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ORIGINAL RESEARCH

Evaluation of Improvement in Exercise Tolerance After Lifestyle Modification: An Institutional Based Study

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ABSTRACT

Introduction: Cardiopulmonary exercise testing (CPX) systems allow for the analysis of exercise integrative physiology involving the pulmonary, cardiovascular, muscular, and cellular oxidative systems. Subsequently, exercise tolerance is determined by pulmonary gas exchange; cardiovascular performance, including the peripheral vascular tree; and skeletal muscle metabolism.Thus, present study was commenced to evaluateimprovement in exercise tolerance after lifestyle modification using Cardiorespiratory Exercise Testing.

Materials and Methods: This study was conducted at a Cardiopulmonary exercise testing unit of Grant Government Medical College & Sir J.J Group of Hospitals (Mumbai) among 50 subjects. The subjects were told to follow a lifestyle modification which included any form of physical activity preferably brisk walking for a duration of 30 minutes at least 5 times a week for 3 months. The paired t test was used to study the exercise tolerance of subjects after 3 months.

Results: The VO_2max, AT and METS were significantly higher in non-sedentary subjects compared to sedentary subjects. There was significant improvement in VO_2max, AT and METS after exercise.The average VO2max after exercise was 48.38 ml/kg/min, i.e. there was 11.3 % improvement in VO2 max post exercise which was very highly significant. The average METS after exercise was 13.81, i.e. there was 11.1% improvement in METS post exercise which was significant. The average AT after exercise was 67.04% of VO2max, i.e., there was 10.33 % improvement in AT post exercise which was significant.

Conclusion: The exercise tolerance of non-sedentary subjects was significantly higher than sedentary subjects. Majority of subjects showed significant improvement in their exercise tolerance after lifestyle modification in the form of moderate physical activity for 3 months.

Keywords: Cardiopulmonary Exercise Testing (CPX) Systems; Exercise Tolerance; Sedentary Lifestyle.

INTRODUCTION

Cardiopulmonary exercise testing (CPX) systems allow for the analysis of gas exchange at rest, during exercise, and during recovery and yield breath-by-breath measures of oxygen uptake ($\dot{V}O_2$), carbon dioxide output ($\dot{V}CO_2$), and ventilation ($\dot{V}E$).[1]Compared with traditional exercise tests, cardiopulmonary exercise testing (CPET) provides a thorough assessment of exercise integrative physiology involving the pulmonary, cardiovascular, muscular, and cellular oxidative systems.[2] These advanced computerized systems provide both simple and complex analyses of the data which 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. CPX can even be performed with adjunctive imaging modalities for additional diagnostic assessment.[1]Hence, compared with traditional exercise tests, cardiopulmonary exercise testing (CPET) provides a thorough assessment of exercise integrative physiology involving the pulmonary, cardiovascular, muscular, and cellular oxidative systems.[3]

Exercise and physical activity have been used synonymously in the past, but more recently, exercise has been used to denote a subcategory of physical activity: “physical activity that is planned, structured, repetitive, and purposive in the sense that improvement or maintenance of one or more components of physical fitness is the objective”.[4]Peak exercise capacity is defined as “the maximum ability of the cardiovascular system to deliver oxygen to exercising skeletal muscle and of the exercising muscle to extract oxygen from the blood”.[5] Subsequently, exercise tolerance is determined by pulmonary gas exchange; cardiovascular performance, including the peripheral vascular tree; and skeletal muscle metabolism.[4] Thus, present study was commenced to evaluateimprovement in exercise tolerance after lifestyle modification using Cardio Respiratory Analysis Test System.

MATERIALS AND METHODS

This prospective study was conducted at a Cardiopulmonary exercise testing unit of Grant Government Medical College & Sir J.J Group of Hospitals (Mumbai). The participants of the study were adult subjects above the age of 18 years. Before proceeding for the study, the required proforma and plan of the study were submitted to the Ethics committee for research on human subjects of the institute and were approved. In all, a total number of 50 subjects were selected for the study.

