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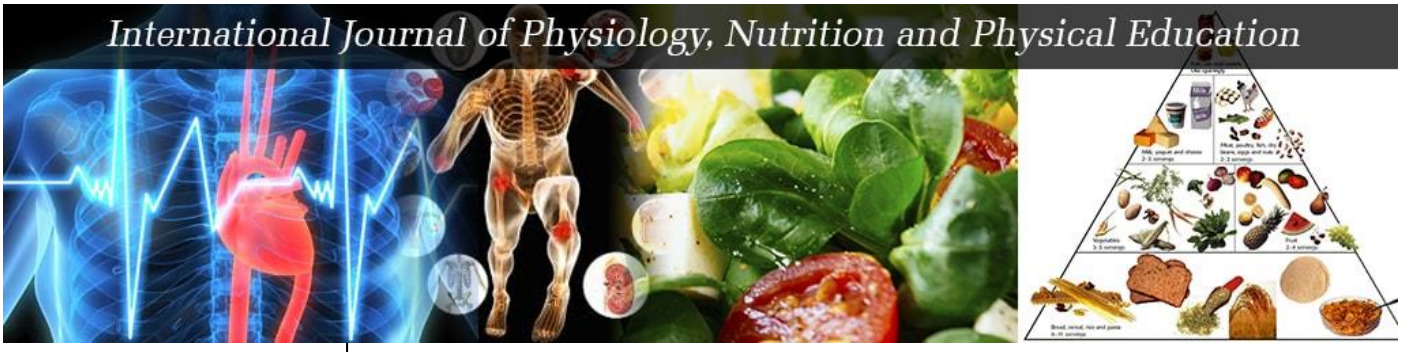

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Effect of $\dot{V}o_{2max}$ on left ventricular functions in athletes

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Abstract
The prêsent study was done to found out a co-relation between $\dot{V}o_{2max}$, and left ventricular functional activities in athletes through treadmill. $\dot{V}o_{2max}$ is an important determinant of cardiorespiratory fitness and aerobic performance. Sample collection was done in D Y Patil Hospital and Research Center, Nerul, Navi Mumbai after taking permission from medical ethic committee.40 subjects were asked to do treadmill and their $\dot{V}o_{2max}$ and left ventricular functions were assessed through various parameters as systolic time intervals and duration of exercise. After doing treadmill for 2 weeks, it is found that there is significant (P<0.05) co-relation between $\dot{V}o_{2max}$, tension time index and ejection fraction, showing $\dot{V}o_{2max}$ affects left ventricular functions in athletes which is our conclusion.

Keywords: $\dot{V}o_{2max,}$ left ventricular functions, athletes, treadmill, cardiorespiratory fitness, aerobic performance, tension time index, ejection fraction

Introduction
The maximal rate of oxygen uptake ($\dot{V}o_{2max)}$ is an important determinant of cardiorespiratory fitness and aerobic performance. More the amount of blood the heart can eject per heart beat, more work an individual will be able to do. Stroke volume can be defined as the amount of blood ejected from the left ventricle of the heart during a contraction which is measured in mL/beat. [1] Endurance training has the biggest impact on increase in stroke volume of an individual. An increase in stroke volume from training creates a heightened ability of the left ventricle to fill more completely during the diastole phase. The ability of the left ventricle to fill more completely is also linked to a decrease in resting heat rate because if there are fewer beats per minute, the heart won't be pumping out blood as fast, therefore allowing more blood in. Training also increases blood plasma volume and this result in even more blood being able to enter the left ventricle. Endurance training can increase blood volume by half a liter in only 8 days and this result in further stretching of the ventricular wall. [5] Adaptation The maximal rate of oxygen uptake uptake ($\dot{V}o_{2max)}$ is an important determinant of cardiorespiratory fitness and aerobic performance. The quantity of work that can be performed by the muscles is dependent on the volume of blood that can be delivered by heart. Intense exercise may lead to change in left ventricular systolic functions. These tools are more sensitive in assessing systolic adaptations to exercise.

Methodology
Sample collection: After getting approval from medical ethics committee, this study was done in Stress Test Lab at Dr. D. Y. Patil Hospital & Research center, Nerul, Navi Mumbai. For this study, 40 athletes were chosen (age-group above 18 - 24 years).

