Original Research Article

Correlation of exercise capacity with left ventricle diastolic function

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Abstract

Introduction: Exercise may be good for the heard but good diastolic function also appears to protect the capacity for exercise researchers found.

Objectives: To correlate exercise capacity with the left ventricle diastolic function.

Material and methods: The Study was conducted on 100 subjects at Haldiram and Moolchand Heart Centre, PBM Hospital, S.P. Medical College, Bikaner. First a resting echocardiography was performed to evaluate cardiovascular diastolic function. After echocardiography the subjects were underwent Bruce protocol treadmill test.

Results: Diastolic dysfunction was strongly and inversely associated with exercise capacity. Compared with normal function, those with resting diastolic dysfunction had substantially lower exercise capacity.

Conclusion: Left ventricular diastolic function were independently associated with exercise capacity.

Key words

Exercise capacity, Left ventricle diastolic function, Correlation.

Introduction

Exercise may be good for the heard but good diastolic function also appears to protect the capacity for exercise researchers found. Any level of resting diastolic dysfunction whether moderate to severe or mild substantially lowered exercise capacity [1]. Consequently the use of tissue Doppler imaging and analysis of diastolic function may be useful to explain the correlation between the presence of diastolic function and maximal exercise capacity on exercise test. Doppler echocardiography can provide an estimate of left ventricle function; however, few studies have assessed whether diastolic dysfunction is associated with abnormal HR recovery and whether modify exercise capacity. Doppler echocardiography can now characterize left ventricle diastolic function through a combination of measurement which shows evidence of slowed ventricular relaxation, increased left ventricular stiffness, or abnormal left ventricular filling. The aim of this study were to determine the relationship between left ventricular diastolic function determined by echocardiography and exercise capacity and to determine if there is a difference in the magnitude of association of diastolic function parameters with exercise capacity. Doppler echocardiography can also provide an estimate of left ventricular filling pressures, one component of diastolic function that reflects pulmonary capillary wedge pressure. In prior small series, these parameters have been shown to correlate with exercise capacity [2-4].

Materials and methods

Patient Population

The Study was conducted on 100 subjects at Haldiram and Moolchand Heart Centre, PBM Hospital, S.P. Medical College, Bikaner. This study was approved by the S.P. Medical Ethical Board, and verbal consent was obtained at the time of echocardiogram. Necessary information as per study was collected from the hospital record of the study participants undergoing routine measurements of left ventricular diastolic function by 2D echocardiography and treadmill test by Bruce protocol. For this analysis, we excluded patients who had atrial fibrillation/flutter at the time of exercise; had moderate or severe valvular heart disease; had poor image quality, which prohibited a final impression; had ejection fractions of less than 50%; or had echocardiographic evidence of exercise induced myocardial ischemia; any respiratory disease; suffering from any chronic or acute disease; taking any drugs that could affect the heart.

Anthropometric variables like height and weight were obtained and BMI and BSA were calculated from them. BMI was calculated from the formula =weight (kg)/ height $(m)^2$. BSA was calculated by formula = 0.0001x71.84 x (weight in $kg)^{0.425}$ x(height in $cm)^{0.725}$. Echocardiographic images had to be of sufficient quality to allow reproducible cross sectional, M mode, and Doppler studies.

First a resting echocardiography was performed to evaluate cardiovascular diastolic function. After echocardiography the subjects were underwent Bruce protocol treadmill test.