Subjects (interns, residents, staff nurses and relatives of patients) with no active complaints were selected randomly at our centre and were screened for the presence of respiratory disorders (chronic obstructive pulmonary disease, bronchial asthma, interstitial lung disease) and cardiac disorders (ischemic heart disease, angina, cardiac myopathy, rhythm abnormalities) by symptomatology, history, clinical examination and chest X-ray. After these preliminary investigations, Pulmonary Function was done to ruled out respiratory disorders. Routine blood investigations were done to rule out anemia, renal, hepatic or metabolic abnormalities, which could compromise the exercise function testing. ECG was done to ruled out cardiac disorder. In total 50 patients were selected who met the inclusion criteria and who completed the cardiopulmonary exercise tests. Both males and females were recruited for the study. The rest of the subjects who were not able to perform the test correctly or did not meet the inclusion criteria were excluded.

Inclusion criteria was healthy adults between 18-45 years of either gender.Exclusion criteria consisted of individuals who have any form of habit e.g. tobacco in any form and alcohol, individuals with active respiratory or cardiac complaints, immunocompromised individuals,

individuals with hypertension or renal disease or with morbid obesity, those with electrolyte imbalance or any cerebrovascular accident and those with any orthopedic impairment that compromises exercise performance.

Cardiorespiratory Analysis Test System was carried using ultima CPX which is a stationary cardiopulmonary function testing system that monitors cardio respiratory functions during exercise tests. Furthermore, it allows the monitoring of vital parameters and can be used for measurement in adults and children from age group of 14 up.With it is possible to measure all relevant spirometry parameters. The measured data are transferred to the computer. After being transferred to computer the data is analyzed with powerful Breeze software.

Informed consent was taken from the subjects in their preferred language.

The subject's age, height and weight (wearing indoor clothes without shoes) were recorded. Subject's occupation was recorded to know the nature of work whether sedentary or nonsedentary predominates in his daily activities. Sedentary activities included sitting and computer use for much of the day with little or no vigorous physical exercise. Subjects were classified as sedentary, which was defined as reporting less than 30 min per day of moderate exercise on two days per week over the previous six months.

Subject was asked regarding exercises done presently; amount of leisure time spent in sedentary manner. Physical inactivity was defined as reported inactive leisure time including at most occasional walks.

Patient was asked for symptoms of breathlessness, cough, chest pain, other respiratory complaints, cardiac complaints such as palpitations, syncope, chest pain, history of cerebrovascular disease, renal disease, history of immunocompromised state.Relevant family history was inquired into i.e., hypertension, ischemic heart disease, and sudden cardiac death in family, respiratory disease such as asthma, cerebrovascular events.After complete examination of the patient laboratory investigations were carried. Modified Bruce protocol was used to provide gradual increase in exercise.

Subjects were told to increase their regular walking and advised to accumulate at least 30 min of moderate physical activity on most, preferably all days of the week or at least 5 days a week, in a manner consistent with their lifestyle and daily schedules.Subjects were followed up for further evaluation after 3 months when Cardiopulmonary Exercise Testing was repeated.The statistical analysis of the data was done, for quantitative data using mean, standard deviation, correlation co-efficient, paired and unpaired t test were used.The qualitative data was analyzed using proportional method. P value <0.05 was considered significant, $p <0.01$ was considered highly significant and $p<0.0001$ was considered very highly significant.The exercise tolerance of the population was measured using VO_2max, Anaerobic Threshold and Metabolic Equivalents.The exercise tolerance was then correlated with age, gender and anthropometric parameters such as height,weight, body mass index(BMI) and statistical analysis was done for determination of significance of correlation. Unpaired t test was used to establish significance of difference in exercise tolerance of sedentary and non-sedentary subjects.The subjects were told to follow a lifestyle modification which included any form of physical activity preferably brisk walking for a duration of 30 minutes at least 5 times a week for 3 months.The paired t test was used to study the exercise tolerance of subjects after 3 months.