Inclusive criteria: Inclusive criteria was BMI should be 18–24.6m2/kg (according to National Institute of Health Science)

Exclusive criteria: Exclusive criteria was–1.subject should have a 2 –3 hours gap between diet and exercise, 2.subject should not have cardio respiratory or orthopedic disease.
Safety parameters chosen were age, height, weight, blood pressure, pulse, systolic time intervals (pre-ejection phase, Left ventricular ejection phase, duration of systole. i.e. total electromechanical systole) derived from Echocardiography and $\dot{V}o_{2max}$ was taken as a predictor. After signing informed consent form, athletes were asked to do treadmill by using

Bruce protocol and from above safety parameters, $\dot{V}o_{2max}$ was calculated to predict left ventricular functions. Duration of exercise was also taken into consideration.

Systolic time intervals: Systolic time intervals. i.e. pre-ejection phase (PEP), Left ventricular ejection time (LEFT), duration of systole. i. e. total electromechanical systoles (QS2) were measured through 3D echocardiography

3DEchocardiophy: 3D echocardiography is done by Doppler's method, which is a standard method to record systolic time intervals, transducer used is of frequency 21HZ, velocity – 2 to 2.5 megavolt,

Measurement of systolic time intervals

Duration of systole (QS2) = Pre-ejection phase (PEP) + Left ventricular ejection time (LVET)

Pre-ejection phase (PEP) = represent time for electrical as well as mechanical events that precede systolic ejection, is due to transmission delay. Normal range for pre-ejection phase -129 msec,

Duration of systole (QS2) = Period between onset of Q-wave to closure of aortic valves as determined by onset of second heart sound. Normal range for Duration of systole – 539 msec. Left ventricular ejection time (LVET) = Period from beginning of carotid pressure rise to the dicrotic notch, a small oscillation on the falling phase caused by vibrations set up when the aortic valve snaps shut. Normal range for LVET-410 msec

Calculation of $\dot{V}o_{2max}$

$\dot{V}o_{2max}$ (ml/kg/min) = 3.62 x T + 3.91 (Treadmill)

Thus left ventricular functions were predicted through $\dot{V}o_{2max}$ in athletes

Result

Parameters	Treadmills	N	Mean	Stdev	Unpaired T Test	P-value	Significant at 5% level
Duration	Normal Treadmills	14	11.8329	1.2216	2.052*	0.048	Yes
	Athelets Treadmills	21	12.6352	1.0720			
Sys. time interval							
$\dot{V}o_{2max}$	Normal Treadmills	14	46.6314	4.2500	2.168*	0.037	Yes
	Athelets Treadmills	21	49.6471	3.8824			
PEP	Normal Treadmills	14	65.5714	4.2193	0.750	0.458	No
	Athelets Treadmills	21	64.2857	5.3958			
LVEP	Normal Treadmills	14	288.1429	21.4758	5.992**	<0.001	Yes
	Athelets Treadmills	21	356.2857	38.6357			
Duration of systole	Normal Treadmills	14	350.0714	23.2857	5.787**	<0.001	Yes
	Athelets Treadmills	21	411.6190	34.8590			
Ejection Fraction	Normal Treadmills	14	5.7921	1.0628	2.380*	0.023	Yes
	Athelets Treadmills	21	6.6129	.9559			
Recovery time	Normal Treadmills	14	3.7736	1.2701	1.850	0.073	No
	Athelets Treadmills	21	3.2476	.2683			
Tension time index	Normal Treadmills	14	180.8557	18.0159	3.477*	0.001	Yes
	Athelets Treadmills	21	222.4181	42.0654			

