering from pulmonary disease. The main aim however is to increase its recognition amongst the chest physicians of this neglected subject of cardio-pulmonary exercise test.

II. Material And Methods

Healthy persons were those who visited for complete health check-up scheme of the hospital and found free from any physical disorder. Patients suffering from pulmonary disease were those with established diagnosis.

Healthy group comprised of total 40 of which 27were males and 13 females. Pulmonary disease group comprised of total 17 patients of which 8 were males and 9 females. 8 patients suffered from bronchial asthma, 3 from COPD, 3 from sarcoidosis, 1 from ILD, 1 from systemic lupus and 1 from neurocirculatory asthenia.
Study Design: Prospective observational study
Study Location: This studywas done in Department of Respiratory MedicineMedicine, at Jaslok Hospital and Research Center, Mumbai, India
Study Duration: February 2013 to November 2013.

Inclusion criteria:.

1. Healthy persons were those who visited for complete health check-up scheme of the hospital and found free from any physical disorder.
2. Patients suffering from pulmonary disease were those with established diagnosis.
3. Either sex
4. Aged ≥ 18 years,
5. Patients who were ready for giving written consent for the test

Exclusion criteria:

1. Pregnant women;
2. Patients with heart diseases
3. Unstable angina
4. Uncontrolled hypertension
5. Aortic stenosis
6. Hypoxia (Pulse oximeter saturation <85%)
7. Epilepsy
8. Locomotor disorder
9. Patients who did not give consent
10. Acute febrile illness

Procedure methodology

After written informed consent was obtained, a well-designed performa was used to collect the data of the patients prospectively. The performaincluded socio-demographic characteristics such as age, gender, nationality, height, weight, physical activity, lifestyle habits like smoking and alcohol and any history of chronic illness.

Exercise test was carried out with Jeager equipment using treadmill. Separate protocols were used for healthy persons and for patients suffering from pulmonary disease. We introduced VO2 Max test for normal healthy subjects in 1978[2], but with simple equipment and standard treadmill protocol. Over the years the protocols were required to be modified to suit the subjects. Accordingly we used VO2 Max protocol to evaluate fitness in healthy subjects and separate peak V02 protocol to estimate disability in patients suffering from pulmonary disease. Physical work capacity (PWC) was calculated for each stage by using treadmill ergometry for the body weight of each subject. In treadmill ergometry work is equal to force into distance with the value for angle of elevation and expressed in joules. Power is amount of energy required for work accomplished per unit of time and is expressed in METS which is measured by oxygen consumption. One MET is equal to 3.25 ml of O2/kg/minute. There is therefore direct relationship between duration, work load and energy cost. During test procedure continuously changing values every fifteen seconds of eleven parameters were displayed on the monitor screen for observation. Parameter values seen on the screen were V02; VCO2; RER; H.R; HRR; SpO2; VE; BR; BF; VO2/Kg; O2/HR.

On completion of test, a print-out of all recorded data including METS was available along with graphs showing relationship results of important parameters. Graphs were for VO2 & VCO2; Eq O2 and Eq CO2; VE; RER; HR and O2/HR; VE and Work-load over the time period of the test.

Statistical analysis

All data was entered in MS Excel spreadsheet. Analysis was done using Epi info 7.1.1.Continuous variable are presented as mean (standard deviation) in case of well distributed data and median (Interquartile range) in skewed distribution respectively. Categorical data are presented as frequency (percentage). Appropriate statistics was used for analysis of data.

III. Result

Since V02 Max study of 1978 and over the period on the basis of the number of tests done, we developed for our subjects normal standard values of 30 ml/kg for males and 25 ml/kg for females. However, for comparison of the results of this study normal reference values for VO2 Max of 50 percentile was selected from normative table for maximum aerobic power (V02 Max) by age and gender from American College of Sports Medicine Guidelines for exercise testing and prescription which is accepted internationally[3].

TABLE no.1 : VO2 max test values in Healthy male subjects

AgeGroup	Duration	Work-load	Energy (METS)	RR	VE	HR	Vo2max	VO2/HR	VCO2	VO2/Kg	VO2/Kg Predicted
20-29	13.15	177	10.55	52.62	91.12	194	2513.66	14.47	2775.62	43.9	42.5
30-39	12.78	125.15	10.6	44.28	74	157	2162.14	13.6	2306	33.4	41.0
40-49	8.07	74.51	9.75	48	84	138	1372	14.35	2627.5	34.25	38.10
50-59	10.25	103.4	7.55	38.75	68.75	141	1770.40	13.6	2030.7	26.45	35.20
60+	14.3	130.01	5.25	38.5	53	148.5	1078	17.65	1197	18.25	31.80
Male Healthy	11.71	122.01	8.63	44.43	74.17	155.7	1779.24	14.73	2187.36	31.25	37.72

Table –1 shows average of all parameters of VO2 max test values in healthy males subjects of various age (in years) groups.