RESULTS

The average VO2 max in sedentary individuals was 41.29 ml/kg/min and in non-sedentary individuals it was 44.29 ml/kg/min (Table1). The average METS in sedentary individuals were 11.54 and in non-sedentary individuals they were 13.26. The average anaerobic threshold in sedentary individuals was 57% of VO2 max and in non-sedentary individuals it was 63.92% of VO2max.

Using unpaired t test in sedentary and non-sedentary population it was found that there was very highly significant difference in VO2 max ($p<0.0001$) (table 2). In our study there was very highly significant difference in METS of sedentary and non-sedentary individuals ($p<0.0001$). There was significant difference between AT of sedentary and non-sedentary subjects($p<0.05$).

The average VO2max after exercise was 48.38 ml/kg/min, i.e. there was 11.3 % improvement in VO2 max post exercise. In our study, 47 subjects showed improvement in VO2max, 1 subject showed no improvement and 2 subjects showed deterioration**.** There was very highly significant improvement in VO2 max after exercise ($p<0.0001$) (table 3).

There was highly significant improvement in METS after exercise ($p<0.01$). The average METS after exercise was 13.81, i.e., there was 11.1% improvement in METS post exercise. Out of 50, 49 subjects showed improvement in METS, 1 subject showed no improvement and no subject showed deterioration (table 4).

There was highly significant improvement in anaerobic threshold after exercise ($p<0.01$) (table 5). The average AT after exercise was 67.04% of VO2max, i.e., there was 10.33 % improvement in AT post exercise. In our study, 47 subjects showed improvement in AT, 3 subjects showed no improvement and no subject showed deterioration.

Table 1: VO_2max comparison between sedentary and non-sedentary individuals

Baseline comparison between sedentary & non-sedentary					
	Lifestyle	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
VO2max	**Sedentary**	25	41.29	7.001	1.021
	Non-sedentary	25	44.29	6.504	1.263
METS	**Sedentary**	25	11.543	2021	.512269
	Non-sedentary	25	13.261	1.902	.672245
AT	**Sedentary**	25	57.60	9.032	1.806
	Non-sedentary	25	63.92	12.550	2.510

Table 2: Statistics comparison between sedentary andnonsedentary individuals

Comparison based on lifestyle							
	t-test for Equality of Means	95% CI					
	t	df	Sig.	Mean Difference	Lower	Upper	
VO2max	**Equal variances assumed**	-3.901	48	.000	-7.680	-11.638	-3.722
	Equal variances not assumed	-3.901	4.712E1	.000	-7.680	-11.640	-3.720
METS	**Equal variances assumed**	-3.901	48	.000	-2.194	-3.324	-1.063
	Equal variances not assumed	-3.901	4.712E1	.000	-2.194	-3.325	-1.062
AT	**Equal variances assumed**	-2.044	48	.046	-6.320	-12.538	-.102
	Equal variances not assumed	-2.044	4.360E1	.047	-6.320	-12.554	-.086

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Table 3: Paired t test for VO_2max before and after exercise (Improvement in VO2 max post exercise)

Number of patients (n)	50	
Mean VO2max	Pre exercise	43.44
	Post exercise	48.38
'p' value	<0.0001	

Table 4: Paired t test METs before and after EXERCISE(Improvement in METS post exercise)

Number of patients (n)	50	
Mean METS	Pre exercise	12.43
	Post exercise	13.81
'p' value	0.0029	

Table 5: Paired t test for AT before and after exercise (Improvement in Anaerobic Threshold post exercise)

Number of patients (n)	50	
Mean AT	Pre exercise	60.76
	Post exercise	67.04
'p' value	0.0035	

DISCUSSION

The gold standard for identifying exercise limitation is cardiopulmonary exercise testing (CPET). CPET provides an integrative evaluation of cardiovascular, pulmonary, hematopoietic, neuropsychological, and metabolic function during maximal or submaximal exercise. It is useful in clinical setting for differentiation of the causes of exercise intolerance, risk stratification, and assessment of response to relevant treatments.[6]

In the present study, there were 25 people with a sedentary lifestyle and 25 people with non sedentary lifestyle. Using unpaired t test in sedentary and non-sedentary population it was found that there was very highly significant difference in VO2 max ($p<0.0001$).In our study there was very highly significant difference in METS of sedentary and non-sedentary individuals ($p<0.0001$).There was significant difference between AT of sedentary and non-sedentary subjects ($p<0.05$).