*Statistically significant at 5% level i.e., $P<0.05$

**Statistically highly significant at 0.01% level i.e., $P<0.001$.

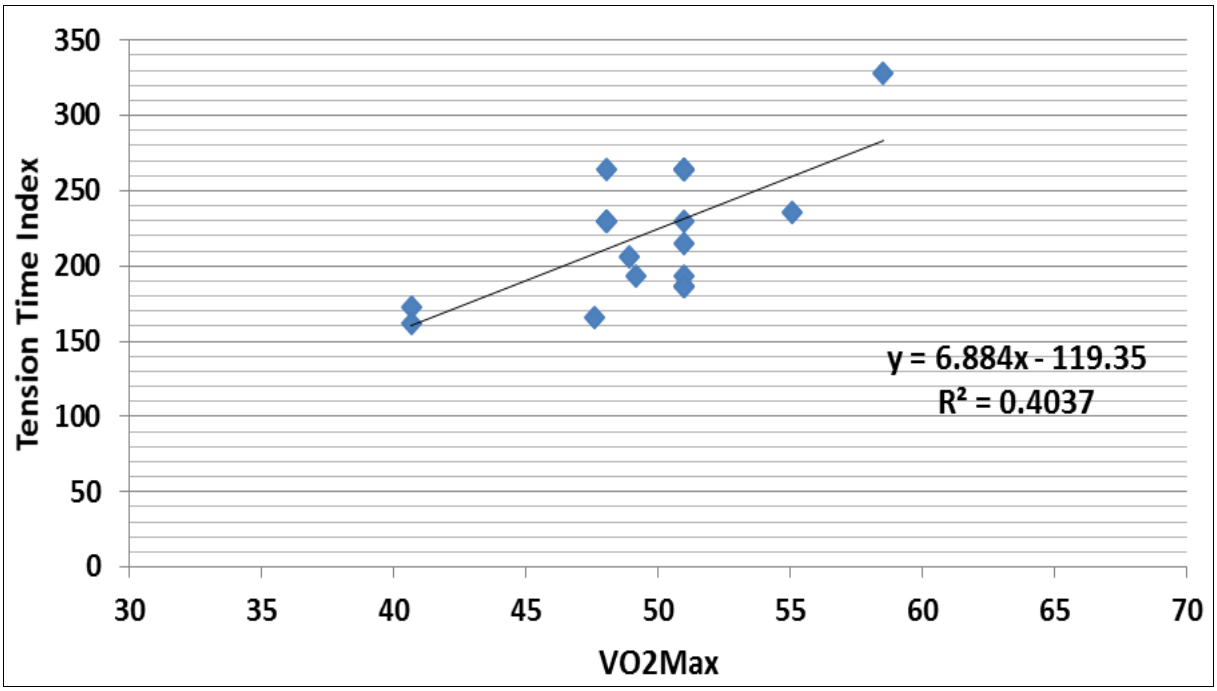

Fig 1: VO2Max correlated with Tension time index in Athelets after treadmil

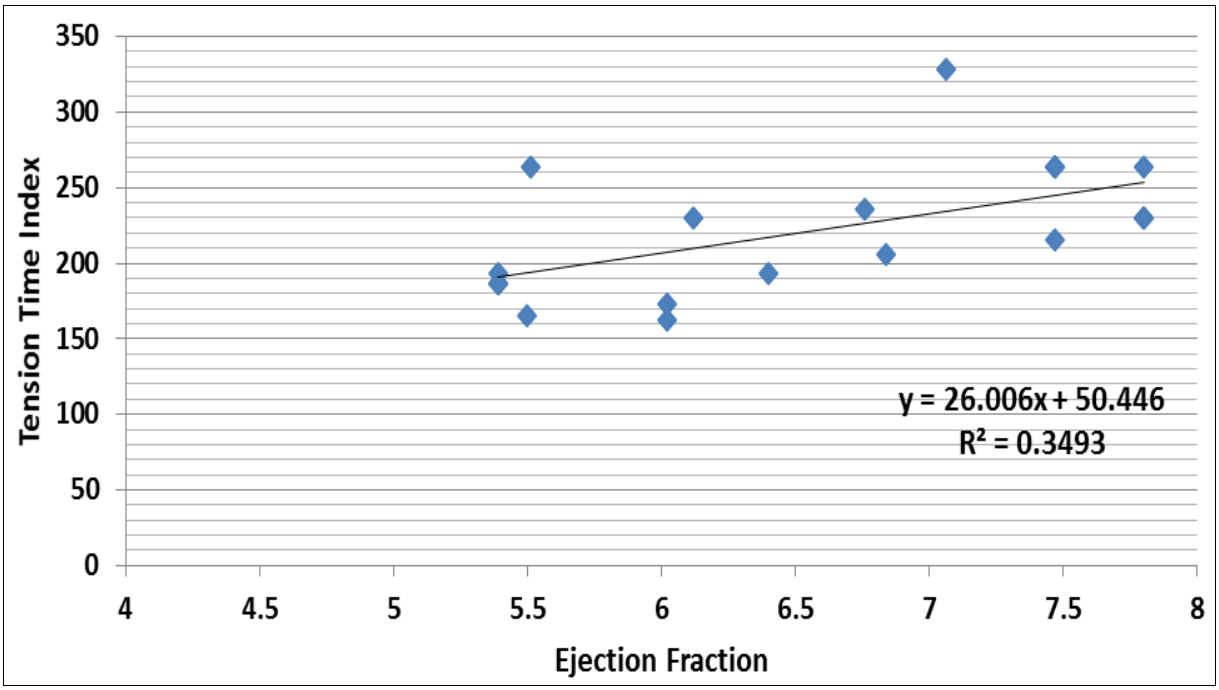

Fig 2: Ejection Fraction correlated with Tension time index in Athelets after treadmil

From the above table, it is found that there is significant (P<0.05) co-relation between $\dot{V}o_{2max}$, tension time index and ejection fraction, which shows that $\dot{V}o_{2max}$ affects left ventricular functions in athletes.

Discussion

The present study was done to found out a co-relation between $\dot{V}o_{2max}$ and left ventricular functional activities in athletes through treadmill. During incremental exercise, stroke volume plateaus at 40% of $\dot{V}o_{2max}$.However, recent research has documented that stroke volume progressively increases to $\dot{V}o_{2max}$ in both trained and untrained subjects. Endurance trained subjects have significantly longer ventricular ejection times, greater myocardial contractility, greater left ventricular diameter and mass and significantly shorter diastolic filling times than untrained subjects.

For athletes, the proposed mechanism for progressive increase in stroke volume to $\dot{V}o_{2max}$ are enhanced diastolic filling, enhanced contractility, larger blood volume, and decreased cardiac afterload. During incremental exercise, stroke volume increases with maximal oxygen uptake, in endurance trained athletes, which leads to decreased duration of time intervals of the heart cycle. Stroke volume increases progressively with increasing levels of exercise in most subjects, but the relation between stroke volume and $\dot{V}o_{2max}$ was not linear. Changes in stroke volume during exercise need to be interpreted in respect to alterations in heart rate and myocardial functional capacity.

Cardiac adaptations in these master athletes are manifested by left ventricular enlargement and enhancement of left ventricular systolic performance during exercise as evidenced by [1] a significant decrease in end-systolic volume during exercise in the master athletes despite similar increases in systolic blood pressure in the trained and untrained men, a larger