Table no.2 : VO2 max test values in females with pulmonary disease

Age Group	Duration	Work-load	Energy (METS)	RR	VE	HR	Vo2max	VO2/HR	VCO2	VO2/Kg (ml)	VO2/Kg Predicted
20-29	11.45	116.27	6.8	36	69	154	1821	11.8	1958	23.7	42.5
30-39	20.45	191.75	8.2	34	64	149	1692	11.4	1976	28.7	41.10
40-49	12.3	213.18	4.9	34	60	152	1735	11.6	175.6	17	38.1
50-59	8	90.32	2.8	28	28	154	794	8.7	704	9.9	35.2
60+	13.70	134.54	5.21	37.83	54.33	138.5	990.75	17.41	1258.33	21.08	31.80

Table –2 shows average of all parameters of VO2 peak test values in pulmonary disease group in male patients of various age(in years) groups.

TABLE no. 3: VO2 max test values in Healthy females

AgeGroup	Duration	Work-load	Energy (METS)	RR	VE	HR	Vo2max	VO2/HR	VCO2	VO2/Kg	VO2/Kg Predicted
20-29	13.86	119.5	7.4	38.75	45.25	168	1375.75	8.85	1416.75	16.7	35.20
30-39	11	93.18	6	38	46.66	145	1271.33	8.86	1339.33	25.85	33.80
40-49	8.8	71.69	6.4	41	55	178.5	1350.66	8.0	1505.5	21.65	30.90
50-59	11.05	94.10	6.37	31.33	33.5	114	757	7.56	815.33	14.46	28.20
60+	8.0	79.03	3.8	36	43	124	925	7.5	1056	13.20	25.8
Female Healthy	10.54	91.5	6.54	37.02	44.68	145.9	1135.95	8.15	1226.58	18.37	30.78

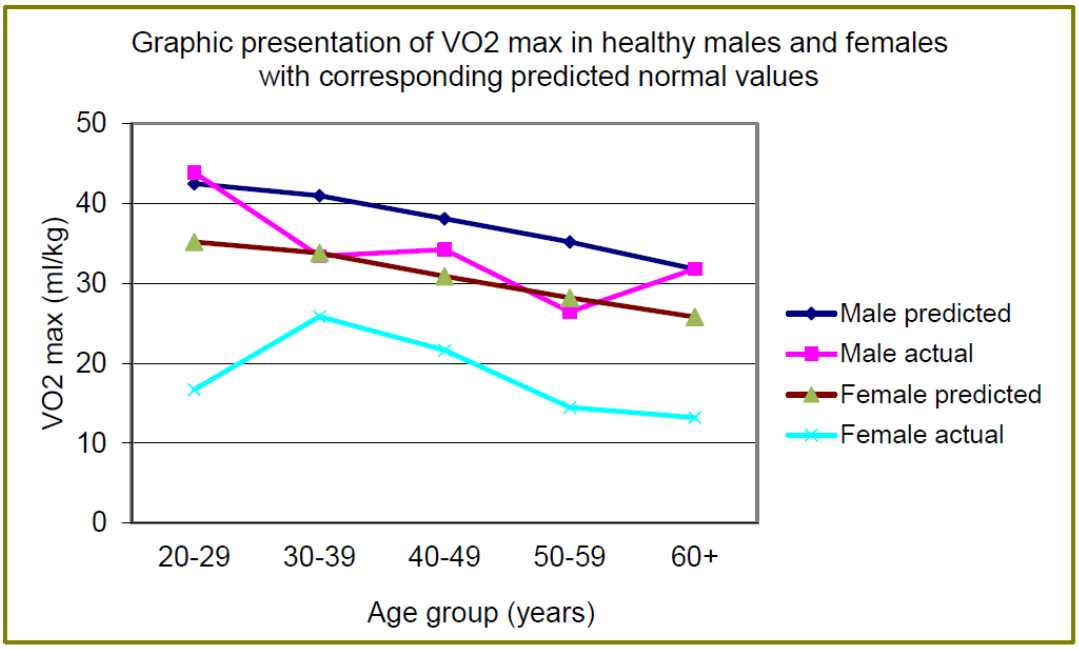
Table –3 shows average of all parameters of VO2 max test values in healthy female subjects of various age (in years) groups.

