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Cardiopulmonary Exercise Testing in Apparently Healthy Indian Male Population: A Pilot Study

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Abstract

Introduction: CR fitness is important for performing daily activities and mobility. It has been reported that VO_2 peak values below 20mL * kg−1* min−1 is associated with limited physical function for instrumental activities of daily living.

Methodology: They were subjected to CPET (Cardio Pulmonary Exercise Test) after ruling out structural heart disease by echocardiogram. Their smoking habit and indication of performing the investigation was documented. Post exercise test, the data was recorded and tabulated.

Result: These males were subjected to cardiopulmonary stress test, after an echocardiogram was done to rule out structural heart disease. The data obtained was classified into different age groups starting at less than 20 y, 20–39 y, 40–49y, 50y and beyond.

Conclusion: This study conclude that, the baseline data will make way for routine CPET in assessment of reflighting of pilots with respiratory and cardiac disorders based on Maximum oxygen consumption , Stroke volume improvement, Lactate threshold reached at level of exercise (in METS), VE/CO_2 slope and the usual exercise stress parameters based on ECG findings.

Keywords: Cardiopulmonary Exercise; Healthy Population; O_2; CO_2.

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Introduction

Exercise testing provides valuable diagnostic and prognostic information regarding patients with cardiovascular and pulmonary disease. The addition of ventilatory gas exchange measurements during exercise testing allow for the analysis of gas exchange at rest, during exercise, and during recovery and yield measures of oxygen uptake (O_2), carbon dioxide output (CO_2), and ventilation (E). These data can be readily integrated with standard variables measured during exercise testing, including heart rate, blood pressure, work rate, electrocardiography findings, and symptoms, to provide a comprehensive assessment of exercise tolerance and exercise responses [1].

CR fitness is important for performing daily activities and mobility. It has been reported that VO_2 peak values below 20mL*kg−1 *min−1 is associated with limited physical function for instrumental activities of daily living [2-3].

Over the past decades, numerous scientific reports

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have examined the relationships between physical activity, physical fitness, and cardiovascular health. Expert panels, convened by organizations such as the Centers for Disease Control and Prevention (CDC), the American College of Sports Medicine (ACSM), and the American Heart Association (AHA) [4-6], along with the 1996 US Surgeon General's Report on Physical Activity and Health [7], reinforced scientific evidence linking regular physical activity to various measures of cardiovascular health. The purpose of this study was to measure exercise tolerance in normal healthy adults and to evaluate variations in exercise tolerance as per age, gender and anthropometric parameters.

To assess baseline oxygen consumption, ventilatory parameters and exercise ECG in healthy adults and build up data pool on Indian population.

Material And Methods

We included 72 males from age group 18 – 60 y by random selection during medical for initial entry to Airforce and routine annual medical in serving personnel. They were subjected to CPET (Cardio Pulmonary Exercise Test) after ruling out structural heart disease by echocardiogram. Their smoking habit and indication of performing the investigation was documented. Post exercise test, the data was recorded and tabulated. Those with a positive stress test were not included in the data set, so as to keep this data for comparison as a normogram in future studies. QUARK CPET coupled along with Mortara treadmill was used. Bruce protocol for graded exercise was used to standardize results of stress test along with ventilatory protocols.

Quark CPET is manufactured by Cosmed and gives 01 min analysis of oxygen consumption, CO_2 production. It has an inflow and an outflow sensor for oxygen and CO_2, which enables these measurements. The lactate threshold is a derived parameter from this. There is a turbine in the breathing apparatus which measures flow rates and minute ventilation. The equipment needs preparation with regular calibration using a standard premixed gas cylinder supplied by the company. The individual is made to wear the breathing mask in an airtight manner and then made to exercise on the treadmill (Fig. 1,2).