left ventricular exercise reserve, a greater rise in ejection fraction in the master athletes at comparable increases in end-diastolic volume during exercise in trained and untrained persons. Greater rise in stroke volume provides evidence of enhanced left ventricular function independent of pre-load. Greater rise in stroke volume provides evidence of enhanced left ventricular function independent of pre-load. [5]

It is clearly documented that the ventricles empty more completely (as a consequence of enhanced myocardial contractility) as work load increases, yet the volume expelled per beat (stroke volume) remains stable (after an initial refilling phase). This quandary is resolved by recognizing that the enhanced contractility serves to eject the same volume of blood during a progressively shortening ejection time. The effect of augmented myocardial contractility with progressive exercise, therefore, is to *maintain*, rather than increase, stroke volume in the face of an increasingly abbreviated ejection period. Other factors being constant, an increase in stroke index or myocardial contraction results in a diminution of the pre-ejection period/ejection time ratio, whereas a rise in arterial pressure has the opposite effect

After physical training, $\dot{V}o_{2max}$ improvement mainly originates during exercise with increasing stroke volume. The maximum rate of work that can be performed is limited by combined capacities of cardiovascular and respiratory system to take in, transport and use oxygen. Systolic time intervals (STI), in particular the pre-ejection period (PEP), are demonstrated to reflect cardiac sympathetic influences on myocardial contractility. Thus, monitoring the response of systolic time interval measures during exercise and recovery may provide insights into cardiac sympathetic activity (inotropic influences). [6]

Thus maximum oxygen intake measures functional capacity of cardiovascular system and is useful criteria for assessment of overall capacity to perform work. $\dot{V}o_{2max}$ will be the ultimate limiting factor in endurance activities for the chronically trained athlete

Conclusion

After doing treadmill, $\dot{V}o_{2max}$ affects left ventricular functions in athletes.

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