The average VO2 max in sedentary individuals was 41.29 ml/kg/min and the average VO2 max in non-sedentary individuals was 44.29 ml/kg/min. Thus, the VO2max in non-sedentary individuals was more than sedentary individuals by 7.26 %.The average METS in sedentary individuals were 11.54 and the average METS in non-sedentary individuals were 13.26. Thus, the METS in non-sedentary individuals were more than sedentary individuals by 14.90 %.The average AT in sedentary individuals was 57.60 % of VO2 max and the average AT in non sedentary individuals was 63.92 % of VO2 max Thus the AT in non-sedentary individuals was more than sedentary individuals by 10.9 %.

The subjects were advised to follow an exercise regimen which involved moderate physical activity such as brisk walking for 30 minutes at least five times a week for three months and their cardiopulmonary exercise testing was repeated. In our study, 47 subjects showed improvement in VO2max, 1 subject showed no improvement and 2 subjects showed deterioration. In our study, 47 subjects showed improvement in AT, 3 subjects showed no improvement and no subject showed deterioration. Out of 50, 49 subjects showed improvement in METS, 1 subject showed no improvement and no subject showed deterioration. The paired t test was used to evaluate the significance of improvement post exercise.The average VO_2max after exercise was 48.38 ml/kg/min, i.e., there was 11.3 %

improvement in VO2 max post exercise. There was significant improvement in VO_2 max after exercise ($p<0.0001$).
The results of this study are similar to results of small cohort of sedentary, obese premenopausal participants, lifestyle modification incorporating moderate-intensity supervised exercise training can modestly improve VO2peak and provide some functional cardiac gains by Carrol S et al.[7]
American College of Sports Medicine (ACSM) issued guidelines for cardiovascular fitness. Basic aerobic endurance training that following the ACSM's recommended guidelines for cardiorespiratory fitness training was known to improve VO2max. For an average unfit person following the ACSM's guidelines to experience a 15% improvement in VO2max after 2 to 3 months of regular training.[8,9]Ritzel A et al[10] conducted echocardiography and cardiopulmonary exercise testing (CPET) were done at baseline and after 3 months lifestyle modification (LSM) and after one year of follow-up a modest but significant reduction of left atrial size and mitral flow to mitral annulus velocity ratio E/E´, thus, successful lifestyle modification in obese, prediabetic patients with heart failure with normal ejection fraction (HFNEF) improves diastolic left ventricular function and cardiopulmonary exercise capacity.
In the present study, the average METS after exercise was 13.81, i.e., there was 11.1% improvement in METS post exercise. After exercise there was significant improvement in METS ($p< 0.01$).The average AT after exercise was 67.04% of VO2max, i.e., there was 10.33 % improvement in AT post exercise. There was significant improvement in AT after exercise ($p<0.01$).
CPET may be particularly helpful when job-related or exertionalcomplaints are disproportionate to measured PFT impairments; when concurrent conditions (heart disease) or otherfactors (smoking) may limit exerciseand when used in combination with job-related energy andenvironmental conditions, so that an accurate rating of impairment/disabilitycan be established.[11]Jakovljevic D[12] revealed that regarding different modalities of exercise training, in contrast with resistance training, aerobic exercise training may increase both maximal flow-generating capacity of the heart and peak oxygen consumption and also delays anaerobic metabolism in patients with stable chronic heart failure. Improved peak oxygen consumption, following aerobic exercise training, is closely associated with an exercise-induce increase in cardiac output.

CONCLUSION

The exercise tolerance of non-sedentary subjects was significantly higher than sedentary subjects. Majority of subjects showed significant improvement in their exercise tolerance after lifestyle modification in the form of moderate physical activity for 3 months.As the population of this study was small, the findings of this study need to be confirmed on a larger population.

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