Fig. 1:

Fig. 2:

Observation

These males were subjected to cardiopulmonary stress test, after an echocardiogram was done to rule out structural heart disease. The data obtained was classified into different age groups starting at less than 20y, 20 – 39y, 40 – 49y, 50y and beyond. Selected parameters from the data obtained have been projected below:

Table 1: Age less than 20 years

	VO_2 MAX (ml/Kg/min)	% Pred.	METS	VE (ml/min)	SV Peak (ml)	VE/VCO_2 SlopE
1	46.63	74	13	60.9	84	27.3
2	31.86	57	9.1	52.9	77	28
3	43.77	72	12.5	70	90	27.6
4	32.27	53	9.2	64	65	0
5	30.11	49	8.6	46.2	57	0

6	39.8	68	11.3	79	72	27.8
7	49.65	273	14.1	125.1	97	37.4
8	55.75	309	15.9	98.8	92	30.5

Table 2: Age 20–29 years

	VO_2 MAX (ml/Kg/min)	% Pred.	METS	VE (ml/min)	SV Peak (ml)	VE/VCO_2 SlopE
1	35.69	75	10.1	81.9	73	29.7
2	42.68	80	12.1	81.5	88	29.7
3	29.6	61	8.4	85	71	28.2
4s	46.05	85	13.1	91.7	92	31.9
5	33.48	66	9.5	63.3	83	30.8
6	42.78	86	12.2	83	92	30.3
7	45.4	88	12.9	79.5	110	26.2
8	38.71	71	11	75.1	74	30.8
9	42.51	71	12.1	101.9	78	26.8
10	40.03	77	11.4	108.6	86	24.2
11	30.92	53	8.8	139.8	59	60.6

Table 3: Age 30 – 39 years

		VO_2 MAX (ml/Kg/min)	% Pred.	METS	VE (ml/min)	SV Peak (ml)	VE/VCO_2 SlopE
smoker	1	22.62	48	6.4	76.1	66	
	2	41.33	76	11.8	63.9	71	24.1
	3	39.48	81	11.2	74.5	89	27.4
	4	35.64	76	10.1	78.4	70	28.9
	5	34.88	75	9.9	72.8	77	29.5
	6	39.36		11.2	84	88	24.1
	7	38.81	75	8.2	105	90	0
	8	35.8	84	10.2	100.5	97	17.1
	9	32.16	72	9.1	68.6	88	28.8
	10	28.56	64	8.1	88.9	57	27.4
	11	32.5	70	9.2	75.3	65	32.5
smoker	12	24.15	54	6.9	49.1	53	31.3
	13	28.5	77	8.1	110.8	103	27.1
	14	26.46	58	7.5	75.6	51	38.2
smoker	15	34.45	76	9.8	85.5	82	0
smoker	16	34.55	68	9.8	66.2	74	29.4
	17	31.33	72	8.9	56.6	79	30.9

Table 4: Age 40 – 49 years

	VO_2 MAX (ml/Kg/min)	% Pred.	METS	VE (ml/min)	SV Peak (ml)	VE/VCO_2 Slop E	
1	37.86	93	10.8	73.1	95	0	
2	28.3	78	8	90.2	83	0	smoker
3	35.31	87	10	91.2	74	29.7	
4	30.01	78	8.5	79.5	84	30	
5	30.13	76	8.6	86.1	75	37.8	
6	25.43	72	7.2	118.5	72	48.5	
7	29.65	77	8.4	107.6	78	41.4	
8	38.75	105	11	108.5	97	36.3	
9	28.73	85	8.2	98.6	92	46.7	
10	31.92	81	9.1	59.9	72	29.3	
11	32.48	80	9.2	101.8	85	31.9	
12	32.78	78	9.3	96	90	0	

13	35.03	88	10	87.5	119	0	
14	42.83	110	12.2	108	117	0	
15	42.7	99	12.2	112.1	101	36.7	
16	29.51	72	8.4	76.5	74	36.7	smoker
17	27.91	65	7.9	72.1	54		
18	27.33	73	7.8	80.4	71	38.5	
19	31.03	75	8.8	88.7	97	31.9	
20	29.13	69	8.3	59.7	73	37	
21	33.37	95	9.5	125.1	125	29.1	
22	34.64	82	9.8	98.7	85	0	
23	27.69	65	7.9	90.7	67	32	

Table 5: Age 50 years and above

	VO_2 MAX (ml/Kg/min)	% Pred.	METS	VE (ml/min)	SV Peak (ml)	VE/VCO_2 SlopE
1	21.33	58	6	72	56	0
2	24.72	69	7	70.3	88	36.2
3	28.48	83	8.1	103.1	96	45.7
4	30.37	86	8.6	95.5	81	40.2
5	28.96	76	8.2	71.2	67	31
6	29.24	81	8.3	63.5	69	27.2
7	35.06	106	10	106.4	105	31.2
8	31.43	86	8.6	89.9	79	33.2
9	40.72	108	11.6	102	91	0

