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Correlation between VO2max and systolic time interval in athletes

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Abstract

The goal of my study was to correlate $\dot{V}O_{2max}$ and systolic time interval as a evaluator of cardiovascular fitness in athletes. Depending on the need of oxygen to tissues $\dot{V}O_{2max}$ increases with a increase in cardiac output, stroke volume, left ventricular ejection fraction and myocardial activity as a athlete does treadmill from moderate to maximal, Data collection was done at Stress test lab. at Nerul, Navi Mumbai after taking permission from medical ethic committee. Athletes were asked to do treadmill and their $\dot{V}O_{2max}$ and systolic time interval were assessed with their duration of exercise by taking their BMI into consideration. For proper results, athletes were asked to do treadmill for 2 weeks In athletes, after doing unpaired T - test a gradual increase in systolic time interval as left ventricular ejection phase and duration of systole ($P<0.001$) left ventricular ejection fraction was somewhat increased ($P<0.005$) without any change in pre-ejection phase with increase in $\dot{V}O_{2max}$ (P<0.001).as athlete perform treadmill. Thus in athletes, $\dot{V}O_{2max}$ is much more correlated with systolic time intervals (P<0.001).

Conclusion: Thus it was concluded that in athlete, $\dot{V}O_{2max}$ is directly correlated with systolic time interval.

Keywords: $\dot{V}O_{2max}$, Treadmill, Athletes, Systolic time intervals, Left ventricular ejection fraction.

Introduction

Student of cardiovascular physiology have recognized left ventricular ejection time as main parameters of cardiac function, which is closely related to $\dot{V}O_{2max}$ in athletes. Along with left ventricular ejection fraction, left ventricular performance can be assessed through systolic time interval which is affected by $\dot{V}O_{2max.}$

$\dot{V}O_{2max}$ and systolic time interval gives as important guidance about oxygen requirement of heart per beat. As exercise intensity increase, oxygen consumption reaches point where exercise intensity can continue to increase without the associated rise in oxygen consumption. Therefore cardiorespiratory fitness can be a limitation for $\dot{V}O_{2max,}$ which is an important component of health-related physical fitness Endurance conditioning increases work capacity, reduces myocardial oxygen demand, increases potential oxygen supply. During endurance training, increase in stroke volume of an individual creates a heightened ability of the left ventricle to fill more completely during the diastole phase.

Enhancement of the intrinsic contractile properties of the myocardium, response to inotropic stimulation and extramyocardial adaptations that have secondary effects on performance of left ventricle --e.g, increased ventricular filling or decreased myocardial work.

Materials and Methods

Data Collection

Data collection was done at Stress test lab. at Nerul, Navi Mumbai after taking permission from medical ethic committee which included 40 athletes from age-group 18 - 24 years.

During this study, criteria kept were, BMI should be 18–24.6m2/kg (according to National Institute of Health Science), and subject should have a 2 –3 hours gap between diet and exercise and should not have cardio respiratory or orthopedic disease.[7]

Parameters chosen were age, height, weight, systolic time intervals (pre-ejection phase, Left ventricular ejection phase, duration of systole. i.e. total electromechanical systole) derived from Echocardiography and $\dot{V}O_{2max}$

After signing informed consent form, athletes were asked to do treadmill by using Bruce protocol. 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 by Doppler's method, which was a standard method to record systolic time intervals, In this transducer used is of frequency 21HZ, velocity – 2 to 2.5 megavolt,[7]

Measurement of systolic time intervals Duration of systole (QS2) = Pre-ejection phase (PEP) + Left ventricular ejection time (LVET).
Normal range for pre-ejection phase -129 msec,
Normal range for Duration of systole – 539 msec.
Normal range for LVET410 msec (13)

Thus correlation between $\dot{V}O_{2max}$ and systolic time interval was found in athletes, Statistical analysis – For doing statistical analysis, depending on the parameters, unpaired T-test was applied and their significant level (P-value) was found out.

$\dot{V}O_{2max}$ was calculated as.- $\dot{V}O_{2max}$ (ml/kg/min) = 3.62 x T + 3.91 (Treadmill)[10]

Results

Graph 1: VO2Max correlated with Tension time index, derived from systolic time intervals in Athelets after treadmil