The baseline resting assessment included pulsed-wave Doppler measurements of the early (E) and late (A) mitral inflow velocities, the peak early diastolic velocity of the medial mitral annulus (e_) with tissue Doppler in the 4-chamber view, and 2-dimensional measurement of the left atrial size. The ratio E/e_, a measurement of left ventricular filling pressures, was feasible in all patients at rest. Resting diastolic function was graded as normal, mild dysfunction (impaired relaxation), moderate dysfunction (pseudonormal), or severe dysfunction (restrictive). The classification of diastolic function was modified from the algorithm outlined by Khouri, et al. [5]. Instead of pulmonary vein flow measurements, left atrial volume was measured as part of our assessment because it has been shown to be a marker of diastolic dysfunction [5, 6]. Relaxation and restrictive abnormalities were classified based on the mitral inflow patterns, an E/A less than 0.75 and E/A greater than 1.5, respectively. To diagnose a restrictive abnormality, left atrial volume index had to be increased 28 mL/m^2 or more, and E/e_ had to be increased 10 or more, respectively; otherwise, patients were classified as normal. This is especially important in young people because a normal E/A is often greater than 1.5 due to increased early filling with no other echocardiographic evidence of diastolic dysfunction [5]. To distinguish pseudonormal from normal diastolic function (0.75_E/A_1.5), both left atrial volume index and E/e_ had to be increased as described. Left atrial volume was measured according to the area-length method and indexed to body surface area [7].

Tread mill exercise test

The Bruce protocol (Bruce R.A., 1972) [8] for multistage treadmill testing of maximal exercise was used. Resting ECG, pulse rate and blood pressure was measured. Then a standing ECG, pulse rate and blood pressure were recorded. Subjects were explained and demonstrated the procedure and instructed to inform immediately if anything happens or any problem occurs.

VO2 max can be calculated by following formula.

VO_2 max in male =14.8 - (1.379 × T) + (0.451 × T^2) - (0.012 × T^3)

VO_2 max in women =4.38 × T - 3.9 ("T" is the total time on treadmill measured as fraction of minutes).

Results

After obtaining Vo2 max (exercise capacity) from bruce protocol and cardiovascular function i.e. left ventricle diastolic function from echocardiography, correlation was seen between them through appropriate statistical analysis. Analyses were conducted to determine the strongest correlates of exercise capacity. Statistical analysis was done using MS excel and SPSS version 23.0.data was expressed as mean and standard deviation.Vo2 max was calculated using bruce protocol. Mean value of basal echocardiographic characteristic E/A, E/E, LAVI, was observed as per **Table – 1**.

Anthropometric variables like height and weight was obtained and BMI and BSA was calculated from them. BMI was calculated from the formula =weight (kg)/ height $(m)^2$. BSA was calculated by formula = 0.0001x71.84 x (weight in kg)$^{0.425}$ x(height in cm)$^{0.725}$.

Table – 1: Baseline Echocardiography Characteristics.

Variables	**Normal (n = 50)**	**Mild (n = 25)**	**Moderate (n = 25)**
EDD, mean (SD)	4.2 (0.28) $^{\Psi}$	4.0 (0.24) $^{*\xi}$	4.2 (0.22) $^{\Psi}$
E/A, mean (SD)	1.2 (0.3) $^{\Psi}$	0.67 (0.06) $^{*\xi}$	1.2 (0.19) $^{\Psi}$
E/e', mean (SD)	7.3 (1.7) $^{\xi}$	6.5 (1.65) $^{\xi}$	11.0 (1.05) $^{*\Psi}$
LAVI, mean (SD)	14.9 (3.00) $^{\xi}$	15.2 (3.08) $^{\xi}$	28.6 (0.57) $^{*\Psi}$

Pairwise comparisons of continuous data performed with analysis of variance using Turkey honestly significant difference.

*p<0.05 compared to patients with normal diastolic function.

$^{\Psi}$p<0.05 compared to patients with mild diastolic function.

$^{\xi}$P<0.05 compared to patients with moderate diastolic function.

Table – 2: Analysis of Echocardiographic variables with exercise capacity.

Resting variables	**Mean±SD**		**P value**	**95% CI**
Mild diastolic dysfunction vs normal function	Mild 22.7±4.6	Normal 30.8±5.3	P<0.001	-10.5 to -5.7
Moderate diastolic dysfunction vs normal function	Moderate 23.6± 2.1	Normal 31.9±5.7	P<0.001	-9.01 to 5.54
Resting E/e'≥ 10	E/e'>10 24.4±3.3	E/e'<10 28 .0± 6.4	P<0.001	1.7 to -5.6
Left atrial volume index > 28 ml/m^2	Lavi>28 23.6± 2.1	Lavi<28 28.1±6.4	P<0.001	2.8 to -6.2

Statistically significant differences p<0.001.