TABLE no. 4 : VO2 peak test values in females with pulmonary diseases

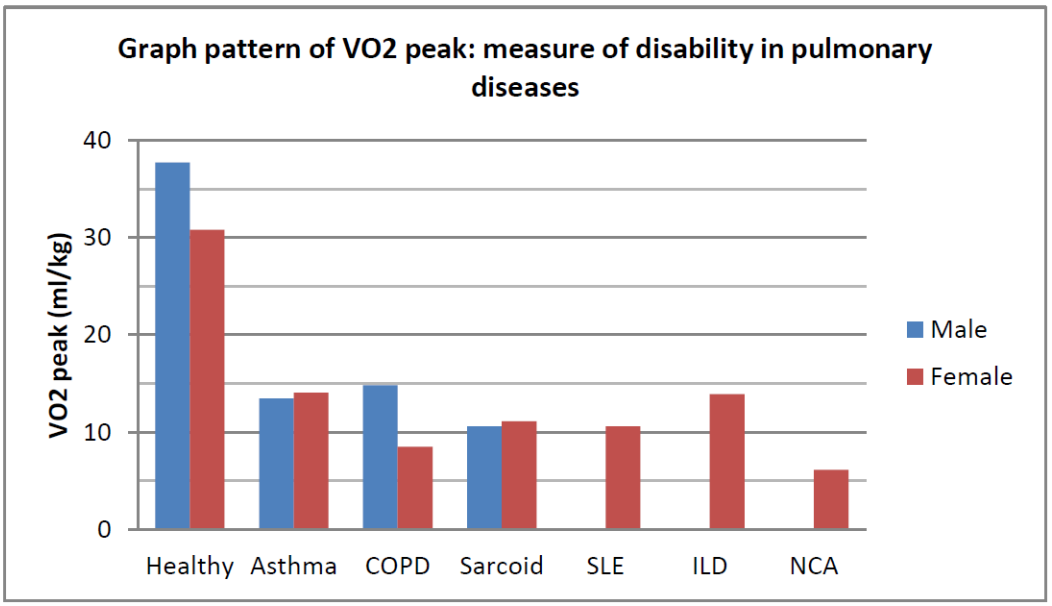
Age Group	Duration	Work-load	Energy (METS)	RR	VE	HR	Vo2max	VO2/HR	VCO2	VO2/Kg (ml)	VO2/Kg Predicted
20-29	8.15	48.54	1.7	39	41	173	261	1.5	1168	6.1	35.2
30-39	11.3	113.25	4.5	38	38	183	1169	6.4	1203	15.6	33.80
40-49	8.15	73.38	5.3	36	49	69	1201	17.4	1379	18.5	30.9
50-59	7.30	127.49	5.0	47	45	144	1040	7.2	1234	17.4	28.20
60+	14.87	115.28	4.46	45	36	127.15	715.25	6.2	797.66	13.46	25.8

Table – 4 shows average of all parameters of VO2 peak test values in pulmonary disease group in female patients of various age(in years) groups.

Graphs 1 Shows VO2 Max values of healthy maleswith corresponding predicted.



Graph 2: VO2 Max values for healthy females with corresponding predicted.



IV. Discussion

This is prospective sample study but results are quite indicative of the trends. In healthy male groups fitness was excellent in 20-29 age group. It declined by about 30% in 30-39 age group. Remaining were also quite below predicted normal standard. In healthy females of 20-29 age group fitness level was poor below 50%. Amazingly while 30-39% were just below normal. 50-59 age group were in excellent fitness state above predicted normal. In patients suffering from pulmonary disease least affected were asthmatics , chronic obstructive pulmonary disease related disability was crippling in females. Interstitial lung disease was intermediate.

Incremental exercise stresses the reserve of physiologic systems by increase in cardiac output mainly heart rate, increase in oxygen consumption, increase in minute ventilation to maintain alveolar oxygen and remove excess CO2 produced. In patients with cardiac disease heart rate increases, and arterial mixed venous oxygen difference widens more at given level of VO2. Patients with lung diseases are not limited by

hemodynamic compensation, but mainly by ventilation functions and pulmonary gas exchange compromise. Therefore use of heart rate to guide maximal exercise or rehabilitation target is not so useful. This is the importance of pulmonary exercise testing. To meet the demand of exercise in health, the physiological parameters- VO2, VCO2, VE, HR and ((A-a)O2 are classical and with characteristic pattern and closely related to work-load and energy required.

Health is a physiologic state free of disease. Fitness is ability to use body systems for physical work capacity at the optimal level possible. A man may be healthy but because of deconditioned state he may not be totally fit.

For poor physical work capacity related to limited VO2 uptake and early onset of anaerobic threshold, the most important cause is lack of physical exercise. With onset of cardio-respiratory diseases, these representative subjects would be far more disabled than the physically fit candidates.

The exercise test measures physical work capacity and thereby provides quantitative evaluation of effort tolerance since the physical work capacity depends on cardio-pulmonary reserve. Quantitative evaluation of fitness in various states of health provides detection of also earliest impairment of the reserve due to disease process. The most significant data regarding the cardio-pulmonary metabolic and physiological state of the patient can be obtained.

V. Conclusion

CPE test is a global test of the cardiorespiratory capacity that reflects the entire oxygen transport system starting with the lungs and ending with the skeletal muscles. The results emphasize need for optimal fitness in health and importance of rehabilitation in pulmonary diseases.

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Ambika Sharma. "Cardio-Pulmonary Exercise Test in Health and Disease." IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), vol. 18, no. 6, 2019, pp 79-83.