Echocardiographic Features of Cardiac Fatigue

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Background: Little information is available regarding the effects of strenuous exercise on cardiac function.
Objectives: We evaluated the effect of severe prolong exercise on ventricular performance.
Methods: Army rangers were invited to participate in this study. All patients underwent transthoracic echocardiography using tissue Doppler imaging.
Results: A total of 45 consecutive male rangers who completed ranger training program were included in this study. Peak systolic myocardial velocity (*S*) decreased significantly after training (12.46 ± 0.54 vs. 9.93 ± 0.45 cm/s; $P < 0.001$). In the right ventricle, tissue Doppler measures of systolic and early diastolic function decreased significantly after training.
Conclusion: In conclusion, strenuous prolonged exercise may result in depressed left ventricular contractile function.

Keywords: Exercise, Myocardial function, Tissue Doppler

Introduction

Previous studies have shown that very strenuous prolonged exercise may result in depressed left ventricular contractile function. This raises the possibility of cardiac fatigue.[1] It is postulated that plasma free fatty acids may increase after prolong exercise and elevated plasma free fatty acids may result in impaired myocardial performance.[2] Army rangers represent a unique group of athletes capable of exhaustive exercising for very long periods without rest. In the present study, we aimed to evaluate features of cardiac fatigue in army rangers after arduous exercise.

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Materials and Methods

From March 2008 to November 2008, participitants in ranger training were invited to take part in this prospective study and were asked to provide informed written consent. All patients underwent transthoracic echocardiography using tissue Doppler imaging before and after strenuous exercise. All measurements were made by *ACUSAN* echo ultrasound imaging system. Myocardial tissue Doppler peak systolic (*S*), early diastolic (*E*) and late diastolic (*A*) velocities were measured (in cm/s) with the sample volume positioned at the septal and lateral angles of the mitral annular ring as well as on the lateral angle of the tricuspid valve. [3-7]

Table 1. Echocardiographic Data of the Subjects before and after Training

	Rangers before Training (n=45)	Rangers after Training (n=45)	P value
End-Systolic Dimension (mm)	31.05 ± 1.95	35.56 ± 2.47	< 0.001
End-Diastolic Dimension (mm)	46.77 ± 3.42	48.53 ± 3.38	NS
Fractional Shortening (%)	33.38 ± 4.86	26.62 ± 3.79	< 0.001

Statistical Analysis

All values are presented as mean ± SD. Comparisons between groups were made using Student's t test. Repeated measure of analysis of variance using paired t-tests was used to compare tissue Doppler parameters before and after the course. For all analyses, P value less than 0.05 was considered significant.

Results

A total of 45 rangers who completed eight weeks of training were included in this study.

Rangers after training exhibited increase in end-systolic diameter (31.05 ± 1.95 mm vs. 35.56 ± 2.47 mm; P< 0.001) whereas no significant change was detected in end-diastolic diameter (46.77 ± 3.42 mm vs. 48.53 ± 3.38 mm; P= non significant). Consequently, fractional shortening decreased significantly after training (Table-1). Left ventricular lateral function (S wave) decreased significantly after training (12.46 ± 0.54 vs. 9.93 ± 0.45 cm/s; P<0.001). Right ventricular longitudinal function (RV S wave) decreased significantly after exercise (11.39 ± 0.70 vs. 7.87 ± 0.62 cm/s; P<0.001). Diastolic myocardial function was also affected by training program as peak early diastolic function (E wave) decreased significantly in the lateral area compared to pre-training values (Table-2). Figure 1 illustrates left ventricular systolic and diastolic function in a ranger after completion of training.

Discussion

In our study, fractional shortening was found to decrease by an average of 20% (P<0.001). However, this index of myocardial performance is load dependent.[4,5,7] This suggests that the decrease in fractional shortening may be due to impaired contractility as well as altered preload. Because of load dependence of conventional echocardiographic parameters, tissue Doppler parameters are preferred for determination of myocardial function. Accordingly, we used tissue Doppler imaging to determine the effect of extreme exercise on myocardial function. Our findings regarding systolic dysfunction after extreme exercise are

Table 2. Myocardial Function before and after Training

		Before Training	After Training	P value
Left Ventricle	*S* (cm/s)	12.46 ± 0.54	9.93 ± 0.45	< 0.001
	E (cm/s)	10.20 ± 0.37	7.75 0.53	< 0.001
Right Ventricle	*S* (cm/s)	11.39 ± 0.70	7.87 0.62	< 0.001
	E (cm/s)	10.12 ± 0.41	7.75 0.53	< 0.001

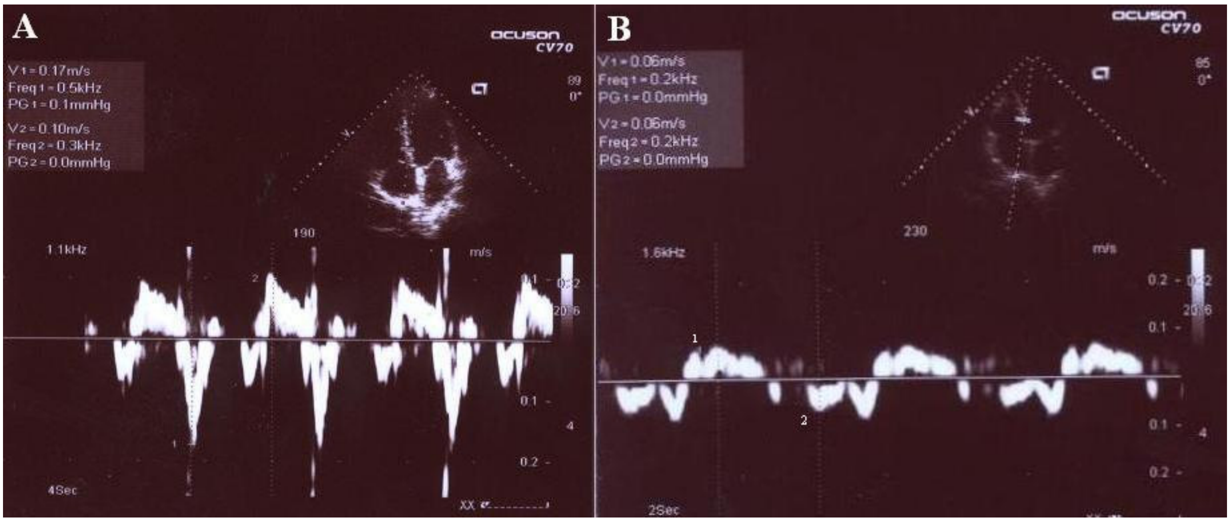

Figure1. illustrates decrease in LV systolic and diastolic function in a ranger after completion of training. **A:** before training; **B:** after completion of training. Myocardial **S** wave velocity decreased from 10 cm/sec to 6 cm/sec. Myocardial **E** wave velocity decreased from 17 cm/sec to 6 cm/sec.

concordant with previous studies. In one study, responses of rat myocardium to exhaustive exercise were evaluated and authors noted a decrease in peak isometric tension and velocity of shortening (due to glycogen depletion) after prolonged stimulation of isolated rat myocardium.[8] Despite evidence that systolic function is unfavorably affected by prolonged severe exercise, only one study have examined diastolic performance[1] and the authors concluded that abnormal diastolic filling may be due to reduced ventricular compliance or increased myocardial stiffness.

In conclusion, very strenuous prolonged exercise may result in depressed left ventricular contractile function. This raises the possibility of cardiac fatigue.

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