Discussion

Normal diastolic function was observed in 50% of the individuals; 25% showed mild diastolic dysfunction; 25% showed moderate diastolic dysfunction.

Undoubtedly, the presence of diastolic dysfunction has a physiological ground on the decreased exercise capacity since, during exercise, the maximal cardiac output is dependent on the diastolic filling. In exercise-induced tachycardia, the diastole is shortened. If diastole is accompanied by left ventricular relaxation and filling abnormalities, the lowest filling rates are achieved and become inadequate to supply the cardiac output required during exercise, with a subsequent increase in filling pressures and decrease in the maximal capacity [9]. The more abnormal the baseline diastolic function, the lower the exercise capacity.

Several studies have demonstrated a good correlation between tissue Doppler of the mitral annulus and functional exercise capacity [10, 11] probably due to the association of the E/e' ratio with left ventricular filling pressures [12]. However, most of these studies were conducted in populations at high cardiovascular risk or in patients with proven cardiovascular disease. In our study, diastolic dysfunction was strongly and inversely associated with exercise capacity similar to Grewal, et al. [13]. Compared with normal function those with moderate/severe and mild resting diastolic dysfunction had substantially lower exercise capacity. Left ventricular filling pressures measured by resting E/e' > 10 was also associated with a reduction in exercise capacity. Grewal, et al. also observed a good correlation between the E/e' ratio and exercise capacity in a population at a moderate cardiovascular risk.

Resting exercise E/e' ≥ 10 was associated with a -3.6(3.1) reduction in exercise capacity (p<0.001) compared with E/e' of <10. Left atrial volume index ≥ 28 was associated with a -4.5(4.3) reduction in exercise capacity (p < 0.001) as compared to left atrial volume <28.

Also, left atrial pressure must increase to a level that creates a pressure gradient large enough to provide adequate ventricular filling during exercise in the setting of impaired left ventricular relaxation.

Tachycardia accompanying exercise shortens the duration of diastole, reducing the time available for the left ventricular filling. Thus the left ventricle must fill more rapidly for the stroke volume to increase (or even be maintained) during exercise according to Little, et al. [14]. Normally this is accomplished without requiring an excessive increase in left atrial pressure by an accelerating of LV relaxation and a fall in LV early diastolic pressure With normal aging early LV filling is reduced and atrial systole is augmented probably reflecting intrinsic alteration in myocardial stiffness with age (Sartori, et al,, 1987) [15].

According to Higginbotham M. B., et al., 1986 [16] in normal individuals the rise in cardiac output during exercise is exclusi, et al., 1983 [17]. Vely brought about by increase in heart rate and myocardial contractility. In study by Heo, et al., 1986 and Oldershaw patients with heart disease have suggested that change in diastolic relaxation and filling of left ventricle may be equally important. It is still unclear however what parameter of left ventricular function is most responsible for the observed individual variability. In a similar study, Hiroyuki Okura, et al. 2000 [18] showed that left ventricular diastolic index was one of the strongest correlate of exercise capacity in normal individuals and E/A may help in predicting exercise capacity in normal individuals independent of other cardiac and extra cardiac factors..

Conclusion

The researchers suggested that one mechanism for the effect of diastolic parameters on exercise capacity might be through their role in generating maximal cardiac output.

"Abnormalities in diastolic relaxation and filling of the left ventricle can result in filling rates that might be too low to achieve adequate cardiac output during exercise even if ventricular systolic properties are normal," they wrote.

In this large population referred for exercise test and echocardiography and not\limited by ischemia, we demonstrated that diastolic dysfunction was strongly related to decreased exercise capacity. Increased resting left ventricular filling pressures are also associated with a reduction in exercise capacity although these data required assessment in large population. Unlike many other factors that are an inevitable consequence of aging, diastolic dysfunction may be a preventable factor in the development of exercise intolerance.

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