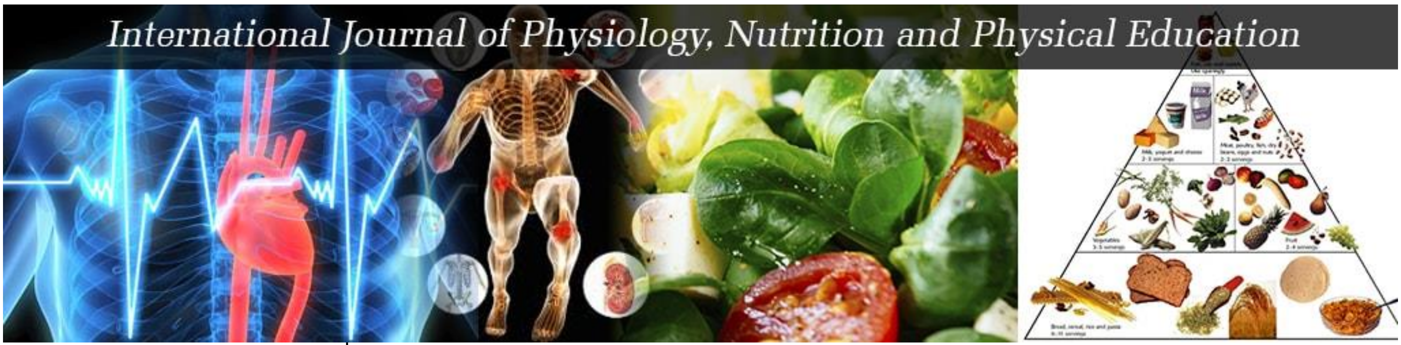

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Tension time index: A best evaluator of exercise performance

Mrunalini Kanvinde and Dr. Vivek Nalgirkar

Abstract
Purpose: Our main purpose was to find out how tension time index can be used to evaluate exercise performance through treadmill. As a subject goes on doing exercise from moderate to maximal, need of oxygen to tissues increases, resulting increased cardiac output, stroke volume, increased left ventricular ejection fraction, increased myocardial activity which is mainly determined by tension time index.
Material and Method: After getting approval from medical ethics committee this study was carried in Stress Test Lab at Dr. D. Y. Patil Hospital & Research center, Nerul, Navi Mumbai. In this study, Athletes (30) and non-athletes (30) were exercised Treadmill for different duration for 3 times a week. (Till to get 90% of maximal, age-predicted heart-rate). Parameters chosen were systolic time intervals (Pre-ejection phase, Left ventricular ejection phase, duration of systole. i.e. total electromechanical systole) were derived from Echocardiography while Tension time index was calculated as Tension Time index = systolic pressure x duration of systole x pulse While calculating Tension time index, duration of systole which is in msec. is converted into minute.
Result: Left ventricular ejection fraction was somewhat increased (*P*<0.005) while systolic time intervals as left ventricular ejection phase, duration of systole and tension time index was found to be much more increased (*P*<0.001) without any change in pre-ejection phase and recovery time after performing treadmill. This shows that regular exercise from moderate to maximum affect left ventricular functions.
Conclusion: Thus it was concluded that as a subject goes on doing exercise from moderate to maximum, depending on the need of oxygen, tension time index also increases, showing tension time index as a best evaluator of exercise performance.

Keywords: Tension time index, treadmill, exercise performance, systolic time intervals

Introduction

Tension time index is a major determinant of myocardial activity. It can be used to evaluate cardiac efficiency of a person in various different fields. Tension time index was first time discovered by Sarnoff *et al.* in 1960 by measuring pressure underneath left ventricular area by inserting intra-aortic balloon. As a subject go on doing exercise from moderate to maximal, need of oxygen to tissues increases, resulting increased cardiac output, stroke volume, increased left ventricular ejection fraction, increased myocardial activity which is mainly determined by tension time index.