Table 6: TMT positive

	VO_2 MAX (ml/ Kg/min)	LT VO_2/ KG	% Pred.	METS	LT METs	VE (ml/ min)	SV Peak (ml)	SV Recov.	VE/VCO_2	VE/VCO_2 Slope
1	18.04	3.26	52	5.1	0.9	48.4	71	72	49	0
2	30.53	28.09	75	8.7	8	64.7	77	75	29.4	28.3
3	29.02	23.28	78	8.2	6.6	70.1	77	77	34.7	29.6
4	28.46	19.12	93	8.1	5.4	70.3	66	66	31.8	30.6

Effort tolerance in most was good with average VO_2 Max, effort tolerance, minute ventilation and stroke volume as noted above for different age groups (Tables 1-5).VE/VCO_2 slopes are indicated of pulmonary embarrassment and normal figures are generally less than 30. They are higher in patients with COPD, Bronchial asthma, pulmonary hypertension etc. We found that older individuals have a higher slope.

All exercise tests were negative except for 04 individuals (Table 6). They have not been included in the normograms (Tables 1-5) mentioned above. They have been mentioned separately in a table below (Table 6) to give an insight into the possibility of its use for further studies in patients with cardiopulmonary disorders. It was noted that individual 1 and 4 who did not have a rise in stroke volume and had an early lactate threshold and a lower VO_2 max (as compared to individual 2 and 3), eventually underwent intervention due to Triple vessel disease and double vessel disease respectively.

Discussion

The cardiovascular and respiratory systems work together to provide delivery system (of O_2) and removal (of CO_2) from the tissues (1). This happens by

(a) External respiration:
   (i) Pulmonary ventilation
   (ii) Pulmonary diffusion, or the exchange of O_2 and CO_2 between the lungs and the blood

(b) Internal respiration:
   (i) Transport of O_2 and CO_2 in the blood;
   (ii) Capillary gas exchange or the exchange of

O_2 and CO_2 between the capillary blood and the working muscle.

Increase in oxygen uptake by the working muscles is contributed most by an increase in cardiac output (heart ratexstroke volume), which may increase to up to 6 times that at rest [8]. Increase in blood flow to the lungs occurs by increased cardiac output and pulmonary vessel dilatation. This is accompanied by a greater extraction of O_2 from the blood, which results in a widening of the arteriovenous oxygen (a– O_2) difference [9].

Increase in minute ventilation (E) during exercise must be matched by an increase in blood flow; that is, cardiac output must increase to appropriately match ventilation so that necessary gas exchange can occur [10]. Mismatch occurs when cardiac output fails to increase as in heart failure, LV dysfunction etc and ventilation fails to increase in pulmonary conditions like COPD, Bronchial asthma, ILD etc [11-12]. This is seen as increase in VE/ CO_2 slope.

This study is a pilot study to collect data with respect to healthy males. It was observed that the exercise in CPET as measured by actual oxygen consumption was lower than that derived by the duration of exercise done on only exercise / treadmill equipment (which is not coupled with ventilation parameters and derives METS by stages and duration of exercise). On an average, smokers had a lower predicted for age maximum oxygen consumption. The exercise training can be used to improve effort tolerance, delaying Lactate threshold and improve efficiency of work in healthy aircrew to improve their performance [13]. Stroke volume calculations help assess improvement in stroke volume in real time during exercise. This along with Maximum oxygen consumption , Stroke volume improvement, Lactate threshold reached at level of exercise (in METS), VE/CO_2 slope and the usual exercise stress parameters based on ECG findings can be used to reflight aircrew with cardiopulmonary disorders in addition to other standard tests [14].

Conclusion

This study is a pilot study to collect data with respect to healthy males to build up a normograms. This information along with spirometry data may form a basis for design of breathing and oxygen generating equipment. The baseline data will also make way for routine CPET in assessment of reflighting of pilots with respiratory and cardiac disorders based on Maximum oxygen consumption Stroke volume improvement, Lactate threshold reached at level of exercise (in METS), VE/CO_2 slope and the usual exercise stress parameters based on ECG findings.

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