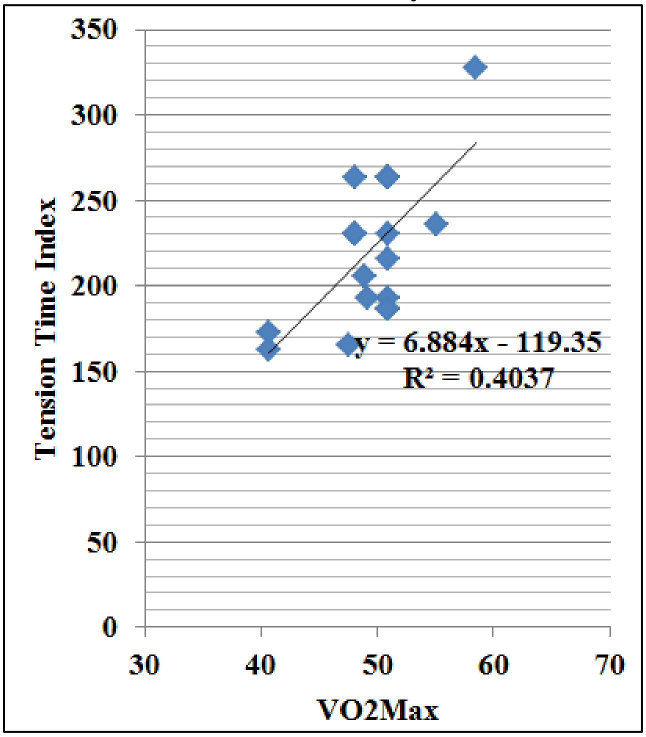

Table 1: (Showed some of the results)

Sub	N	$\dot{V}O_{2max}$	PEP	LVEP	Duration of systole	Ejection Fraction
1	6	58.53	58	410	468	7.06
2	5	47.6	65	281	337	5.5
3	5	48.07	60	390	440	612
4	5	50.97	64	381	432	7.47
5	5	55.06	61	338	388	6.76
6	6	40.68	78	286	352	6.02
7	5	49.16	60	345	405	6.4
8	5	50.97	64	381	432	7.47
9	5	50.97	64	333	397	5.39
10	5	48.07	60	390	440	7.8
11	5	48.07	60	390	440	7.8

Table 2:

Parameters	Treadmills	N	Mean	Stdev	Unpaired T Test	P-value	Significant at 5% level
Duration	Normal Treadmills	14	11.83	1.22	2.052*	0.048	Yes
	Athletes Treadmills	21	12.63	1.07			
	Normal Treadmills	14	46.63	4.25	2.168*	0.037	Yes
$\dot{V}O_{2max}$	Athletes Treadmills	21	49.64	3.84			
Sys. time interval							
	Normal Treadmills	14	65.57	4.21	0.750	0.458	No
PEP	Athletes Treadmills	21	64.28	5.39			
	Normal Treadmills	14	288.1	21.47	5.992**	<0.001	Yes
LVEP	Athletes Treadmills	21	356.2	38.63			
Duration of systole	Normal Treadmills	14	350.0	23.28	5.787**	<0.001	Yes
	Athletes Treadmills	21	411.6	34.85			
	Normal Treadmills	14	5.792	1.062	2.380*	0.023	Yes
Ejection Fraction	Athletes Treadmills	21	6.612	.9559			

*Statistically significant at 5% level i.e., $P<0.05$, **statistically highly significant at 0.01% level i.e., $P<0.001$

Table I and 2, along with graph shows a close correlation between $\dot{V}O_{2max}$ and systolic time interval in athletes and non-athletes after performing treadmill at suitable duration required for obtaining maximal response. $\dot{V}O_{2max}$ and left ventricular ejection fraction was somewhat increased in athletes performing treadmill ($P<0.005$) while systolic time intervals as left ventricular ejection phase, duration of systole was found to be much more increased($P<0.001$) without any change in pre-ejection phase.

Discussion

This study demonstrates that in athletes, echocardiographic parameters showing functioning of left ventricle are mainly and positively correlated to $\dot{V}O_{2max}$. In athletes, there is an increase in work capacity, increased myocardial oxygen demand at any given sub-maximal work. Thus a direct co-relation was found between $\dot{V}O_{2max}$ and left ventricular activities in athletes which clearly reveals that a systematic, graded program of physical conditioning can produce significant hemodynamic alterations in a group of athletes.[12]

As athlete goes on doing treadmill, 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.[14]

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. Moderate-intensity endurance exercise training increases aerobic exercise capacity mediated, in part, by improvement of stroke volume and left ventricular performance.[12]

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]

As per Douglas R. Seals cardiac adaptations in athletes are manifested by left ventricular enlargement and enhancement of left ventricular systolic performance during exercise by a significant decrease in end-systolic volume during exercise in athletes despite similar increases in systolic blood pressure in athletes and non-athletes, a larger left ventricular exercise reserve, a greater rise in ejection fraction in athletes at comparable increases in end-diastolic volume during exercise in athletes and non-athletes. Greater rise in stroke volume provides evidence of enhanced left ventricular function independent of pre-load. These adaptations are mediated by several mechanisms:[16]

As work load of ventricle increases, although stroke volume remains stable myocardial contractility increases, shortening ejection time. An increase in stroke volume or myocardial contraction results in a decrease in pre-ejection period with a rise in arterial pressure.

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, it is concluded that $\dot{V}O_{2max}$ affects left ventricular functions in athletes. Thus there is a close relation between $\dot{V}O_{2max}$ and systolic time intervals.

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I am dedicating this paper to my beloved mother, Anjali and father, Dr. Vasantrao who is not with the world but with me in the form of their ashirwad (Blessing).

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Conflict of Interest: None.

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