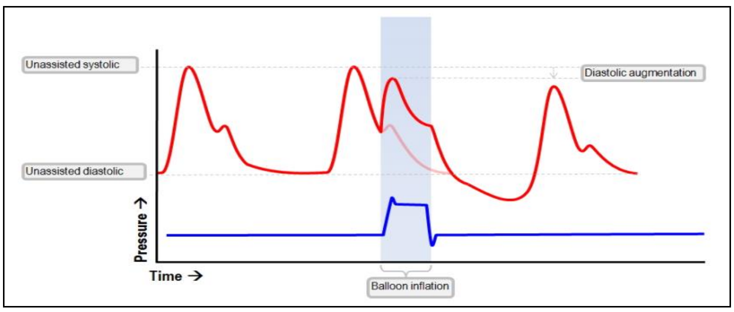

Fig 1: Above diagram shows that as the aortic pressure decreases, the balloon deflates.

Methodology

After getting approval from medical ethics committee and permission from Dr. Priya Cholera and Dr. Kane, this study was carried in stress Test Lab at Dr. D.Y. Patil Hospital & Research center, Nerul, Navi Mumbai under the guidance of Dr. Vivek Nalgirkar. Athletes (30) and non-athletes (30) from age-group 18 – 24yrs were exercised Treadmill for different duration for 3 times a week. (Till to get 90% of maximal, age-predicted heart-rate) (Using Bruce protocol). Treadmill–intensity–10mm/mv, frequency–50 hertz, speed–25 m/sec. Parameters chosen were systolic blood pressure, pulse, systolic time intervals (pre-ejection phase, Left ventricular ejection phase, duration of systole. i.e. total electromechanical systole) were derive from 3D Echocardiography. 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.

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. Duration of systole (QS2) = Period between onset of Q-wave to closure of aortic valves as determined by onset of second heart sound, Left ventricular ejection time (LVET) = Period from beginning of carotid pressure rise to the dicrotic notch.

In this study tension time index was calculated as

Tension Time index = systolic pressure x duration of systole x pulse

While calculating Tension time index, duration of systole which is in msec. is converted into minute-minutes = milliseconds ÷ 60,000

Table I: Statistical analysis

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							
VO2max	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			

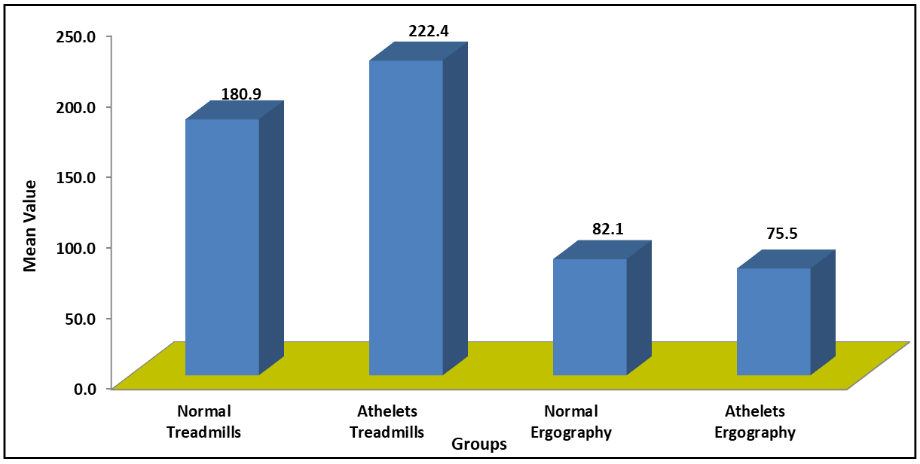

Fig 2: Mean value of tension time index

Result

Tension time index was found to be much more increased in athletes performing treadmill as compared to non-athletes performing treadmill (increased) (P<0.001) and was totally in normal range in athletes and non-athletes performing ergography. Left ventricular ejection fraction was somewhat increased (P<0.005) while systolic time intervals as left ventricular ejection phase, duration of systole and tension time index was found to be much more increased (P<0.001) without any change in pre-ejection phase and recovery time after performing treadmill. This shows that regular exercise mainly affects cardiac function rather than pulmonary function. The maintenance of left ventricular function depends on regular exercise. These findings highlight the plasticity of left ventricular function in relation to the current level of physical activity.

Discussion

The American College of Sports Medicine (ACSM) states that an acute bout of aerobic exercise can be modified by three primary factors constituting the exercise dose: intensity, duration, and modality. Increase in cardiac output during exercise in non-athletes, is due to changes in heart-rate, ejection time is shortened but it rate rises due to positive inotropic action of increased sympathetic activity and reduced peripheral vascular resistance.

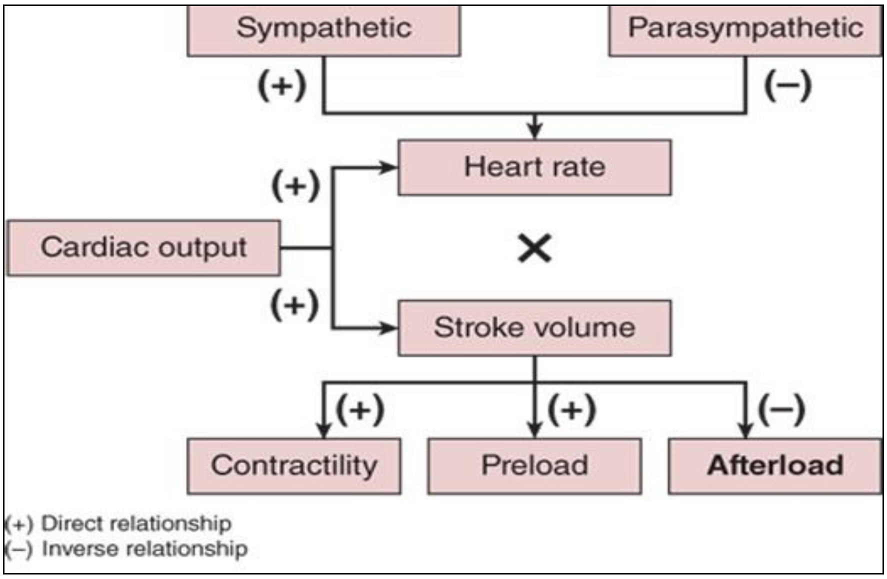

Fig 3: Cardiac output

During exercise with an increase in preload and decrease in afterload, with increase in stroke volume and heart-rate, cardiac output increases which is mainly under the control of autonomic nervous system.

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. (Thomas Rowland).

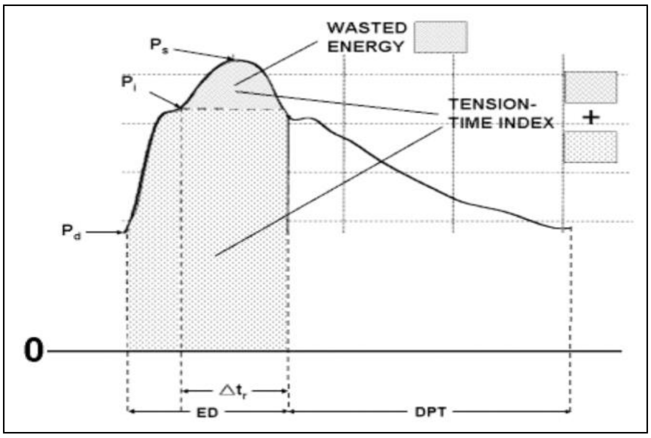

Fig 4: Wasted energy and tension time index

As person goes on doing moderate to maximal exercise, Vo2max goes on increasing with increase in stroke volume but only upto 40% of Vo2max.Extra work done is said to be wasted energy above tension time index.

The athletes tested had shorter pre-ejection periods, longer ejection times, and faster mean systolic ejection rates at the same exercise heart rates than subjects who were moderately trained and untrained from which some authors hypothesized that an enhanced end diastolic volume and ejection fraction were involved in the increased stroke volume in athletes. It has been hypothesized that one of physical training's greatest effects may be via the autonomic nervous system.

Changes in myocardial function may account for the required increase in stroke volume. In addition, long-term changes in myocardial function may contribute significantly by altering diastolic filling and systolic emptying, as indicated by higher ejection fraction and fraction of shortening after training. Although stroke volume is acutely regulated by extra cardiac factors such as venous return, neurohormonal regulation, and afterload.

The athletes tested had shorter pre-ejection periods, longer ejection times, and faster mean systolic ejection rates at the same exercise heart rates than non-athletes who were moderately athletes and non-athletes from which some authors hypothesized that an enhanced end diastolic volume and ejection fraction were involved in the increased stroke volume in athletes.

Conclusion

From above study it was concluded that as a subject goes on doing exercise from moderate to maximum, depending on the need of oxygen, tension time index also increases, showing tension time index as a best evaluator of exercise performance.

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